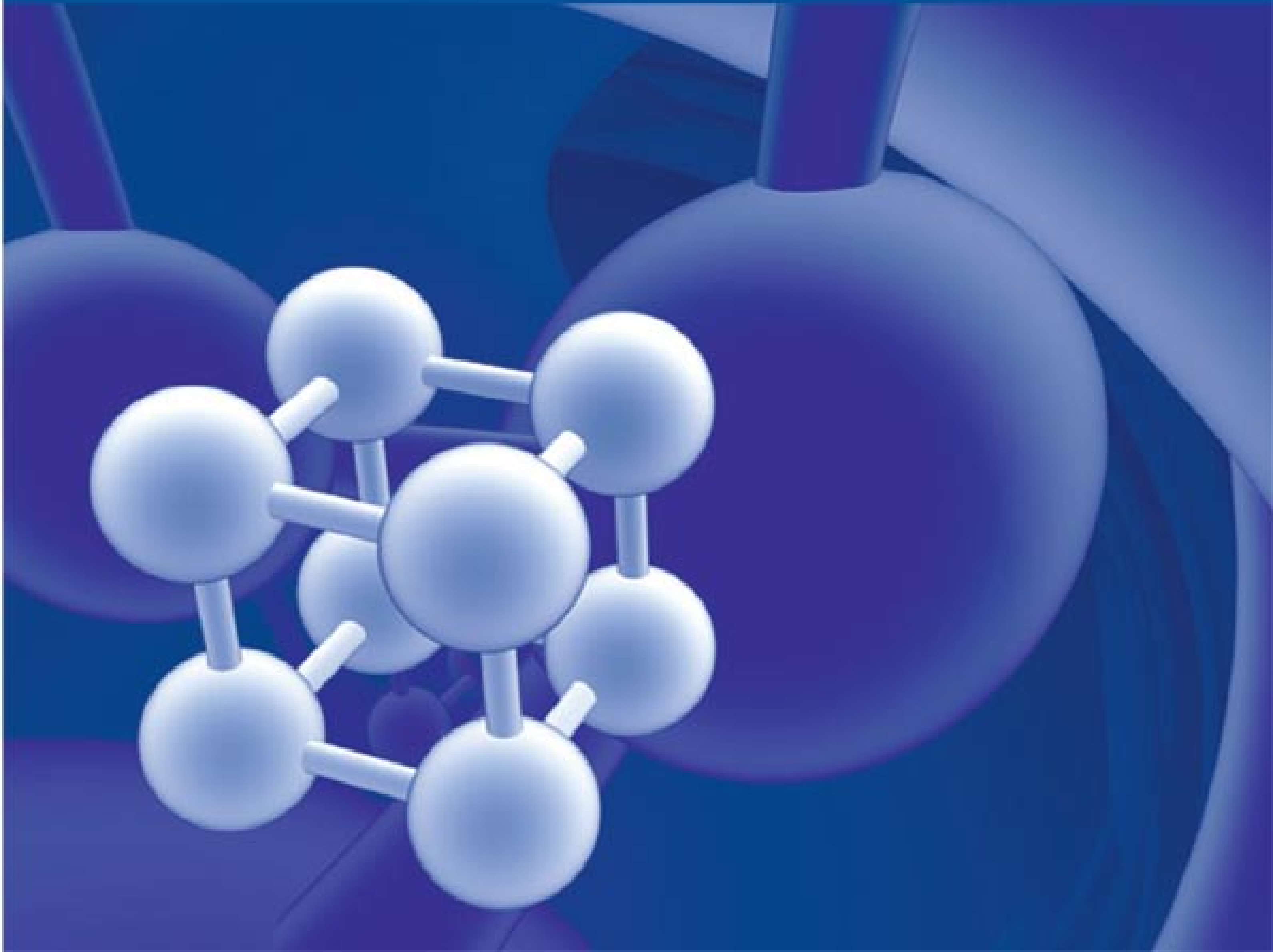
The Research Council of Norway

Basic Chemistry Research in Norway

Evaluation

Division for Science



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To the Research Council of Norway

The Evaluation Committee for the review of basic research in Chemistry in Norway hereby submits the following report.

The task of making a fair and adequate review of the whole field of activities has been demanding. The Committee is of the opinion that the review will be a worthwhile instrument for the Research Council of Norway, as well as for the facilities, institutes, departments and research groups concerned.

The report represents an agreed account of the assessment, recommendations and conclusions.

E. Hey-Hawkins

Evamarie Hey-Hawkins
Chair

Robert J. Cava

Daniel Duprez

David Fowler

Thisbe K. Lindhorst

Paul Madden

Gerhard Schembecker

PREFACE

This is the report of an ad hoc international Committee convened by the Research Council of Norway (RCN) to assess basic research in Chemistry in Norway.

The report has been prepared specifically for the RCN, which reserves the right to use the contents as it sees fit. As the report is expected to reach a wide audience, the Committee hopes its deliberations will promote a useful, constructive debate within the Norwegian chemistry community.

The first review of chemistry research at Norwegian universities and colleges, the “Weitkamp report”, was submitted to the RCN in 1997. The current effort is the second review of basic research in Chemistry of Norway to be commissioned by the RCN. The hearings and meetings with staff of the universities and institutes involved took place between September and October 2008, although the information-gathering process, including factual information, self-evaluation and bibliometric analysis, began in January 2008. The project has involved comprehensive assessments of research efforts at the departmental and research group level. The process of achieving insight into such a wide variety of research efforts and working to come to a fair assessment of their strengths and weaknesses has required substantial effort by the evaluation Committee, the RCN, and the faculty, staff, and Ph.D. students in the evaluated departments.

In spite of the substantial scope of the project, the Committee feels that it was able to discuss research-related issues with a significant number and cross-section of faculty and students, and to obtain sufficient information on which to base balanced and fair assessments. The Committee is confident that its analyses and recommendations are well founded. It is hoped that the report will be viewed as a constructive basis for improvement, development, and change.

1 EXECUTIVE SUMMARY

This is the report of an ad hoc International Committee convened by the Research Council of Norway (RCN) to assess basic research in Chemistry in Norway.

The Committee prepared this written report following a review of the self-assessments provided by the institutions, discussions with staff and visits to most of the research facilities. Assessment of the scientific quality and productivity of research groups was primarily based on the information provided in the CVs as part of the self-evaluations, publications and other printed materials that were available during the interviews, publications that the Committee accessed electronically in databases, and also on a bibliometric analysis, which is included in the appendix. A set of specific recommendations for future development in the field, including potential means of improvement, has been provided in the report.

The first review of chemistry research at Norwegian universities and colleges, the “Weitkamp report”, was submitted to the RCN in 1997. There have been important changes since the last review, especially changes in attitude and in management structures to allow strategic planning in research. Substantial new initiatives have been put in place, but the overall impression conveyed by Weitkamp shares many similarities with the current assessment. The Committee notes that since the time of the Weitkamp report there has been a significant reduction in the size of many of the departments, and thus the opportunities to generate new lines of research seem to have suffered, as the other responsibilities of the staff, including teaching and administration, have not declined proportionately.
The following general observations and conclusions have been made by the Committee:

- Norway has a relatively small academic community. This small size has drawbacks when it comes to international competitiveness, as it limits the number of new directions that can be pursued by a “critical mass” of researchers.
- The number of academic positions in all Chemistry Departments has fallen, in some cases quite substantially. The teaching load for professors who are interested in performing research is often excessive, apparently limiting their research productivity. This problem appears to be aggravated by the fact that there are sometimes non-core courses taught with only a few students enrolled.
- When compared to other countries the current academic chemistry community in Norway appears to have a larger proportion of late career professors no longer very active in research.
- The academic staff lists of the departments the Committee surveyed contained a very high proportion (by international standards) of people who had completed their masters and Ph.D.s in the same department, and had acted as research assistants in

the same research areas; there appears to be a strong culture of appointing the group's intellectual progeny.

- A universally recognized problem was the difficulty of convincing Norwegian students to obtain a Ph.D. degree and the shortage of Ph.D. students in general. The value added of a Ph.D. to a career in industry, which most Norwegian students have as their target, seems not to be widely appreciated.
- Compared to many other countries, the general professional development aspect of the Ph.D. is not emphasized as much as work on the specific project. Given the high number of international students now doing Ph.D.s in Norway this might not be appropriate. Thought should be given to fostering and monitoring the development of transferable skills and to provision of programmes for education in key topics not taught in undergraduate courses. Given the small number of Ph.D. students in most universities, this might need to be implemented at a national level.
- Educational programmes and teacher training only exist at NTNU and the University of Oslo. However, the result of this engagement seems to be limited or ineffective, as nearly all chemical departments in Norway complain about their difficulties in recruiting science students.
- The funding available for research in Norway is a smaller fraction (0.7%) of GDP than in most European countries, well below US levels, and below the EU recommended target.
- Most funding provided by the RCN is through managed programmes (NANOMAT, RENERGI, and FUGE) - there is only a low budget for untargeted responsive-mode applications ("blue skies" research). For the development of new, innovative lines of research, however, a substantial volume of blue skies work is required to sustain the vitality of the field and to develop new talent. The fraction of this type of research is currently much too small in Norwegian chemistry.
- The current funding system for the academic chemistry departments in Norway requires those departments to divide their financial resources among many different expenses. There are high staff costs (sometimes consuming the entire budget), limited strategic support for research, limited technical support, and very limited funds to support start-up grants.
- The research infrastructure is mainly good, in the Centres very good, but there is always scope for improvement. The basic equipment was often running unsupported without maintenance contracts and without dedicated technicians. There does not seem to be a culture of paying for services, which is in contrast to international practices.

- The opportunities for working closely with research institutes and with industrial laboratories in Norway are well developed and compare favourably in international comparisons. In certain cases, there was an indication that such relationships had upset the appropriate balance between applied and fundamental research in the university department.
- The Norwegian chemical and energy industries primarily hire master-level graduates, and, based on the information presented to the Committee, appear to credit little or no added value, either in entry positions or salary, to new appointments with a Ph.D. rather than a master's degree. The Committee understands from the week's testimony that Norway's chemical industry has relatively little interest in the field of organic chemistry and structural chemistry/biology.

Considering the main research areas, the following general observations were made by the Committee. (Specific evaluations and comparative assessments were made at the departmental and research group level.)

- Inorganic and materials chemistry are interdisciplinary specialties in the international chemistry community that have increased in activity and importance in the past decade. On the whole, the health of these chemical sub-disciplines in Norway can be considered as very strong, arguably amongst the strongest in the current Norwegian academic system.
- High-performance computing facilities, which are the most important infrastructural components for theory and computational chemistry, are outstanding in Norway and access is at a world-leading level. The major problems for both subjects are the lack of Ph.D. students and, in many groups, the reliance on very limited responsive-mode funding. Within the spectrum of research regarded as topical in computational chemistry worldwide, several areas are underrepresented in Norway.
- The catalysis groups in Norway should strengthen their mutual collaboration by sharing their own expertise in one or two common projects (other than inGAP). Catalysis in Norway has a good international impact in terms of publications, although improvement is possible. In this respect, catalysis groups could intensify their cooperation with materials science groups.
- There is little life sciences-related research in chemistry departments in Norway, however, the groups engaged in this work are among the most successful that were evaluated. Increasing interactions with bioorganic chemistry should be a mutual advantage for both fields.
- Internationally, organic chemistry is normally a prominent area within chemistry departments. This is not the case in Norway, where organic chemistry is hardly ever

found as a stand-alone area within chemistry departments. The Committee believes that organic chemistry in Norway can become internationally more visible through several changes in the way it is practiced. Further, it appears that there will be no good opportunities for better funding of research in synthesis in the near future. Increased investment would be essential for the health of this discipline, as the success of KOSK has shown.

- Chemical physics is in a particularly precarious position; and this is especially true of classical areas like gas-phase spectroscopy. This means that Norwegian chemistry is turning its back on several laboratory-based subjects with important potential for other areas of chemistry, as well as abandoning classical areas of study that are important to the discipline pedagogically and methodologically. A great deal of the activity described as physical chemistry is motivated by concerns of Norwegian industries and does not reflect the subject as seen globally.
- Environmental chemistry is a Norwegian strength, and the geographical opportunities and environmental threats in and to Norway are a clear driver of the research agenda. The areas of specialisation also provide excellent opportunities for international collaboration, which is very important in the longer term for this community.
- The national effort in nuclear chemistry in Norway is concentrated in one research group in Oslo, where the facilities are excellent but there is a shortage of personnel. There are two strategic reasons why it is critical to maintain nuclear chemistry in Norway. Firstly, radiopharmaceutical chemistry plays an important role in rapidly developing medical technologies. Secondly, Norway has very important deposits of thorium, an alternative base nuclear fuel to uranium. Nuclear energy technologies based on thorium are under development internationally in order to exploit its long-term advantages.
- In applied chemistry and chemical engineering the research questions addressed are driven by the concerns of Norwegian industries. Major societal challenges, including carbon dioxide capture and storage are covered by the research groups in this field. Therefore, the research performed is highly relevant to Norwegian society and global efforts to mitigate global warming. Further, Norway should consider in the near future establishing collaboration between research in chemical engineering and research in the field of biotechnology.
- Analytical chemistry is not a specialized area for many of the departments reviewed and has been effectively integrated within larger research groups.

In spite of the substantial scope of the project, the Committee feels that it was able to discuss research-related issues with a significant number and cross section of faculty and students, and to obtain sufficient information on which to base balanced and fair assessments.

The Committee is confident that its analyses and recommendations are well founded. It hopes that the report will be viewed as a constructive basis for improvement, development, and change.

2 INTRODUCTION

2.1 THE MANDATE FOR THE EVALUATION COMMITTEE

The Division of Science at the RCN has requested an evaluation of basic research activities in Chemistry in Norwegian universities and colleges.

The objective of the evaluation

Specifically, the evaluation process will:

Offer a critical review of the strengths and weaknesses of chemistry research in Norway, both nationally and at the level of individual research groups and academic departments. The scientific quality of the basic research will also be evaluated in an international context.

Identify research groups that have achieved a high international level in their research, or have the potential to reach such a level.

Identify areas of research that should be strengthened in order to ensure that Norway will possess the necessary competence in areas of importance to the nation in the future. And, as one aspect of this, provide information to help the RCN to assess the impending situation regarding recruitment in important fields of Chemistry.

The long-term purpose of the review

The evaluation will provide the institutions concerned with information that will be helpful in raising their own research standards. They will be provided with feedback regarding the scientific performance of individual research groups, as well as suggestions for improvements and priorities.

The evaluation will provide an additional knowledge base for strategic decision-making by the RCN for their work developing Chemistry research in Norway, and represent a basis for determining future priorities, including funding priorities, both within and among individual areas of research.

The evaluation will reinforce the role of the RCN as advisor to the Norwegian Government and relevant ministries.

Methods

An international Committee was appointed by the RCN. The Committee based its assessments on self-evaluations including SWOT analyses provided by the departments and research groups as well as meetings with various departments and research groups. The meetings included oral presentations, formal and informal questioning, and an interview of Ph.D. students. In addition, the Committee carried out site visits to the institutions involved in the evaluation. The departments' self-evaluations included information about organisation and resources, and development and future plans, as well as CVs and publication lists of the scientific staff. Assessment of the scientific quality of research groups was based in particular on the bibliometric analysis, which is included in the appendix. The Committee has written a report with a set of specific recommendations, as requested by the RCN. A preliminary version of the report was sent to the departments for comments, and suggestions for revision were incorporated where consistent with the Committee's views. The final report has been submitted to the RCN's Board of the Division of Science.

2.2 MANDATE

The Committee was requested to evaluate scientific activities with respect to their quality, relevance and international and national collaboration. The Committee was further requested to evaluate the way in which Chemistry research is organised and managed. The Committee prepared this written report based on the self-assessments provided by the institutions, the interviews of staff, and the site visits, with a set of specific recommendations for the future development in the field, including means of improvement when required.

The research groups and institutions included in this evaluation have very different origins, structures, and priorities, some being long established departments within the Norwegian universities while others are very new, and have only had university status for a short time. Some of the groups, both in the Institutes and Universities, have very close links to industry and commercial activities rather than a purely academic orientation. The Committee recognises these differences and has taken them into consideration in the evaluation. Such institutional differences are a cause of some of the differences in outputs of publications. The Committee has analysed the strengths of the research activity for all groups on the same basis, and has used the known differences between the groups and institutions in the interpretation and recommendations.

The conclusions of the Committee have led to a set of recommendations concerning the future development of research in Chemistry in Norway. The following specific aspects have been considered:

General aspects

- Which fields of research in Chemistry have a strong scientific position in Norway and
- Which have a weak position? Is Norwegian research in Chemistry being carried out in fields that are regarded as relevant by the international research community? Is Norwegian research in Chemistry ahead of scientific developments internationally in specific areas?
- Is there a reasonable balance between the various fields of Norwegian research in Chemistry, or is research absent or underrepresented in any particular field? On the other hand, are some fields overrepresented, in view of the quality or scientific relevance of the research that is being carried out?
- Is there a reasonable degree of cooperation and division of research activities at the national level, or could these aspects be improved?
- Do research groups maintain sufficient contact with industry and the public sector?

Academic departments

- Are the academic departments adequately organised?
- Is scientific leadership being exercised in an appropriate way?
- Do individual departments carry out research as part of an overall research strategy?
- What is the balance between men and women in academic positions?

Research groups

- Do the research groups maintain a high scientific quality judged by the significance of contribution to their field, the prominence of the leader and team members, and the scientific impact of their research?
- Is the productivity, e.g., the number of scientific papers and Ph.D. theses awarded, reasonable in terms of the resources available?
- Do the research groups have contracts and joint projects with external partners?
- Do they play an active role in dissemination to industry and the public sector of their own research and new international developments in their field?
- Do they play an active role in creating and establishing new industrial activity?
- Is the international network, e.g., contact with leading international research groups, number of international guest researchers, and number of joint publications with international colleagues, satisfactory?
- Do they actively take part in international professional committees and other professional activities outside their immediate research programmes?
- Have research groups drawn up strategies with plans for their research, and are such plans implemented?

- Is the size and organisation of the research group reasonable?
- Is there sufficient contact and cooperation among research groups nationally, and how do they cooperate with colleagues in the research institute sector?
- Do the research groups take active part in interdisciplinary/multidisciplinary research activities?
- How is the long-term viability of the group evaluated in view of future plans and ideas, staff age, facilities, research profile, new impulses through recruitment of researchers?
- What roles do Norwegian research groups play in international cooperation in individual subfields of Chemistry? Are there any significant differences between Norwegian research in Chemistry and research being done in other countries?
- Do research groups take part in international programmes or use facilities abroad, or might utilisation be improved by introducing special measures?

Research infrastructure including scientific equipment

- What are the status and future needs with regard to laboratories and research infrastructure?
- Is there sufficient cooperation related to the use of expensive equipment?

Training and mobility

- Does the scientific staff play an active role in stimulating the interest in their field of research among young people?
- Is recruitment to doctoral training programmes satisfactory, or should greater emphasis be put on recruitment in the future?
- Is there an adequate degree of national and international mobility?
- Are there sufficient educational and training opportunities for Ph.D. students?

Future developments and needs

The Committee's written report is based on the elements and questions above. The assessments and recommendations are provided at the research group, department, institutional, and national level.

2.3 GRADING

For the assessment of the research groups a grading system has been applied that focusses on the following aspects:

Scientific Quality and Productivity

- internationally applied standards for scientific quality based on bibliometric analysis
- number of Ph.D., master's students and grades awarded
- participation in conferences

Relevance and Societal Impact

Aspects of the science that are not reflected by normal internationally applied scientific measures, in particular, relevance to Norwegian industry, health, national and global environmental issues and culture. This is more difficult to assess quantitatively.

Strategy, Organisation and Research Cooperation

- arrangement of infrastructure to facilitate quality of the work
- organising research group activities to improve funding opportunities
- supportive environment

The grading scale is:

Excellent = 5

Internationally leading position, undertaking original research and publishing in the best international journals. High productivity (including number of Ph.D. theses awarded). Clear and convincing strategy and future planning. Very positive overall impression of the research group and leadership.

Very good = 4

A publication profile with a high degree of international publications in good journals. High productivity and very relevant to international research or to Norwegian society including Ph.D. training. Good strategy and future planning. Very positive overall impression of the research group.

Good = 3

Contribute to international and national research with good quality research of relevance both to international research development and to Norwegian problem solving. Number of Ph.D.s is reasonable. Good balance between international and national publications. Acceptable productivity. Strategic plans are reasonable to good. Positive overall impression of research group.

Fair = 2
The quality of research is acceptable, but the international publication profile is modest. Much routine work evident in research programme design and in publications, few original contributions. Relevance and productivity of research are not exciting. Strategic planning exists, but is not convincing or realistic. Overall impression is positive but with significant reservations by the evaluators.

Weak = 1
Research quality is below good standards and the publication profile is poor. Only occasional international publications. No original research and little relevance to national problems. Diffuse strategic planning. No overall positive impression by evaluators.

2.4 THE EVALUATION COMMITTEE

Professor Evamarie Hey-Hawkins Universität Leipzig, Germany Faculty of Chemistry and Mineralogy Institute of Inorganic Chemistry Johannisallee 29 D-04103 Leipzig	Professor David Fowler Centre for Ecology and Hydrology, Bush Estate, Penicuik, Edinburgh EH26 0QB UK
Professor Robert J. Cava Department of Chemistry Princeton University Princeton NJ 08544 USA	Professor Paul Madden Provost of Queen's College University of Oxford Oxford OX1 4AW UK
Professor Thisbe K. Lindhorst Christiana Albertina University of Kiel, Germany Otto-Diels-Institute of Organic Chemistry Otto-Hahn-Platz 3-4 D-24098 Kiel	Professor Daniel Duprez Laboratoire de Catalyse en Chimie Organique (LACCO), 40, Av. Recteur Pineau 86022 Poitiers France
Professor Gerhard Schembecker Technische Universität Dortmund, Germany Department of Biochemical and Chemical Engineering Laboratory for Plant and Process Design Emil-Figge-Str. 20 D-44227 Dortmund	

Executive Secretary Dr. Doritt Luppa, Universität Leipzig, Germany, was involved in compiling all the input from the Committee members and in processing the report.

3 GENERAL DESCRIPTION

3.1 PARTICIPANTS OF THE EVALUATION

The following institutions are included in the review:

University of Oslo (UiO)
Department of Chemistry
Synthesis and molecular structure
Analysis and environment
Nuclear chemistry
Functional inorganic materials
Catalysis
Polymers – organic materials
Quantum mechanics, structure and dynamics
School laboratory

Norwegian University of Science and Technology (NTNU)
Department of Materials Science and Engineering (DMSE)
Inorganic chemistry
Electrochemistry
Department of Chemistry
Organic chemistry
Environmental and analytical chemistry including chemistry dissemination
Physical chemistry
Department of Chemical Engineering
Catalysis
Colloid and polymers
Process systems engineering
Reactor technology
Separation and environmental technology
Paper and fibre technology

University of Bergen (UiB)
Department of Chemistry
Organic, biophysical and medicinal chemistry
Inorganic chemistry, nanostructures and modelling
Physical-, petroleum- and process chemistry

University of Tromsø (UiT)

Department of Chemistry

Organic chemistry

Inorganic and materials chemistry

Structural chemistry

Theoretical chemistry

University of Stavanger (UiS)

Department of Mathematics and Natural Sciences

Biological chemistry

Chemistry and environment

Norwegian University of Life Sciences (UMB)

Department of Plant and Environmental Sciences (IPM)

Environmental chemistry at IPM

Department of Chemistry, Biotechnology and Food Science (IKBM)

Natural product chemistry and organic analysis at IKBM[1]

Norwegian Institute for Air Research (NILU)

Environmental Chemistry Department

3.2 KEY FIGURES

3.2.1 Graduates

Numbers are taken from the factual information provided by the Departments				
Dr. ing./Dr. scient. graduated	**2005**	**2006**	**2007**	**Total**
University of Oslo				

[1] The research group “Organic Chemistry” was renamed “Natural Product Chemistry and Organic Analysis” throughout this report as requested by UMB

Synthesis and molecular structure	2	1	3	6
Analysis and environment	4	3	5	12
Nuclear chemistry	1	0	2	3
Functional inorganic materials	6	0	3	9
Catalysis	1	2	1	4
Polymers – organic materials	0	2	0	2
Quantum mechanics, structure and dynamics	1	1	1	3
Norwegian University of Science and Technology				
Inorganic chemistry	5	5	2	12
Electrochemistry	6	2	1	9
Organic chemistry	3	2	3	8
Physical chemistry	1	1	4	6
Environmental chemistry including chemistry dissemination	4	2	0	6
Catalysis	4	3	6	13
Colloid and polymer chemistry	3	3	3	9
Paper and fibre technology	0	4	0	4
Process systems engineering	2	1	3	6
Reactor technology	2	4	1	7
Separation and environmental technology	2	0	2	4
University of Bergen				
Organic, biophysical and medicinal chemistry	3	5	2	10
Inorganic chemistry, nanostructures and modelling	0	5	5	10
Physical-, petroleum- and process chemistry	1	2	2	5
University of Tromsø				
Organic chemistry	1	1	0	2
Inorganic and materials chemistry	1	0	0	1
Structural chemistry	1	1	3	5
Theoretical chemistry	0	0	1	1
University of Stavanger				
Biological chemistry	1	3	2	6
Chemistry and environment	1	1	1	3
Norwegian University of Life Sciences				
Environmental chemistry at IPM	2	2	2	6
Natural products chemistry and organic analysis at IKBM	3	0	1	4
Norwegian Institute for Air Research	0	2	2	4

Numbers are taken from the factual information provided by the Departments				
M.Sc. graduated	**2005**	**2006**	**2007**	**Total**
University of Oslo				
Synthesis and molecular structure	3	7	1	11
Analysis and environment	6	10	12	28
Nuclear chemistry	0	1	0	1
Functional inorganic materials	7	5	2	14
Catalysis	2	3	1	6
Polymers – organic materials	1	3	1	5
Quantum mechanics, structure and dynamics	0	1	2	3
Norwegian University of Science and Technology				
Inorganic chemistry	5	6	7	18
Electrochemistry	9	10	15	34
Organic chemistry	11	8	13	32
Physical chemistry	3	4	0	7
Environmental chemistry incl. chemistry dissem.	2	3	7	12
Catalysis	6	8	11	25
Colloid and polymer chemistry	3	1	5	9
Paper and fibre technology	1	3	1	5
Process systems engineering	2	3	2	7
Reactor technology	6	1	6	13
Separation and environmental technology	5	2	2	9
University of Bergen				
Organic, biophysical and medicinal chemistry	2	5	8	15
Inorganic chemistry, nanostructures and modelling	0	5	1	6
Physical-, petroleum- and process chemistry	2	4	5	11
University of Tromsø				
Organic chemistry	3	0	2	5
Inorganic and materials chemistry	0	0	0	0
Structural chemistry	0	0	0	0
Theoretical chemistry	0	0	0	0
University of Stavanger*				
Offshore Environmental Engineering Program	10	12	13	35
Biological Chemistry Program	0	0	8	8
Norwegian University of Life Sciences				
Environmental chemistry at IPM	3	2	7	12
Natural product chemistry and organic analysis at IKBM	9	5	4	18

*The master program in Biological Chemistry started autumn 2006. Members of both research groups have supervised on both master programs

3.2.2 R&D Expenditures by Main Source of Funding (1000 NOK)

Type of expenditures provided by the factual information of the Departments	**2005**	**2006**	**2007**
UiO, Department of Chemistry			
University funding,[1)] salaries (including SMN)	40,500	41,000	40,970
University funding, others	2,700	2,500	2,500
University funding, instruments and equipment	1,700	800	240
University funding, total	**44,900**	**44,300**	**43,710**
RCN, Other national grants (salaries, social costs, overhead, including SMN)	28,000	30,000	38,000
RCN (instruments, equipment)	6,800	3,200	1,000
Other national grants (public or private)			
International grants (including EU)	500	2,600	700
External funding, total	**35,300**	**35,800**	**39,700**
Total expenditures	**80,200**	**80,700**	**83,410**
External funding as % of total expenditures	44	44	47
NTNU, DMSE[2)]			
University funding, salaries	13,000	13,000	13,000
University funding, other costs	1,600	2,300	2,100
University funding, instruments and equipment	1,600		1,900
University funding, total	**16,200**	**15,300**	**17,000**
RCN, grants	14,400	15,900	13,200
Other national grants (public or private)	1,000	1,000	1,000
International grants (including EU)	2,000	2,000	2,000
External funding, total	**17,400**	**18,900**	**16,200**
Total expenditures	**33,600**	**34,200**	**33,200**
External funding as % of total expenditures	51.8	55.3	48.8
NTNU, Department of Chemistry			
University funding,[1)] salaries	23,346	22,696	24,631
University funding, other costs	2,980	3,100	2,150
University funding, instruments and equipment	610	850	2,238
University funding, total	**26,936**	**26,646**	**29,019**
RCN, grants	12,933	10,350	6,545
Other national grants (public or private)	1,754	913	457
International grants (including EU)	1,445	1,325	583
External funding, total	**16,132**	**12,598**	**7,585**
Total expenditures	**43,068**	**39,244**	**36,604**
External funding as % of total expenditures	37	32	21

NTNU, Department of Chemical Engineering			
University funding,[1)] salaries	19,321	19,078	19,858
University funding, other costs	5,190	5,913	7,294
University funding, instruments and equipment	2,383	4,058	4,231
University funding, total	**26,894**	**29,049**	**31,383**
RCN, grants	23,071	28,937	36,002
Other national grants (public or private)	19,073	14,428	14,118
International grants (including EU)	4,684	4,292	4,149
External funding, total	**46,828**	**47,657**	**54,269**
Total expenditures	**73,722**	**76,594**	**90,271**
External funding as % of total expenditures	64	62	60
UiB, Department of Chemistry			
University funding,[1)] salaries	17,300	18,500	20,200
University funding, other costs	10,700	12,100	14,300
University funding, instruments and equipment	8,700	6,800	1,800
University funding, total	**36,700**	**37,400**	**36,300**
RCN, grants	11,800	13,200	17,100
Other national grants (public or private)	1,500	800	1,300
International grants (including EU)	800	600	300
External funding, total	**14,100**	**14,600**	**18,700**
Total expenditures	**50,800**	**52,000**	**55,000**
External funding as % of total expenditures	27.8	28.1	34.0
UiT, Department of Chemistry			
University funding,[1)] salaries	10,432	10,971	11,142
University funding, other costs	5,281	5,077	5,500
University funding, instruments and equipment	2,218	725	3,400
University funding, total	**17,931**	**16,773**	**20,042**
RCN, grants	11,933	11,111	18,453
Other national grants (public or private)	0	120	400
International grants (including EU)	0	54	0
External funding, total	**11,933**	**10,285**	**18,853**
Total expenditures	**26,854**	**32,847**	**33,069**
External funding as % of total expenditures	44	31	57
UiS, Chemistry and Environment			
University funding,[1)] salaries	7,320	6,720	6,420
University funding, other costs	155	155	179
University funding, instruments and equipment	0	500	0
University funding, total	**7,475**	**7,375**	**6,599**
RCN, grants	18	1	4

Other national grants (public or private)	1,750	2,250	3,715
International grants (including EU)			
External funding, total	**1,768**	**2,251**	**3,719**
Total expenditures	**9,243**	**9,626**	**10,318**
External funding as % of total expenditures	19	23	36
UiS, Biological Chemistry			
University funding,[1)] salaries	1,200	4,050	4,600
University funding, other costs	61	81	88
University funding, instruments and equipment	2,500		
University funding, total	**3,761**	**4,131**	**4,688**
RCN, grants	239	2,986	5,567
Other national grants (public or private)			62
International grants (including EU)	4,047	1,658	1,320
External funding, total	**4,286**	**4,644**	**6,949**
Total expenditures	**8,047**	**8,775**	**11,637**
External funding as % of total expenditures	53	53	60
UMB, Environmental Chemistry at IPM			
University funding,[1)] salaries	4,050	4,500	4,700
University funding, instruments and equipment	500	22	437
University funding, total	**4,550**	**4,522**	**5,137**
RCN, grants	3,949	3,302	4,653
Other national grants (public or private)	2,123	1,472	4,061
International grants (including EU)	60	445	439
External funding, total	**6,132**	**5,219**	**9,153**
Total expenditures	**10,682**	**9,741**	**14,290**
External funding as % of total expenditures	57	54	64
UMB, Natural products chemistry and organic analysis at IKBM			
University funding,[1)] salaries	4,164	4,848	5,340
University funding, other costs	1,653	812	760
University funding, instruments and equipment	473	160	200
University funding, total	**6,290**	**5,820**	**6,300**
RCN, grants	0	0	418
Other national grants (public or private)	0	0	250
International grants (including EU)	0	0	0
External funding, total	**0**	**0**	**668**
Total expenditures	**6,290**	**5,820**	**6,968**
External funding as % of total expenditures			9.6
NILU			
University funding,[1)] salaries	9,746	10,717	13,668

University funding, instruments and equipment		2,000	600
University funding, total	**9,746**	**12,717**	**14,268**
RCN, grants	4,823	3,843	7,310
External funding, total	**4,823**	**3,843**	**7,310**
Total expenditures	**14,569**	**16,560**	**21,578**
External funding as % of total expenditures	33	23	34

1) University funding: This refers to the institutions input of own resources such as salaries for scientific personnel (including social costs)

2) The expenditures are estimates since the annual budget and external funding include research groups that are not involved in the evaluation

3.2.3 R&D Personnel

The R&D personnel categorisation is split into the groups professor, associate professor, professor II, postdoctoral fellow, doctoral students, and technical/administrative positions. The specific numbers are given at the department and research group level in the relevant chapters. The distribution of male and female scientific personnel in chemistry research is given in the table below.

	Professor		**Associate Professor and Professor II**		**Scientific Staff**	
	male	female	male	female	male	female
UiO	27	5	15	4		
NTNU	28	7	28	3		
UMB	3	2	7	3		
UiT	7	0	4	1		
UiS	4	2	8	0		
UiB	14	2	8	0		
NILU					9	8
Total	**83**	**18**	**70**	**11**	**9**	**8**

Numbers concluded from the factual information provided by the Departments to the Committee

In general, the percentage of women in the natural sciences depends on the individual disciplines. These numbers vary among different academic levels and usually decrease starting from the master's level.

4 GENERAL CONCLUSIONS

4.1 COMMENTS REGARDING THE WEITKAMP REPORT

This review takes place 11 years after the Weitkamp review, which concluded that the vitality and productivity of chemistry research in Norway did not reflect the economic and academic potential of Norway, and that comparison with near neighbours of a comparable size showed the Norwegian position to be weaker than those countries. In providing the national picture, many generic comments were made to characterise the chemical research community. These comments included aspects of mobility, the output of doctoral graduates, the use of sabbatical leave, the appointment of high-quality applicants to professorial positions, and the fraction of funding available to support 'blue sky' research. The Committee notes that in most of these cases the evidence provided to this Committee shows a similar picture. There have been important changes since the last review, and new initiatives have been put in place, but the overall impression of the chemistry research reviewed in 1997 shares many similarities with the current assessment; there has not been an apparent transformation over the intervening 11 years. The Committee notes that since the time of the Weitkamp report there has been a significant reduction in the size of many of the departments, and thus the opportunities to generate new lines of research have suffered, as the other responsibilities of the staff, including teaching and administration, have not declined proportionately.

4.2 THE NATIONAL PICTURE

The academic community

Norway has a relatively small academic community. This small size has drawbacks when it comes to international competitiveness, as it limits the number of new directions that can be pursued by a "critical mass" of Norwegian researchers. It also limits the force of intellect that can be brought to bear on any single important scientific problem. The Norwegian academic chemistry community makes up for the issue of size by organising into research groups where several professors within a university department are brought together to focus in areas of mutual interest. The resulting academic chemistry community performs good quality work when judged on an international standard, and several of the groups can be considered world-leading. Nonetheless, given the overall standard of living and financial resources of the country, the well-being and international competitiveness of the academic chemistry community could be substantially enhanced if several systemic issues were to be addressed.

The Norwegian academic chemistry community is relatively small, but is not necessarily small in proportion to the overall population of the country. There are, however, a variety of strong forces, described in more detail below, that conspire to limit the opportunities for young people who wish to pursue career paths based on obtaining a Ph.D. and entering the academic system as professors. Given the fact that advances in basic and applied science are most often made by enthusiastic, ambitious young people who look with a new perspective at problems that older generations could not solve, the consequences of this lack of an academic career path for young people in Norway are profound.

It is important to note that while a wide spectrum of chemistry research in Norway is covered by this review, there is much that is not included. The chemistry of the atmosphere (and of the ocean and earth system), in which Norway has considerable strength, may be found in university departments that were not included in this review (e.g., in Geosciences) and in Norwegian Institutes (e.g., the Norwegian Meteorological Institute). As substantial parts of this research operate at the highest levels and is in collaboration with leading research groups globally, our conclusions apply only to the parts of the community included in the review.

Staff and recruitment

A universally recognised problem was the difficulty of convincing Norwegian students to obtain a Ph.D. degree and the shortage of Ph.D. students generally. The fact that the number of university-funded Ph.D. positions has declined significantly means that there are very few positions in groups that do not attract industrial or programme-grant funding, further diminishing the viability of these groups. Even the larger groups were small by comparison with internationally leading groups in the same research area. Although positions are filled everywhere with overseas students, the lack of Norwegian students creates difficulties for supporting undergraduate teaching and leads to a lack of know-how within research groups in dealing with Norwegian institutions and practices. Norwegian Ph.D. students felt they faced an additional, heavy burden as a consequence.

The consequences of national policies became especially obvious during the Committee's interview of a dozen current Ph.D. students. These were smart, articulate, ambitious young people with a clear desire to do well and use their talents to the best advantage. Yet many of them stated that the Ph.D. degree in Norway is no guarantee for opportunities beyond the master's degree, especially for those who do not see their future in academia, and that it might even be a dead-end option.

The academic staff lists of the departments the Committee surveyed contained a very high proportion (by international standards) of people who had completed their masters and Ph.D.s in the same department, and had acted as research assistants in the same research group; there is a strong culture of appointing the group's intellectual children. It can be argued that special features of Norwegian science, in particular the close association between certain research groups and Norwegian industries and the programme management of research funding has led to the refinement of particular specialties, so that the "children" may indeed be the international experts in areas where maintaining expertise is important for Norway. Whilst there were examples that demonstrated this, more generally the Committee believes that this tendency inhibits the development of new internationally recognised research opportunities and also contributes to the perceived barrier between a Ph.D. and an academic position, to which the Committee referred above. Numerous important current research themes in chemistry have not developed at all in Norway (as highlighted below, chapter 3.4 "The Main Research Areas") and this may in part be a consequence of conservative appointments. Academic cultures in the US and Europe try very hard to discourage this culture of faculty hiring, although the problem does exist everywhere. The practice strongly inhibits academic departments from moving in new directions in response to new ideas; institutions that operate in this fashion show a strong tendency to lose their intellectual vitality.

Although an issue at many universities internationally, when compared to other countries the current academic chemistry community in Norway appears to have a larger proportion of late career professors no longer very active in research. This places a substantial financial strain on the system, as such professors do not bring external research funding to their universities from competitive national or international grants. Also, the unproductive professors occupy a non-negligible fraction of the limited number of academic positions available, resulting in a bottleneck that limits the opportunities for academic employment for young people. In addition, due to the low turnover rate of professors, many of the chemistry departments interviewed described plans for implementing change that involved decades, rather than years, strongly limiting the ability of the Norwegian academic system to move into the most current fields of scientific inquiry.

Research and teaching are both important parts of the responsibility of university chemistry departments. Many times during the presentations, the Committee heard testimony that the teaching load for professors who are interested in performing research is excessive, limiting their research productivity. If this is indeed the case, then professors who wish to perform research at internationally competitive levels may be substantially disadvantaged with respect to their international competitors.

Training and career perspectives of young researchers

One of the primary issues the system of science education faces is the value placed on the Ph.D. degree in science in Norway, presenting a situation that is quite different from that in most other developed countries. Typical career paths for Ph.D. scientists internationally are in university or institute research and teaching or in industrial research. There appear to be difficulties with each of these career paths in Norway. As a result, relatively few Norwegian students choose to pursue a Ph.D. degree. Therefore, Norway has a relatively smaller proportion of its workforce trained in the innovative, independent thought and experimentation that critically differentiates scientific Ph.D. degree holders from master's degree holders in other developed countries.

The perceived unattractiveness of the Ph.D. to Norwegian students seems to have several causes. The value added of a Ph.D. to a career in industry, which most Norwegian students have as their target, seems not to be widely appreciated. Moreover, it is not widely recognised that a very high proportion of people at highest levels in industrial research have Ph.D.s. Secondly, master's students are actively recruited by industry or research institutes to considerably higher salaries than are given in a Ph.D. programme. Therefore, without a perceived long-term advantage, the attractiveness of the Ph.D. (if seen as a pathway to an improved career in industry) is limited. Thirdly, because Ph.D. positions are now largely obtained on research grants, the ability to make an early commitment of a position to a promising master's student is diminished. This feature also discourages students from transferring between universities, many staying in the same one in which they did their masters. As the Committee notes below, this has longer term consequences for recruitment to academic positions. Fourthly, the Ph.D. programme seems to be less formally structured than those now offered in other countries. It appears that the perceived objective is solely specialised advanced training in the narrowly-defined research topic, and that more general acquisition of research skills and appreciation of the broader field in which that topic is located are not emphasised. Regular checkpoints, with students giving seminars or preparing formal reports, for example, until the actual submission of the Ph.D. thesis were rarely found. The concept of one person responsible for all graduates, to assist with obtaining support, to complete a research programme, to attend a conference abroad, or to advice about thesis preparation did not seem to be widely available. This creates particular problems for the overseas students and has a knock-on effect for the Norwegian students who are enlisted on an ad-hoc basis by the overseas students to perform these functions. Our observation is that the Ph.D. is managed as if all entrants come through a masters in the same university, whereas the reality is that this is now true in the minority of cases, with a large proportion coming from abroad. Lastly, there are special aspects of the transition from a Ph.D. to an academic position in many departments in Norway that appear to create a large barrier to pursuing an academic career.

Without doubt, the Norwegian Ph.D. students are very attractive to Norwegian industry; those the Committee interviewed were in no doubt that they would readily find positions. The Committee did not have an opportunity to interview non-Norwegian Ph.D. students to discover if they had the same objectives or expectations.

Mobility

The relatively small number of institutions supporting academic chemistry departments and the specialist areas of research in chemistry require the majority of Norwegian research groups to collaborate internationally to be working with the leading scientists in their fields. There are good examples of this activity, and the EU Framework research programmes are an important activity in which some Norwegian research groups are well connected. However, there are groups that have not developed these links, and, given the small size of the research community, schemes specific to Norway are needed to enable individuals to develop new ideas and learn new skills at leading institutions internationally.

Educational programmes and teacher training

Educational programmes and teacher training exist at NTNU and the University of Oslo. Therefore, these academic institutions play an important role in sensitising teachers in chemistry to the future needs of Norwegian society. Educating teachers provides an important opportunity to communicate to pupils the value of Norwegian chemistry graduates in overcoming challenges in, e.g., sustainable energy production, and the exciting career opportunities that are potentially available to chemists. Via this route, Norwegian universities are enabled to encourage young people to study chemistry or chemical engineering. However, the result of this engagement seems to be limited or ineffective, as nearly all chemical departments in Norway complain about their difficulties in recruiting science students.

The educational and teacher training programmes appear to be more a service than a stand-alone research activity. The groups are very small, sometimes consisting of only one person, and their involvement in the educational and teacher training programmes is high. The limited research the group at NTNU performs focusses on topics in non-didactic fields. The school laboratory at UiO does not carry out any research. However, it should be an important objective to understand why young people in Norway are not interested in entering the area of chemistry. One possibility may be to focus the research connected to the education and training programmes on the field of chemistry and its didactics. In order to optimise the limited resources in Norway for chemical education research, the Committee recommends coordinating any future activities in the field between NTNU and UiO. The establishment of a National Centre for Education in Chemistry may be helpful in this regard.

Financial

The funding available for research in Norway is a smaller fraction (0.7%) of GDP than in most European countries, well below US levels, and below the EU recommended target.

A very high proportion of these funds is now distributed through managed programmes, and the funding reserved for untargeted responsive-mode applications is low. The success rate of applications through the latter channel is ~10%, despite the fact that many of the most active groups do not bother with this potential source of funding. At this low success rate, peer review and similar mechanisms break down. The consequence for some branches of chemistry is quite severe, and meaningful research in some mainstream directions of enquiry is not possible. A recommendation would be to increase substantially funds for untargeted mode applications.

The current funding system for academic chemistry departments in Norway requires those departments to divide their financial resources among many different expenses. In all but one case, the funding provided as a block allocation by the parent university or faculty, was entirely consumed by salaries, so that infrastructure and research support positions had fallen away, and the opportunity to provide strategic support of research (as envisaged in the National Funding Strategy) was very limited. One consequence of this situation is the difficulty in maintaining continuity of technical expertise within a research group and supporting research instrumentation with technicians.

The number of academic positions in all chemistry departments has fallen, in some cases quite substantially. At some universities the departmental strength has become so low as to threaten the teaching of a viable chemistry degree and, everywhere, the burden of maintaining the range of courses offered has a very substantial effect on the research time of the academic staff. A further consequence is that some “research groups” are configured to support teaching rather than to respond to research needs and realistic research funding opportunities. The Committee highlights the plight of Organic Chemistry and experimental Chemical Physics below as examples.

Starting professors require an initial funding investment from their academic institution to begin their research efforts. The funds are used to purchase initial equipment and pay for students and postdoctoral fellows to obtain the first research results that new professors need to enter proposals into the competitive funding stream. These “start-up packages” for new academic faculty members in Norway are financed at levels substantially below the international standard. There are two effects of this policy. Firstly, the lack of funding hampers the competitiveness of young researchers at the time in their careers when they are likely to be the most creative and productive. Secondly, the low start-up funding packages make it very difficult for Norway to compete internationally to lure the top foreign researchers into its scientific establishment. Such people can greatly invigorate a research community due to the differences in their research culture and intellectual backgrounds, and are a desirable part of any national scientific system. The number of start-up packages required to make a difference in Norway in chemistry is small, (e.g., bringing just one or two leading international scientists into the community would made a considerable difference) and the absence of a competitive scheme places Norway at a considerable disadvantage.

For the development of new, innovative lines of research a substantial volume of ‘blue sky’ research is required to sustain the vitality of the field and to develop new talent. The fraction of this type of research is currently much too small in Norwegian chemistry.

The role of industry

The opportunities for working closely with research institutes and with industrial laboratories in Norway are very significant, in an international comparison. As illustrated elsewhere, the Committee observed both favourable and unfavourable consequences of these associations for the pursuit of basic research in university departments, even when recognising that industrially-motivated research is often basic (e.g., the topics of the catalysis groups in Norway are essentially concerned with natural gas, synthesis gas, methanol and alkene transformation. All of these topics are strategically important for Norwegian industry and more generally for the country as well as being scientifically interesting.).

The Norwegian chemical and energy industries, which are very healthy by international standards, primarily hire master-level graduates, and, based on the information the Committee was presented, appear to credit little or no added value, either in entry position or salary, to new appointments with a Ph.D. rather than a master’s degree (with an exception, may be, of those students having a Ph.D. contract with research institutes like SINTEF). The result is that there is little financial incentive for students to continue beyond their master’s degrees because the smaller number of years of salary they receive due to pursuing their Ph.D.s does not yield significant advantage to them in the long run. It may be that the current industrial situation in Norway, which is based primarily on the country’s substantial natural resources, is well suited by this system. This may not be an ideal long-term strategy, however, as Norway, like other developed countries, may eventually have to substantially increase the manufacture of high value-added products derived from its natural resources.

Norway clearly has the basic intellectual resources to perform well in the high value-added arena, and should consider better preparing its workforce for participating in such activities.

The Committee understands from the week's testimony that Norway's chemical industry has relatively little interest in the field of organic chemistry. This is in contrast to the situation in many developed countries, where the chemical industry has a very strong investment in the teaching and training of organic chemists at universities. This seems to be due to the lack of fine chemicals and pharmaceuticals in the current Norwegian chemical product line, which is directed more at the export of raw materials. The development of a fine chemical industry would certainly be an excellent opportunity for Norway in the long run, as it adds value to the use of Norway's abundant natural resources. Due mostly to this lack of interest, it seems, synthetic organic chemistry is in a particularly difficult position in Norway compared to the international standard.

Research infrastructure

Generally, the level of provision of basic research equipment seemed to be good, so the model of being able to prioritise particular pieces of equipment and to seek university and Research Council of Norway funding appears to be working. In research groups closely associated with research institutes the access to equipment was often excellent. In some universities, special centres (e.g., in nanoscience) had been created as a consequence of high-level decisions (at the faculty level or above); within research groups these initiatives were sometimes seen as having drawn away resources from their own priorities, but the centres did offer the prospect of a substantial facilities base for innovative activity.

In spite of these facts, the basic equipment was often running unsupported without maintenance contracts and without dedicated technicians. Therefore, whilst the equipment-funding model appears to work, it does not provide appropriate infrastructure support to use the equipment most effectively. There does not seem to be a culture of paying for services; the Committee only saw one or two examples of charging for, e.g., NMR or X-ray facilities. In contrast, models in which charges for services are used to support the long-term viability of facilities infrastructure are most commonly found internationally, and are a major aspect of financial planning in academic chemistry departments.

The Committee was surprised that there was relatively little enthusiasm among the departments for making high-level facilities available at a national level (an exception is high-performance computing, where a world-class, well-coordinated national provision has been made). Reluctance to bid for (say) a national NMR facility seemed to arise from a fear that the difficulties (including cost) of providing the infrastructure for wider use of the equipment outweighs the benefits to the host group. The current absence of a culture of paying for technical services inhibits the development of a business plan for setting up a national for-fee service at major facilities. Such approaches are more the norm in other countries, and would provide assistance in bringing dispersed elements of the Norwegian chemistry community together.

Today there are large-scale items that might be regarded as lacking; an example is a 900 MHz NMR machine. However, there is little specialised NMR research in Norway and there is no institute in Norway where researchers strongly demand the establishment of some kind of research programme that would require high-performance NMR instrumentation (800 or 900 MHz NMR instruments).

4.3 THE ROLE OF THE RESEARCH COUNCIL OF NORWAY (RCN)

Within the RCN there are different sources for funding of Chemistry Research.

The Science Division is responsible for basic research and the universities. Within the division basic research projects are funded, which are selected according to quality; however, funding is very limited (e.g., 15 mill. NOK in the first year for projects in FRINAT, which covers Chemistry, Physics, Mathematics and Geology). There are also small programmes, for example KOSK II and Synchrotron Research. Norway is a member of ESRF, where Switzerland and Norway are financing their own beam line. Other funding instruments of the RCN include large scale programmes that contain chemistry research aspects, e.g., within NANOMAT, but also RENERGI, and FUGE.

A new funding scheme for research infrastructure will be launched in 2009, which will focus on infrastructure of national interest at few locations. The funding scheme will include advanced equipment, large scale infrastructure, and also electronic infrastructure, databases and collections. The Committee observed that there is initiative among the departments in Norway to establish such a facility.

4.4 THE MAIN RESEARCH AREAS

4.4.1 <u>Inorganic and Materials Chemistry</u>

Inorganic and materials chemistry are interdisciplinary specialties in the international chemistry community that have increased in activity and importance in the past decade. This is due both to the emergence of nanoscience as a large and active discipline, and the realisation by chemists that the design of molecular and non-molecular solids with specific physical properties can be both challenging and rewarding. Nanoscience in particular, where the primary challenge is often to determine how to crystallise in a controlled fashion very small, very uniform particles, has captured the imaginations of many chemists world-wide. In inorganic chemistry, the design of molecules with specific magnetic, optical and electrochemical properties is of particular current interest, especially as it connects with potential applications such as solar energy conversion, and, on the basic science side, as it challenges theoretical models to explain and predict the properties of molecules through understanding their electronic structures.

Inorganic and materials chemistry are currently primarily pursued by two large, dynamic research groups in Norway, one in Functional Inorganic Materials at UiO and one in the Department of Materials Science and Engineering at NTNU. One smaller but also dynamic group works in this area at UiT. The NTNU Department of Materials Science and Engineering includes many researchers who can be considered as leaning more towards classical materials science, though all are interested in the impact of the chemistry of materials on the properties of solids. Materials chemistry also has a substantial impact on the research of groups specialising in catalysis, and in that form is found in many other research groups in chemistry departments in Norway. On the whole, the health of this chemical sub-discipline in Norway can be considered as very strong, arguably one of the strongest sub-disciplines in the current Norwegian academic system. Within this strong community, the area of nanoscience, currently less vigorously pursued, would benefit from further development. Investment in strong leadership and young professors recruited internationally may be required to make the level and quality of the nanoscience activity in Norway commensurate with what is generally seen internationally.

Detailed analysis of the individual groups is presented later in the report, but briefly, the Functional Inorganic Materials Group at UiO performs research in inorganic, solid state, and materials chemistry, and includes work in chemistry-based nanoscience. Their primary interests lie in the discovery and development of materials for advanced energy technologies, but they are active in other current areas as well, including for example thermoelectrics and microporous materials. The key areas for research in inorganic and materials chemistry carried out in the Department of Materials Science and Engineering at NTNU are light materials, materials for energy technology, materials for oil and gas, and materials for electronics and sensors. In energy technology, hydrogen production by membranes and water electrolysis, gas separation membranes, fuel cells and solar energy cells are of particular interest. The electrochemistry subgroup at NTNU has strong links to Norwegian industry and research institutes such as SINTEF and IFE, and is especially well connected with the aluminium industry. Finally, the Inorganic and Materials Chemistry Group in Tromsø, though very small, is similarly highly productive and dynamic. Major current thrust areas are in synthesis, chemistry and modelling of functional materials.

4.4.2 Theory and Computational Chemistry

It is important to realise that theoretical and computational chemistry are distinct subjects, certainly as far as their practitioners are concerned. Appointment of a computational chemist is not necessarily seen as strengthening theoretical chemistry, and vice-versa (though it would be seen as strengthening the intellectual environment). Theoretical chemistry is concerned with the exploration of the underlying origins of phenomena as well as the development of new methods to allow them to be analysed or quantities to be calculated; the underlying disciplines are quantum mechanics and statistical mechanics. Computational chemistry, on the other hand, involves calculations based on existing methods with the objective of obtaining values that will help in the interpretation of experiment. Both subjects are well represented in Norwegian chemistry and in some case within the same research group.

High-performance computing facilities, which are the most important infrastructural component for both subjects, are outstanding and access is at a world-leading level. The major problems for both subjects are the lack of Ph.D. students and, in many groups, the reliance on responsive-mode funding. Recruitment of Norwegian students is particularly difficult, in part because there is little emphasis on theory and computation in undergraduate courses, but also because most Norwegian students are focussed on doing research for which they see an industrial link; this might be applicable for computational work but is less easily appreciated for theory. There seems to be a good level of coordination between groups in the different universities in planning shared formal training programmes to support theoretical and computational work, for which a chemistry master (either from Norway or abroad) is unlikely to provide an adequate preparation. This is an important initiative and should be supported as it holds the key to making Norway an attractive centre for students and postdocs. Lectures and exercises could be shared between different sites, either by holding intensive workshops to which students from several centres were invited, or by videoconferencing them (see the SUPA initiative in Scotland for a good example of how a national training may be provided in a small country). The Centre for Theoretical and Computational Chemistry (CTCC) has boosted facilities and the number of positions at Tromsø and Oslo quite substantially, and has primarily supported the international quality of theoretical quantum chemistry groups there.

Within the spectrum of research regarded as topical in computational chemistry worldwide, several areas are poorly represented in Norway, including some that would certainly link to the subject areas of important experimental and theoretical groups. These include:

- Computer simulation methods (molecular dynamics, Monte Carlo, and mesoscale) and theory of "soft-matter". With the exception of some work on protein simulation, this area is not strong. Yet classical simulation could play a valuable role in areas with a lot of experimental and industrial activity in Norway, like absorption in porous media, membrane separation of gases, ionic conductors and the performance of fuel cells, the phase behaviour and self-organisation of gels, colloids and surfactants. Apart from applications like these, there is strong methodological development in the field, for example, in the study of rare events and the development of techniques for multiscale modelling. Although experimental work in colloids and complex fluids is strong at several points, there is a feeling that this work is not fully informed by the theoretical developments which have taken place in this field in the last decade or so.
- Alongside the above, the area of *ab initio* simulation is under-represented (save for one user of VASP, which is really a total energy package). These methods are now widely used around the world as interpretive aids in much condensed matter science. This field is strongly linked to theoretical work on improved electronic energy functionals and their practical implementation. *Ab initio* simulation has underpinned an improvement of the mutual understanding between statistical (thermal) behaviour and electronic structure. This does not yet seem to have been transmitted into Norwegian chemistry.

Targeting appointments in these areas would allow full exploitation of the excellent computational resources, improve the links between theoretical groups and practical chemistry, and underpin an improved approach to teaching statistical mechanics and thermodynamics as key elements of chemistry courses.

In general, the Norwegian activity in Theoretical and Computational Chemistry is good, and in some cases considerably better than that. This strength could be increased by targeted appointments in areas like those highlighted, by facilitating the funding of research which is not closely tied to particular technological targets, and encouraging a coordinated national effort to provide training for Ph.D.s and postdocs.

4.4.3 Catalysis

As catalysts are chemical substances that accelerate reaction rates in the right direction to get the desired products, catalysis occupies a central place in industrial chemical processes. It is a Norwegian strength because of the interest and support of the oil industry.

Several groups in Norway are involved in research in catalysis. Two groups are primarily specialised in this area. These are:

- University of Oslo/Department of Chemistry: Section for Functional Materials Chemistry, research group: Catalysis (and CATMAT Gemini Centre with SINTEF)
- Norwegian University of Science and Technology (NTNU) at Trondheim: Department of Chemical Engineering, research group: Catalysis (and KinCat Gemini Centre with SINTEF)

One group has significant and increasing activities in catalysis:

- University of Bergen/Department of Chemistry: Research group in Inorganic Chemistry, Nanostructures and Modelling

Other groups have minor or limited activities in Catalysis:

- Norwegian University of Science and Technology (NTNU)/Department of Chemistry: Research group in Physical Chemistry.
- Norwegian University of Science and Technology (NTNU)/Department of Materials Science and Engineering: Research group in Inorganic Chemistry.

The groups in Oslo and Trondheim are closely connected to SINTEF research programmes in catalysis via Gemini centres.

The topics of study in the Oslo group cover homogeneous catalysis and heterogeneous catalysis on zeolites and MOFs (metal-organic frameworks). Most of the reactions studied in this group are acid-base reactions or bifunctional reactions (metal-acid). The methanol-to-olefins process is one of the most studied reactions.

The topics of study in the Trondheim group cover natural gas conversion to hydrogen and synthesis gas and Fischer-Tropsch reactions. Some environmental problems are also treated. This group primarily has a chemical engineering approach, with microkinetic modelling studies, catalyst deactivation and use of complex reactant mixtures.

The topics of study in the Bergen group are not totally devoted to catalysis. The research of the small sub-group working in catalysis covers alkene activation reactions by means of homogeneous catalysts or supported organometallic complexes.

The catalysis groups seem to have organised to avoid duplication of the different research topics: there is virtually no or little overlap. The positive aspect of this situation is that there is practically no redundancy among the projects in Oslo, Trondheim and Bergen. The negative aspect is that there is neither national competition nor synergy among these groups on their own research topics. Motivation for the research originates in large part from discussions with industry, which occupies a central role in coordinating catalysis actions. It also comes from international cooperation, Norwegian groups being relatively well represented in European networks of excellence and in FP projects.

Finally, several groups working in physical chemistry and materials science collaborate with catalysis groups, either to prepare new materials for possible applications in catalysis or to characterise them by means of sophisticated techniques.

To complete the picture, catalysis groups collaborate with groups or teams specialised in quantum chemistry for modelling elementary steps in catalysis (e.g., adsorption on active sites, surface reaction mechanisms). This category of study, largely initiated on model catalysts (e.g., metal complexes, homogeneous catalysis), is becoming more and more popular in heterogeneous catalysis due to the dissemination and good access to powerful computational tools now possible. In this respect, the Centre for Theoretical and Computational Chemistry (CTCC) could play a central role in modelling studies in catalysis.

As a general recommendation, the catalysis groups in Norway should strengthen their mutual collaboration by sharing their own expertise in one or two common projects. Catalysis in Norway has a good international impact in terms of publications, although improvement is possible. In this respect, catalysis groups could intensify their cooperation with materials science groups. Very interesting work is carried out on known catalysts. However, the tendency should be to go further in evaluating catalytic properties of new compounds that result from the research in inorganic, organic and materials chemistry laboratories. High-level interdisciplinary publications should originate from this type of fruitful cooperation.

4.4.4 Life Sciences

Chemical research can be regarded as part of the life sciences when it deals with questions that are related to the structure and function of biomolecules and biosystems such as cell mimetics, organelles or whole cells, or even bigger biosystems. Thus it can be at the interface with structural biology, biochemistry or pharmacy and medicine. Chemistry in life sciences tries to solve problems in living systems on a molecular level and with chemical means. Naturally, such research is highly interdisciplinary and requires basic understanding of related areas in science. The synthesis of biologically interesting or active compounds alone cannot be regarded as life sciences.

According to this classification, there are few places in Norway where research in the life sciences is performed.

At UMB, the Norwegian University of Life Sciences, most of the life science areas were not evaluated by the Committee. Within the research group 'Natural Product Chemistry and Organic Analysis'[2], with its four professors, there is one subgroup that performs research in the study of enzyme-ligand interactions using a variety of biophysical methods and different assays. This research is relevant and published very successfully and the group operates at the leading edge of international research in this field. This group might benefit from interactions with other related areas at UMB, such as the proteomics lab.

At the University of Stavanger, the whole Biological Chemistry Group in total is deeply embedded in biological research, much more explicitly than any other group that was evaluated. The group's research focusses on cellular processes in cells and organelles, with a special focus on function and development and environment response. While among the adjunct professors associated with this group some synthetic chemistry plays a role, the principal investigators in the group do not use synthetic molecules or any kind of target-designed mimetics for their research, neither in-house nor in collaboration; thus the work is mainly that of biochemistry. This group has an internationally significant biochemical research programme and their work is published in highly ranked journals. There is the potential growth in future collaborations with synthetic chemists, for example, for testing of inhibitors, metabolic tracers, or functional biomimetics. In addition, the arsenal of modern biochemical methods (e.g., patch clamp, kinetics, mutagenesis) that is available to this group could be of great interest in bioorganic chemistry.

The Structural Chemistry Group at the University of Tromsø is the third place in Norway (evaluated as part of this study) where significant research in the area of the life sciences is performed. Methods employed cover protein expression, fermentation and purification facilities, combined with an up-to-date setup for protein characterisation and crystallisation, and the essential international collaborations needed to provide synchrotron X-ray data collection for structure determination. Studies in the structural analysis of different proteins (e.g., enzymes and DNA-binding proteins), mutation studies and evaluation of their function, mechanism, ligands and inhibitors, are at the top international level and have been successfully published in highly ranked journals. The Tromsø group, which has organised the Norwegian Structural Biology Centre (NorStruct), clearly has the best visibility in life sciences among the groups that have been evaluated in this study.

[2] The research group "Organic Chemistry" was renamed "Natural Product Chemistry and Organic Analysis" throughout this report as requested by UMB

Taken together, there is little life sciences-related research in chemistry departments of Norway, however, the groups engaged in this work are among the most successful ones that were evaluated. Increasing interactions with bioorganic chemistry should deliver a mutual advantage for both fields.

4.4.5 Organic Chemistry

Internationally, organic chemistry is normally a prominent area within chemistry departments. This is different in Norway: organic chemistry is hardly ever found as a stand-alone area within chemistry departments. This may be due to the small sizes of the groups and to the attempts to combine forces in pursuit of a strategy. These attempts seem not to have been very successful in most of the cases, as it is difficult for a group of individual professors to agree on one main research strategy, for example, combining different interests in synthetic organic and bioorganic chemistry. There are, however, a number of obvious potential possibilities for strong and effective collaborations within the different organic chemistry sections, which are currently not used. Rather, the research is often spread too thinly, mainly due to limited human resources, and therefore is not being performed on an internationally competitive level.

In synthetic organic chemistry the size of a typical research group at a Norwegian University is small (by a factor of 3-10) when compared to most international research groups in organic chemistry. In this very important and work-intensive field, this discrepancy in research effort places Norwegian organic chemists at a distinct disadvantage in international competition for both funding and scientific excellence. The number of professors has declined considerably during the last 10 years due to retirements, however, this does not appear to be the main reason for the plight of organic chemistry in Norway; even more so as there are not even enough Ph.D. students for the professors left to build up effective groups. Typically, the reputation of an organic chemistry group in Norway is kept up by a minority of its members; occasionally this is just one professor who has enough funding and students to perform internationally competitive research.

At the same time, organic chemistry does not seem to be appreciated at all within the industrial landscape of Norway. A handful of start-up companies have emerged from university groups, however, there is no big market and little demand for organic chemists with a Ph.D. degree. Consequently, the funding situation in organic chemistry is difficult - even more so as industrial funding plays a big role in other areas of chemistry research in Norway.

Overall, organic chemistry in Norway has no obvious international reputation, nor does it show a particular strength in any specialised area. Total synthesis, which is traditionally a well-appreciated main topic of classical organic chemistry research world-wide, is almost invisible in Norway, with very few examples. Other areas of research often practiced within organic chemistry, such as catalysis and materials science, are separated from organic chemistry in Norway, and, most surprisingly, there are no strong interactions with those areas. There are some attempts in Norwegian organic chemistry to focus on molecules of medicinal and biological interest, including projects aiming at the marine environment, which is an important research area in Norway. Again, the existing strategies to consolidate focussed research lines, with organic chemistry being a major player, are either non-existent or floundering. Currently, organic chemistry is not an important partner at the interface of related areas such as biochemistry and biology or materials science and catalysis. In addition, ambitious national-level plans are lacking in organic chemistry; a combined national effort to develop a Centre of Excellence in this area, for example, would be of interest.

The status of the equipment and infrastructure necessary for performing organic chemistry research is widely varying in Norway. While the large scale instrumentation that is typically required in organic chemistry is often of an impressively high standard, the laboratories are mostly very old, and often of unacceptable quality. In addition, intermediate scale instrumentation and standard supplies are often lacking or are not sufficiently available.

We believe that organic chemistry in Norway can become internationally more visible through several changes in the way it is practiced. One possibility is for forces to be combined within a synthesis group by making a serious effort to develop collaborative strategies for future development, including the focussed dedication of new appointments. Another possibility is for organic chemistry to gain higher visibility through effective networking with related research areas, such as, for example, with structural chemistry or biological and medicinal chemistry. At present, it appears that there will be no good opportunities for better funding of research in synthesis without any convincing national or local strategies and collaborative proposals. Funding of modern organic chemistry in Norway is, however, essential for the health of the chemistry as a whole, as the success of KOSK has shown.

4.4.6 Physical Chemistry

Physical chemistry is one of the major branches of the subject, at least from a traditional perspective, and would form a part of an undergraduate degree in chemistry. It is the part of chemistry associated with quantitative measurement and the interpretation of quantitative experiments. For the purpose of the review, it might be convenient to divide the subject matter, somewhat artificially, into “chemical or molecular physics” and “physical chemistry, per se”. In the latter are included measurements done on bulk properties, such as thermodynamic or electrochemical quantities, absorption isotherms or the rates of chemical reactions. Chemical physics would be directed at structural etc. characterisation of molecules or assemblies of molecules using methods like spectroscopy and diffraction with a view to providing microscopic interpretations of phenomena or measured quantities. The quantities measured in physical chemistry *may* be *directly* related to industrial or environmental processes, whereas this is unlikely to be the case for chemical physics. As such, and because of other factors, the two branches of the subject are in somewhat different states in Norwegian science, and in neither case is the work overall prominent at an international level.

Chemical physics is in a particularly precarious position; this is especially true of classical areas like gas-phase spectroscopy. The equipment needs of chemical physics tend to be specialised, expensive, and unlikely to be used by several groups. With a lack of suitable funding opportunities and a lack of interest from Ph.D. students the opportunities for developing high class laboratories does not exist within the current funding model and climate of opinion. (An exception can be through the use of international centres, like the European Synchrotron Radiation Facility (ESRF), where the opportunity to combine high-quality physical measurements with materials characterisation creates viable opportunities for quality work.) This means that Norwegian chemistry is turning its back on several emerging laboratory-based subjects with important potential for other areas of chemistry, as well as abandoning classical areas of study that are important to the discipline pedagogically and methodologically. Amongst the former one might include single-molecule spectroscopy, sum frequency methods, and fluorescence resonance energy transfer, which have important applications in studying the dynamics of biomolecular conformation and assembly, and also the use of lasers and microscopes in manipulation (optical tweezers etc.) which have important applications in self-organisation of nanomaterials and biological assemblies. The consequences of abandoning chemical physics by neglect, especially with regard to the expertise and infrastructure required for future developments, should be carefully evaluated at a national level.

A great deal of the activity in physical chemistry is motivated by the concerns of Norwegian industries. In some cases, this has led to very good outcomes; for example, the high quality of the work in chemometrics and in one or two individual laboratories working on emulsions, suspensions and the rheology of polymers. Here the problems posed by industry have been cast in general scientific terms and this has motivated insightfully directed research of significant impact outside the immediate area of application which has been published in international journals. However, in a substantial number of cases the relationship is too close to lead to good basic science. Here measurements are carried out on specific complex fluids produced in particular industrial processes, for example. Such work does not have a general impact. Although it may be of national importance its contribution to "basic" or long-term science cannot be evaluated using the available measures like the number and quality of research publications and the suspicion is that it is too narrowly motivated to be labelled good. It is important to consider how appropriate motivation could be provided to encourage such researchers to set themselves long-term scientific goals.

4.4.7 Environmental Chemistry

Environmental chemistry is a Norwegian strength, although it is not represented at all of the universities or institutes visited and only a part of the overall effort in the academic community in Norway is included in this review. The areas in which Norwegian research groups are strongest are focussed on the chemistry of the atmosphere, sources and effects of pollutants and especially a focus on high latitudes and polar environmental chemistry, with specialised research facilities. Strengths are also found in radiochemistry and both short lived and long lived pollutants in organic and inorganic compounds. Thus the geographical opportunities and environmental threats in and to Norway are a clear driver of the research agenda. These areas of specialisation also provide excellent opportunities for international collaboration, which is very important in the longer term for this community. The subject area has been maintained through recent years at several of the universities and institutes visited, but not all. The universities having little or no research in this area are Tromsø, Bergen and Stavanger.

The research group at the University of Oslo, especially at senior levels comprises mainly academics approaching retirement and, while the publication outputs have been maintained and are satisfactory, these draw mainly on past achievements. The future work and innovations taking place elsewhere are not reflected to the same degree in this department. The aging research group in this area at Oslo lacks the vitality, new ideas and forward thinking to maintain an effective research programme in the longer term. The department has appointed several adjunct professors to assist with teaching and research, and this clearly serves well in the short term. This approach will not serve the longer term unless this area has only a limited future. This would be an important missed opportunity as environmental chemistry in other countries continues to grow and to be strongly coupled with interdisciplinary research (including links with climate change and global biogeochemical cycling). Clearly there will be further opportunities to build on past achievements, but the vision for work in this area is lacking. In contrast the research groups at Trondheim (NTNU

Chemistry) have a high international profile, e.g., in metals. Especially at trace levels the work at NTNU and at the Norwegian University of Life Sciences (UMB) on the development of highly spatially resolved metal deposition estimates has led to international developments in monitoring techniques using passive sampling with biological material. The continued leadership in radiochemistry at UMB is also a notable strength and continues to prosper. The work on persistent organic pollutants, including PCBs, and emerging environmental pollutants and the focus on polar chemistry of the atmosphere and precipitation at NILU and the associated analytical techniques and international collaboration place this team at the cutting edge of developments.

4.4.8 Nuclear Chemistry

The national effort in nuclear chemistry in Norway is concentrated in one research group at the University of Oslo. The Committee will report on this group in detail below; here the Committee will merely summarise the level of activity from a national perspective.

There are two strategic reasons why nuclear chemistry is critical to maintain in Norway, even given the current abundance of non-nuclear energy sources in the country. Firstly, radiopharmaceutical chemistry, including Positron Emission Tomography (PET), plays an important role in rapidly developing medical technologies. Since the radioisotopes used decay on very short time scales, the radiochemicals must be developed *very* close to the site at which the therapies are to be applied. Secondly, Norway has very important deposits of thorium, an alternative base nuclear fuel to uranium that is more abundant and does not generate plutonium as a fission product. Nuclear energy technologies based on thorium are under development (in so-called Generation IV) internationally in order to exploit these long-term advantages. In order to exploit current and future developments, as well as to support other applications like radiotracer methods, it is necessary to maintain appropriate facilities and to provide a training base for the skilled personnel and decision makers to work in these fields.

Research is conducted in radiopharmaceutical chemistry, radiotracer technology, nuclear structure and heavy element science. Of these, the latter two activities may be regarded as traditional pure nuclear chemistry *per se*, and Norway has a good international reputation and collaboration network for this work. The radiochemicals work is only recently emerging. The Oslo group is embedded in SAFE, a national Centre of Excellence for Accelerator-based Research and Energy Physics, created in 2005 and in operation since January 2008. The centre is based on the use of the Oslo Cyclotron Laboratory, which is a small but versatile facility, recently refurbished, that enhances teaching and research in this field through ease of access for Norwegian researchers. It includes a newly built, state-of-the-art PET (Positron Emission Tomography) imaging facility, closely linked to a radiomedical team in the Faculty of Medicine. The planning and investment in physical research infrastructure in this field therefore appears to be at an exceptionally good level. Nuclear labs need strong support from mechanical and electronic workshops and highly qualified technical staff with long-term expertise in techniques, safety and procedure. At present there appears to be a shortfall in this aspect of provision.

There is also a major shortage of research personnel to carry this field forward and to make good use of the facilities created. Investment of positions for young researchers in this area is viewed by the Committee to be an important step that should be taken in the near future to maintain the viability of this type of research in Norway. Given the fact that this is an important field, and the fact that the job market in this area is good, it can be expected to greatly benefit from any nation-wide changes that may be instituted in Norway's Ph.D. programme in chemistry in response to the recommendations of this Committee.

4.4.9 Applied Chemistry and Chemical Engineering

The research in applied chemistry and chemical engineering in Norway is mainly motivated by the nation's access to raw materials and its long history in pulp and paper technology. Consequently, the research questions addressed are driven by the concerns of Norwegian industries. All groups maintain a close cooperation with Norwegian industry, SINTEF or the Paper and Fibre Research Institute (PFI). Some groups have built up an extensive international network. Most of the groups in the field are concentrated at NTNU in Trondheim. Some of the research of the Physical-, Petroleum- and Process Chemistry Group in the Department of Chemistry at University of Bergen may be considered as belonging to this research field.

The Department of Chemical Engineering at NTNU is the only one of its kind in Norway. It hosts all major research areas necessary to develop chemical processes in Norway: reactor technology, separation and environmental technology and process systems engineering. Moreover, it hosts the Paper and Fibre Technology Group also having a unique position in Norway.

In addition, the Group in Physical-, Petroleum- and Process Chemistry at UiB works on various applied research questions dealing with processes for oil production.

Due to the intensive cooperation with industry, most of the research groups in chemical engineering and applied chemistry seem to have access to substantially higher budgets than groups engaged in basic research only. Their research facilities are in general excellent and seem to attract national and international students to join the groups in order to work on Ph.D. theses. This, among other reasons, explains why the number of master's and Ph.D. students is significantly higher than the average numbers in other chemistry areas in Norway.

Most of the chemical engineering research groups at NTNU show a good scientific output compared to international standards, and in some cases considerably better than that, on an individual level even excellent. Their international visibility is high and the cooperation with other international research groups is very good, and in some groups excellent.

Major societal challenges, like how to deal with the CO_2 generation and sequestration problem, are covered by the research groups in this field. Therefore, the research performed by the chemical engineering community is highly relevant to Norwegian society. Remarkable is the fact that the groups at NTNU have obviously recognised that the CO_2 problem presents a research challenge and complexity that cannot be addressed by one single research group alone. Their initiative to join forces and to establish the department as “National Centre for Research on CO_2 removal”, which includes setting up a joint laboratory, is strongly supported by the Committee.

Norway should consider in the near future how to establish collaboration between research in chemical engineering and research in the field of biotechnology. Many of the technologies and tools developed in the field of chemical engineering can be successfully applied to the production of biochemical products.

4.4.10 Analytical Chemistry

Analytical chemistry is not a specialised research area for many of the departments reviewed. In particular the universities at Tromsø, Bergen, and Stavanger do not include analytical chemistry as a specialist research area. At Oslo, The Norwegian University of Life Sciences, NTNU (Chemistry) Trondheim, and NILU there are specific analytical chemistry activities, although not always described as such. The number of senior staff in analytical chemistry is not large overall, but has increased since the last review, while the total staff numbers in many departments have declined. Analytical chemistry has not generally suffered as badly as other more specialised areas. The analytical service to departments and to research projects appears to be matched to needs. Little by way of innovative new techniques at the cutting edge of international developments was evident except in highly specialized areas of organic contaminants at the NILU laboratory and radiochemistry at the Norwegian University of Life Sciences. The basic techniques required for analytical chemistry were provided by up to date equipment and methods at all of the sites visited, and some in really excellent modern laboratories.

Analytical equipment in the departments evaluated appeared to be adequate for the research in progress, and at most locations was fully up to international standards. Whether the equipment was effectively or fully utilised was less clear, and this seemed to differ considerably between the different departments. Also, many research groups indicated in their submissions and presentations that the replacement of equipment and service and maintenance costs were not adequately supported. The issue of funding service and repair costs was mentioned by half of the groups, but the scale of the requirements for replacement equipment was not clear and might not be a major problem.

For the specialised research on radiochemistry, trace persistent organic pollutants and trace metals, the analytical equipment was adequate or there were well developed plans for replacement.

5 GENERAL RECOMMENDATIONS

5.1 AT THE NATIONAL LEVEL

The overriding view of chemistry research in Norway from this, the second international review, is that the productivity has increased in recent years while the overall size of the academic effort has declined, so that there has been a clear increase in efficiency. There are some very good research groups working at the leading edge of international research and publishing well. However, the overall community is small even for a country of this size, as may be seen in international comparisons with countries of a similar size, and some of the research groups are not operating at a very high level in an international context. Thus, the Committee recommends new efforts to strengthen the research teams, and increase staff numbers in the key departments to allow the best researchers to spend more of their time in research. Furthermore, the Committee feels that a new competitive grant awarding system to encourage the appointment of new truly excellent postdoctoral research staff into the community should be a very high priority. There is also a need for a larger number of purely 'blue sky' research grants, to encourage diversity of research topics at the Ph.D. level.

Staff and recruitment

Appointments and fellowships: To address the issues raised in this report about the tendency to recruit from the undergraduate students to Ph.D. positions, and then to retain these as academic staff, which promotes the current lines of research and limits the infusion of new ideas in the research groups, the Committee suggests a system that encourages new postdoctoral staff from a wider pool of applicants. The vitality of the chemical research community in Norway would benefit from a system in which highly competitive research fellowships were awarded for 5 years (extensible to a further period of up to 10 years in total). The positions would depend on the quality of the research proposal AND the applicant. The application would specify the project in sufficient detail to facilitate peer review by the Research Council of Norway and examination of the candidates to a similar degree of scrutiny. There should be a large enough number of these fellowships to generate an infusion of new blood over the next 5 years to this community. Norway may wish to consider a system in which the financing for these fellowships might be provided in part by the government and in part by the chemical industries.

The career bottleneck: Due in part to a non-negligible proportion of late career professors who are not very active in research and occupy some of the limited number of academic positions available, the opportunities for academic employment for young people are limited. The Committee feels that it is very important to investigate and address this issue at a national level, with the goal of finding a socially acceptable process to move the more senior professors into primarily teaching roles, in order to free research resources for promising early career researchers. This process need not necessarily prevent these near-retirement academics from continuing to complete important aspects of their research or publications. An alternative possibility, analogous to a procedure that has been successful in private universities in other countries, may be to institute a national retirement programme for professors in science departments. For professors between the ages of 65 and 69, for example, a lump sum payment could be offered to people who agree to leave their position within 6 months. At the same time, other incentives should be considered for opening more positions to young people, in order to prevent a recurrence of the present situation.

<u>Research and teaching:</u> Some professors have moved toward increased interest in teaching rather than research over the course of their careers, a situation that is not uncommon in countries outside of Norway. Such professors often have no external funding for supporting research programmes. They are valuable members of the academic system, but they do not meet the international standard for what is expected for a university professor, which involves both teaching and research. The Committee recommends that the Norwegian academic chemistry community considers a policy in which professors with no external research funding be encouraged to contribute more to teaching and thus free more time for the junior academics to expand their research activity. Many of the departments interviewed described academic programmes in which a significant number of the courses offered annually enrol only a few students, often as few as 1-4. This is a very inefficient use of time for professors, for whom available time for research is often a limiting factor in success. The Committee strongly recommends that departments review the courses that they require for degrees in chemistry: courses that are not at the core of chemistry should not be offered yearly; courses that currently typically enrol 1-4 students should be offered at most once every two years. Many international academic institutions offer their non-core curriculum in this fashion, and students plan their course schedules accordingly.

In addition, the possibility of offering lectures that are given at one university and are broadcasted simultaneously at other departments should be considered for courses that have only a small number of students enrolled nationally.

Training, mobility and career perspectives of young researchers

<u>Ph.D. programmes:</u> The Committee observed that academic inbreeding in chemistry in Norway starts at an earlier stage than at the new-professor level. The issue begins at the level of recruiting students for Ph.D. programmes. The heavy demand for master’s level students by industry, and the limited opportunities for Ph.D. degree holders in chemistry in

Norway lead to a shortage of students choosing to pursue Ph.D. level work. Thus, through personal interactions, the faculty are most successful in recruiting Ph.D. students from the ranks of their own undergraduate and master's level students. This is a natural consequence of the current system.

The Committee does not recommend radical restructuring of the system to address this issue, which has several quite complex causes. However, the potential strategic benefit to Norway of a larger pool of researchers trained to Ph.D. level is large, and therefore specific initiatives should be developed to encourage more Ph.D. studentships together with the industrial sectors to help them to recognise the benefits of this form of training for long term. An example of an instrument to promote such activities would be the inclusion of studentships in all large consortia grants, engaging them to explore the fundamental aspects of the consortia goals, and engaging with the large teams at different institutions. Such an approach would also have the benefit of providing additional studentships in areas of pure academic research.

Financial

<u>Departmental funding system:</u> The current funding system for academic chemistry departments in Norway requires departments to divide their financial resources among many different expenses. In many cases, this has caused departments to forego the appointment of new professors to replace faculty retirees in order to maintain the funding for already existent facilities and technical staff that cannot be eliminated or down-sized non-voluntarily within the current rules. This method of funding threatens the size of the professoriate in many departments.

To address this issue, the Committee recommends that the departmental funding system should be changed so that faculty salaries are separated from departmental operating costs. Discussions at a national or university level should be made to explicitly determine the size of the professoriate in a department, based on factors such as undergraduate enrolment, importance of discipline, and research, for example, and then the appropriate amount of salary should be separately allocated to fully fund the professor salaries.

<u>Start-up funding packages:</u> "Start-up packages" for new academic faculty members in Norway are financed at levels substantially below comparable packages available elsewhere. The Committee recommends that steps be taken at the national level in Norway to remedy this discrepancy, which, given the size of the Norwegian academic science research establishment, can be done at a relatively low cost. The Committee suggests for example a competitive process of instituting one "national young professorship" per year in each major

scientific discipline (chemistry, physics, and biology) with the award of an amount start-up funding consistent with the current international standard in the field.

Research infrastructure

Funding for research instrumentation: The availability and quality of instrumentation play an important role in research programmes in experimental chemistry. Many of the chemistry groups in Norway were found to have bench-top laboratory instrumentation that is up to international standards, especially in groups with close ties to SINTEF. Nonetheless, many of the groups report serious concerns that they are not keeping up with international standards for research instrumentation.

Beyond research institute and industrial funding, RCN is the primary source of funding for instrumentation in basic chemistry research in Norway. In the current process for distribution of RCN funding, the faculty at each university agrees on a list of instrumentation priorities by consensus that is then forwarded to the university administration. The administration of each university submits their priority list to RCN, which then sends the university the funds for the first few items on the list. This system works to help assure that resources are distributed by consensus. The Committee recommends, however, that a second track for instrumentation funding by RCN, individually competitive, should be added to the system. The instrumentation for this part of the programme would be awarded to the research groups whose individual proposals to RCN are judged to be best by peer review. The addition of this second, individual track for attaining new infrastructure would have important positive effect of increasing the responsiveness of the system to rapid developments in the field and enhancing the international competitiveness and research success of the most productive and creative research groups.

Synthetic organic chemistry: One possibility for creating excellence in synthetic organic chemistry would be to identify a selection of Norwegian universities where this field will receive a special focus. In addition, these places should not emphasise the same main focus area, but one place should, e.g., concentrate of synthetic methodology, another one on catalysis, and a third one on biological chemistry. This model could include downsizing synthetic chemistry at a small number of the universities to a limit that is just sufficient to maintain the scientific environment for the department and the teaching programme. Such an approach might also help to create a dynamic environment in Norway, allowing the best students in the field to gather at the internationally most recognised places for their training.

A second possibility for achieving excellence in synthetic organic chemistry would be to start a national collaborative network as a centre of excellence in Norway. To improve the current national situation, this centre should appoint one or two external excellent researchers in the field and attract candidates with large enough start-up funds. Without creating a positive, dynamic environment at least at one internationally recognised centre or university in Norway for the practice of this field, chemistry as a whole in Norway suffers greatly.

Nanoscience: Nanoscience is an important new branch of science that has increased in importance world-wide in the past decade. The most active branch of this field internationally can most often be found in chemistry departments, though there are also many practitioners in physics, materials science and applied engineering departments.

Norway has begun to make a significant investment in the infrastructure needed to work in this field through the establishment of the national nanoscience laboratory (NTNU Nanolab) at NTNU. The Committee's interviews of chemistry departments indicated relatively little involvement of chemistry faculty in this field nationally, however, and the Committee found that there were few if any chemists nationwide who would classify themselves primarily as experts in nanoscience. If a first-rate nanoscience programme is to be established in Norway to take advantage of the current and planned nanoscience infrastructure, then finding a researcher to act as the national leader in the field would be extremely beneficial. The Committee recommends that high-quality, ambitious, early career scientists should be hired from an international nanoscience laboratory to help establish a first-rate nanoscience research programme in Norway. This is a highly competitive field internationally, implying that substantial further investment will have to be made to create a new internationally-competitive research group.

5.2 RECOMMENDATIONS REGARDING THE RESEARCH COUNCIL OF NORWAY

The Committee recommends that a system should be implemented that allows research teams to suggest new, forward-looking national level research programmes to the RCN with the programmes operating at the research consortia level, to encourage at least three research groups from different institutions or departments to develop proposal at the 3 year, 4 to 8 M€ level. These proposed new national initiatives could be evaluated by an expert team, and if judged to be viable, could be considered for support by the RCN. This possibility would present an additional channel and would supplement the present system, in which research programmes are suggested by the RCN. This new approach would allow for more bottom-up initiatives, and encourage more initiative within the Norwegian scientific community.

6 ASSESSMENT OF THE DEPARTMENTS AND RESEARCH GROUPS

6.1 UNIVERSITY OF OSLO

6.1.1 Department of Chemistry

The Department of Chemistry (KI) is organised as a conventional university institute. As a result of the reorganisation in March 2005, the institute currently comprises two sections "Section for Life Sciences Chemistry" and "Section for Functional Materials Chemistry" in contrast to its former 4 sections. The number of research groups has been reduced from 14 to 7 in order to concentrate efforts in fewer research fields, to make the research groups more robust and to improve the cooperation between the formerly small groups. The department interacts with other departments, universities, the institute sector and industry through several centres and research programmes. In particular, a number of RCN funded Centres of Excellence have been established under the leadership of the department or jointly with other Norwegian chemical institutes. An overview of the institute's interactions is shown in Figure 1.

The research groups are assigned to the sections according to their research profile as given in Fig. 1. In accordance with the faculty's strategic planning, the department aims at providing cutting-edge research within the two broad thematic areas "Life Sciences Chemistry" and "Functional Materials Chemistry". In particular, the department benefits from the centres, which aim at promoting inter-faculty collaboration. In the reorganisation of the department, individual staff members were allowed to choose the research group they would join. The large research groups incorporate sub-research groups, each of which is headed by a leader in order to promote joint research initiatives.

The current chemistry building does not satisfy modern requirements for a safe and suitable environment for experimental research. In accordance with the strategic development of the research profile, the University Board agreed to construct a substantial new building "The Chemistry-Pharmacy-Life Sciences Complex" in Gaustadbekkdalen (GBD) in 2017, which will host the Centre for Materials Science and Nanotechnology (SMN), the Chemistry Department, the Pharmacy Department and the Life Science groups. SAFE will not move to GBD, but will either stay close to the cyclotron or move to the Institute for Energy Technology (IFE).

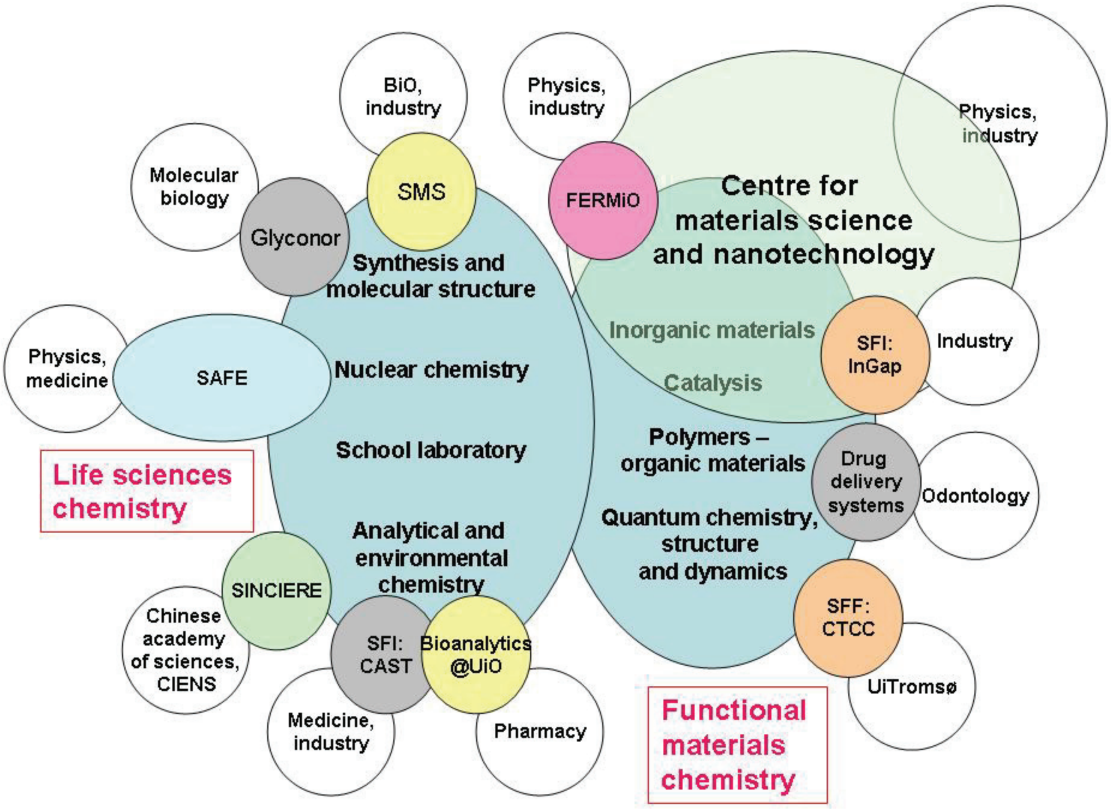

Fig. 1: Institute's activities and interactions with centres, programmes and main collaborating institutions
RCN Centres of Excellence: dark yellow; UiO top programme: red; UiO development programme: yellow; UiO new initiative programme: light blue; bilateral agreement: green. In all these, KI is the major contributor. Centres and programmes with other departments as the major contributor are shown in grey. *Abbreviations:* SMS: Faculty research programme "Synthesis and Molecular Structure"; Glyconor: Faculty research programme; SAFE: Faculty centre of nuclear competence; SINCIERE: Research platform for environmental research collaboration between Norway and China; CAST: Node of CoE (SFI) centre of tumour stem cells; CTCC: CoE (SFF) Centre for Theoretical and Computational Chemistry; inGap: CoE (SFI) Centre in Catalysis; FERMiO: CoE (SFF) finalist in materials chemistry

The organisational and leadership structure of the institute reflects the general changes at the UiO in accordance with the new law of higher education in 2003. The department itself has an institute board, an institute head, a deputy head, and a leader group. According to the new regulations, the institute head, which can either be elected or appointed by the faculty, reports directly to the dean of the faculty and makes both major and everyday decisions. The board is mainly responsible for strategic long-term decisions and the budget, while the leader group has an advisory function. Teaching matters have been delegated to the deputy head.

	Total	
Positions	**Univ.**	**Extern**
Professor	34	0
Associate professor	3	1
Professor II	1	11
Postdoctoral research fellow	9	36
Doctoral students	21	45
Technical/administrative positions*	32	0
	100	**93**

Table 1: Numbers taken from the factual information provided by the Department

”Univ.” = persons financed by the university

”Extern” = persons financed by external research grants

* Technical/adm. positions: Positions supporting research (technical/administrative staff members are not permanently allocated to a research group)

The staff key data are summarised in Table 1 (detailed information at the level of individual research groups is given in the following sections). During the last 15 years, the number of permanent scientific positions at the institute has been reduced from 51 to 36 due primarily to financial considerations. Postdoctoral positions are almost exclusively financed by external sources.

The age distribution among professors in permanent positions is summarised in the following table.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
1	2	3	5	10	7	3	5

Table 2: Age distribution among professors in permanent positions

Related to the generally difficult situation in Norway concerning the recruitment of students to the sciences, and especially to Ph.D. programmes, the number of Ph.D. candidates and doctoral degrees awarded (see Table 3) in relation to the number of staff is very small when considered by international standards.

Graduates	2005	2006	2007	Total
Dr. ing./Dr. scient. graduated	15	9	15	39
M.Sc. graduated	19	30	19	68

Table 3: Number of graduates

(5-6 candidates graduating each year from the MENA programme are not included)

In order to compensate for the relatively small number of Norwegian students, the department and research centres work to attract candidates at the Ph.D. and postdoctoral levels from abroad. However, applicants with mastery of a Scandinavian language are needed as teaching assistants. To help address these issues, the Department of Chemistry is supporting initiatives at the faculty level of the university and is working with public schools to increase interest in chemistry in Norway. The strategic plan for the department postulates an increase in the recruitment of Ph.D. students by 30% and a corresponding percentage increase in the number of temporary positions (Ph.D. and postdocs) in the period 2007-2012.

The department emphasised its relatively high research productivity in the interview with the Committee. Selecting 2006 as a recent year for reference, they pointed out that they have 5.4 publications per faculty for their department in that year, a significantly larger number than is found in the UiO physics (4.3), astrophysics (3.5) and biology (3.5) departments. This represents a good level of productivity on the international standard, though the overall university science average of 3.1 publications per faculty member is relatively low.

The department’s future planning and long-term objectives are included in the strategic plan 2006-2012.

Assessment and recommendations

This is the premier academic research institute in chemistry in Norway and therefore there is an expectation that this department is well resourced, innovative and offers excellence in the areas of both personnel and infrastructure. Overall, this is an excellent department of researchers that meets many, but not all of these expectations.

There have been major reorganisations along the lines suggested by Weitkamp, and in most cases this has led to strong strategically oriented research groups, with excellent morale, generating a high level of excitement and activity. These groups have been very successful in obtaining research funding (local, national and EU) which has been used to obtain equipment of very high quality and to create excellent infrastructure. There are numerous institutes and centres on and in close proximity to the campus which further enhance the opportunities for collaborative research grant applications and the available infrastructure.

However, several major issues arose over the course of the discussions that should be addressed.

As for the case of the other departments who testified before the Committee, this group pointed out the difficulties in recruiting Ph.D.-level students into their education and research programme. Given the desirable location of the institute and its national status, these difficulties are a reflection of the problems associated with the doctoral degree in Norway as a whole. The Committee recommends that steps be taken country-wide to address this issue. Those recommendations are described elsewhere in this report.

The allocation of limited internal financial resources is a major issue for this department. One consequence is that, although the level of equipment was excellent, much of this was running without maintenance contracts and without an appropriate level of support from specialised technicians. Past practices have apparently resulted in the fact that the department is currently in significant debt. This high debt, which constrains current spending, significantly limits the options for funding new initiatives, which is not a desirable condition for a premier institution in a fast-moving interdisciplinary field like chemistry. An additional consequence of this indebtedness is the fact that during the last 15 years the number of permanent staff positions in the chemistry department has decreased from 51 to 36. This has had a substantial impact on the general outlook of this group. During the discussions, they expressed the desire to be able to determine specifically which areas should be decreased in size in the department so that they can maintain high-quality efforts in the areas they judge to be most important. This is apparently not possible in the current system, where rules dictate that certain responsibilities cannot be cut and personnel cannot be asked to leave non-voluntarily. The Committee does not believe that this is a preferred situation for a major academic chemistry department and encourages the university and national research administration to work with the department to provide adequate tools to reorganise and restructure the department to its best advantage. Some recommendations related to the issue of department funding structure are also elucidated elsewhere in this report.

In contrast to these financial issues, the department reported to the Committee that the University Board has decided to construct a building on the UiO campus of very substantial size that will accommodate the chemistry department, the life sciences department, and the pharmacy department in a single location. The Committee applauds this substantial investment in scientific infrastructure. The co-housing of these departments will serve to increase interactions and collaborations in different departments, and will promote interdisciplinary research as well as benefit the individual research groups.

The department presented strategic plans for where they would like to be ten years from now, at the opening of the new building, and those plans seemed sound. Given the fact that moving into new areas in chemistry through hiring early career professors is largely controlled by rates of voluntary retirement, the amount of change presented in those plans is relatively minor. Some suggestions of the Committee about how the opportunities for hiring young faculty might be enhanced are described elsewhere in this report. The suggestion that research should be increased in the areas of bio-nanoscience and sustainable energy are good ones. Computer simulation could play an important role in bridging the gap between different activities and the environment should be very stimulating for such research, in soft-matter, biosystems, porous materials etc. As the Committee notes elsewhere, gaps (mirrored throughout Norway) will soon develop in experimental chemical physics and physical chemistry and, as the nationally leading institution, the department should consider what new research areas it would like to develop. These areas are difficult to support because of the shortage of funds for non-application oriented research, so the issue may require resolution at the RCN level.

6.1.1.1 Synthesis and Molecular Structure

This group is arranged within the section ‘Life Sciences Chemistry’, comprising three research groups and the school laboratory. It is planned to consist of 7-8 professors in the future. Currently there are 6 full professors and one associate professor, who is the current group leader. The group’s research is focussed on organic synthesis of bioactive molecules and structural chemistry of biomacromolecules together with NMR spectroscopy. Though the group has seven professors, it is small, due to weak recruitment of graduate students. It has significant international as well as national interactions. The group’s activities are within the programme ‘Synthesis and Molecular Structure’ (SMS), which has been designated a strategic research area at the university. In part the group overlaps with the interdisciplinary group ‘Glyconor’.

Assessment and grading

This group has the highest international visibility within organic synthesis in Norway. The research projects which are dealt with are of current interest and up to date science. Throughout the group there is a focus on bioactive molecules, and also the method development research is modern (e.g., organocatalysis). The combination of subgroups working on synthetic projects and those which are specialised on structural chemistry (X-ray and NMR) is beneficial and can be fruitfully further developed. It is in line with the university’s development programme, where ‘Molecular Life Sciences’ has been defined as a priority area, involving a Synthesis and Molecular Structure priority area (SMS) with a focus on drug development and structural chemistry and bioanalytics. Thus, this group performs highly relevant research with high international visibility and its activities are supported by the university strategic planning, both of which are very positive. However, the group suffers from a lack of Ph.D. students, which is severe, and from old laboratories, which are far below acceptable standards. Some improvements have been made lately in one of the laboratories, whereas many other labs are not close to international standard. Furthermore, the MS lab has moved away from the group's premises, while it is important for organic chemists to have easy access to analytical methods such as NMR spectroscopy and mass spectrometry.

Scientific Quality and Productivity	5/3 *)
Relevance and Societal Impact	3
Strategy, Organisation and Research Cooperation	3,3,4 **)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

This group largely has an excellent to very good publication record with a significant number of papers in level 2 journals. However, a minority of group members publishes rather little and overall the percentage of level 2 journal papers is below the Norwegian average. As the group's research is basic and has not led to a significant industrial collaboration, the societal impact and relevance of this group cannot be considered as especially high, though the group has that potential. The group composition has started to become homogeneous, but so far the strategy for the future is not completely evident. Also the infrastructure of the group needs improvement. Research collaborations, both nationally and internationally, are very good, however, there could be more overlap with other groups, such as catalysis, which could be beneficial for this group.

Recommendations

This group is on its way to becoming a unified effort in the field of research on bioactive molecules. This involves synthetic projects and structural chemistry projects. Biological testing of bio-relevant molecules is done in well-working collaborations, and it does not appear sensible for the group to make efforts to build up its own assays. However, ligand-receptor interactions should be investigated wherever there is a chance for collaborative projects between structural and synthetic chemistry within this group. This is an ideal field to combine synthesis with NMR research and X-ray studies to come up with internationally very competitive projects. New positions in organic and analytical chemistry should be assigned accordingly, to strengthen research on biologically interesting molecules and to support the existing expertise, both in synthesis as well as in structural chemistry. Such a strategy should eventually facilitate new funding programmes in addition to the existing ones, especially the KOSK programme of RCN, which is currently of high importance for organic chemistry in Norway.

A collaborative platform between organic chemistry in Chemistry and Pharmacy is desirable; unfortunately it has no visibility as yet. The network Glyconor offers a chance for better networking. Thus, priority should be given to the development of Glyconor, which is a priority strategic area at the faculty. In accordance with the university's priorities, Glyconor is combining researchers from chemistry, pharmacy and the Institute of Molecular Biophysics (IMBV). The strategic research area SMS further supports this approach. It seems to be essential for the group to increase the number of Ph.D. students, though the postdoc situation looks rather good. The number of beginning students has increased lately; efforts to stabilise this trend are necessary. Attractive collaborative projects can be supportive in this regard.

The NMR section is strong and could be further expanded, given that the necessary premises and permanent staff will be available. It is advisable for UiO and the Oslo region to develop the NMR group into a strong service and research centre, with nation-wide importance. The advantages of an analytical centre in Oslo, including mass spectrometric instruments should be carefully considered. The reorganisation process of the chemistry department is ongoing and the Synthesis and Molecular Structure Group has to play a vital role in this process. Strategic planning in this regard is even more essential for this group as the new premises, which are planned for 2017, are planned as a Chemistry-Pharmacy-Life Sciences building. In order to make a central impact in the future, synthetic and structural chemistry should improve their collaborations now (e.g., utilise the Glyconor network). A clear and comprehensive strategic plan is needed to develop the future for the Synthesis and Molecular Structure Group, which could strengthen its profile as *the* leading life sciences organic chemistry group in Norway.

The current premises of this group are large. However, the laboratories are old and require minimum renovation as soon as possible, without waiting until the new building is ready.

6.1.1.2 Analytical and Environmental Chemistry

The group consists of five professorial staff, four of which are over 50 years of age, five adjunct professors, one postdoc, ten Ph.D. students and eleven master's students. The overall age profile of the senior staff is strongly weighted towards staff close to retirement age and this area lacks leadership at present. The number of postdocs is very small for a group of this size whereas the Ph.D. and M.Sc. student numbers are reasonable.

The two parts of this group have a different history and were brought together in a logical grouping of these two potentially very complementary fields in 2005.

The analytical equipment and general facilities are adequate and the publications from the group are reasonable and close to the mean of the department as a whole.

Assessment and grading

The Analytical and Environmental Chemistry Group contributes approximately one third of the Ph.D. students and almost half of the M.Sc. graduates in the department and therefore accounts for a substantial fraction of departmental activity. The range of topics and issues on which members of this group have published is broad and includes a substantial effort in China. The group received advice from an international advisory panel in 2006 on the development of the group. However, financial constraints prevented important recommendations from the 2006 review being implemented. In particular there was no appointment of a new professor to provide leadership in environmental science. This appointment would have helped to develop a strategy for the future and there appears to be little intellectual leadership of a very able group of individuals.

Scientific Quality and Productivity	4/3 [*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	2,3,4 [**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

The grades given for quality and productivity reflect the quality of the science produced, as evidenced by the publication outputs, which are close to the mean values for the department overall and are reasonably well cited. It is acknowledged that the group as a whole has been publishing well. The value is moderated by the fact that much of the output of the environmental chemistry part of the group reflects the past and evidence of new developments in the science by this section of the group is limited, while the analytical component of the group is maintaining its publication outputs. The relevance and societal impact score relatively well reflecting the way the group has identified important developments in the science of pollutants of wider concern globally and especially in rapidly developing regions of the world as well as to Norway specifically.

The strategy and organisation score less well due to the lack of vision in not appointing key new staff in full time positions to take this area of science forward. It is useful in the short term to appoint adjunct professors to the department, and these have made important contributions, but full time dedicated leaders are needed to develop the department in the longer term. Given that by 2010 there will be two key posts unfilled, a clear strategy to appoint an international leader in this field is certainly needed.

Recommendations

At least one new appointment should be made at the professorial level, bringing into the department an environmental or analytical chemist with an international reputation, along with at least two postdoctoral research staff and some Ph.D. students, in an area of science complementing the existing lines of research. The 'start-up' package discussion elsewhere in this review would match the needs of this group, and the department.

6.1.1.3 Nuclear Chemistry

The nuclear chemistry group is incorporated within the chemistry department in the section for Life Sciences Chemistry. The group consists of 2 professors, 1 associate and 1 professor II with two postdocs and 4 doctoral students. However, one professor and one associate are currently 50% and the other professor is leader of SAFE (the Centre for Accelerator-Based Research and Energy Physics, a multidisciplinary centre within UiO). The staffing levels thus appear precarious but the creation of SAFE provides a far more substantial base for development than is immediately apparent. The number of postdoctoral fellows (2.5), Ph.D. students (5) and master's students (6) in this field, though small on a national level compared to the importance of this field, is actually relatively large given the small size of the current professoriate. The group reports difficulty in recruiting native Norwegian students, in spite of the fact that the job market in this area is good, and a significant number of their students are international.

Assessment and grading

The existence of a recently refurbished cyclotron on-site creates opportunities which are available in few other places, worldwide, both for home-based research and also training in nuclear chemistry. The SAFE group is Norway's largest provider of education and training in nuclear fields, at all levels. A broad range of courses is offered using dedicated teaching facilities. New outstanding laboratories have been created to support Positron Emission Tomography (PET) and there is close connection with radiobiologists in the medical centre. This should be the base for a significantly enhanced activity, due to the critical importance of this field in medical treatment and diagnosis. The Chemistry and Physics Departments have promised to provide technical support for this group at the technician level. In the long term, the Chemistry Department expects this group to consist of three professors.

The group has strength in super-heavy element chemistry for which it has an important international reputation. Through this work it is involved in numerous international collaborations with leading centres including IFE, CERN, GSI, LBNL, TUM, and Chalmers. Based on their current efforts, they can be considered the world leader in the “recoil transfer chamber” technology employed in certain nuclear chemistry experiments at large international facilities for research directed at producing very heavy atoms. Whereas parts of the current group are very strong, other parts should work to increase their research productivity.

The fact that this one small group is responsible for all the education and research in this important field in Norway has placed a significant strain on its current members. It is significantly understaffed at the professorial level and there is a difficulty in recruiting Ph.D. students from master degree programmes in chemistry. In addition, the level of technical support is low: Nuclear labs need strong support from mechanical and electronic workshops and highly qualified technical staff with long-term expertise in techniques, safety and procedure. Research activity in the recent past has not been high and can be considered as a weakness, though this has been a period of restructuring. The overall accomplishment of this group in the area of nuclear chemistry is presently clearly inhibited by its very small size and the significant responsibilities for research and education that it bears at the national level.

Scientific Quality and Productivity	4/2*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,4,5**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

Based upon normal measures (numbers of publications, conferences, number of Ph.D.s) the level of scientific quality and productivity is only good, especially when it is recognised that a good deal of the work on PET has been conducted elsewhere. There is a variable amount of research productivity, from high to low, within the group. Nonetheless, some of the publications are at international quality levels, and there are clearly very talented people in the group.

According to the relevance and societal impact the group is extremely well placed to play a strong role in Norwegian and international science through the development of unique facilities for research training in nuclear chemistry, links to international groups in nuclear chemistry, and the development of links to radiomedicine in Norway. Nuclear chemistry has critical applications in medicine, and therefore the societal impact of the work of this group could not be greater. The grade of 4 reflects the fact that this is potential rather than already delivered activity.

Finally, the researchers have done well, given the very small size of the group, to organise their university, departmental, and institute affiliations to get their work done.
The leader of this group is a very dynamic individual with strong connections to international research programmes. An outstanding infrastructure has been created for this group, excellent links have been forged with the medical centre, the activities address Norwegian and international needs extremely well. The interdisciplinary character and unusual nature of this field makes reaching critical mass very difficult within the small scientific research community in Norway, and the group has established extensive international collaborations to facilitate its work. At present, the human resource dimension is lacking at the level of academic staff, students, and research technicians and the Committee was not made aware of more than outline plans to address these deficiencies.

Recommendations
Much of the infrastructure has only recently been created (especially the PET lab) and development of the human resources to exploit this capability is vital, given the shortage of trained personnel to participate in nuclear programmes. With these facilities, the possibility for international training programmes is a significant opportunity. The Committee understands that at present there is no RCN programme for nuclear chemistry, and the Committee recommends that this be examined as soon as possible. Nuclear chemistry is expensive because of the size of the instruments needed but also because the requisite safety measures contribute a massive overhead.

The PET research programme creates possibilities for organic and pharmaceutical chemists to collaborate in designing ligands etc. The current Nuclear Chemistry Group would benefit from establishing a very close collaboration with an expert or experts in organic or inorganic molecular synthesis. The molecular chemist would design and synthesise molecules that would incorporate radionuclides and would interact with different molecular components of biological systems in order to deliver the radionuclides in a targeted fashion. This kind of collaboration, highly desired by the current members of this group, would represent a substantial opportunity for an interested synthetic chemist, and it may be desirable for the

RCN or UiO to establish funding for a targeted research programme in this collaborative area.

The field of nuclear medicine is extremely important from the point of view of medical diagnosis and treatment. Norway is, however, in the unusual position of having very few internal experts in this field. The handful of researchers at UiO in this area provide a good foundation for maintaining this critical expertise in Norway, but the Committee was left with the impression that the group is in danger of disbanding in the near future. The group is currently well-placed in the Department of Chemistry in the 'Life Sciences Chemistry' area. However, it is not clear that future plans, which will separate this group from the remainder of the Department of Chemistry on the opening of the new research building in 2017, will be good for fostering its collaborative interactions with chemists, pharmacists, and life scientists who may be interested in working in this area.

Given the fact that this is an important field, and the fact that the job market in this area is good, this group can be expected to greatly benefit from any nation-wide changes that may be instituted in Norway's Ph.D. programme in chemistry in response to the recommendations of this Committee.

The importance of this group for the development of nuclear chemistry cannot be overstated. Few universities, worldwide, offer the opportunity to work close to a cyclotron and with "hot" laboratories which are equipped at this very high level. The Committee recommends that the viability of this group should be looked at carefully at the national level, and that efforts should be made, by investment in personnel, technical support, and infrastructure, to maintain this expertise in the country.

6.1.1.4 Functional Inorganic Materials

The Functional Inorganic Materials Group at UiO performs research in inorganic, solid state, and materials chemistry, and includes work in chemistry-based nanoscience. Their primary interests lie in the area of discovery and development of materials for advanced energy technologies, but they are active in other areas as well, including, for example, functional oxides and microporous materials. The group is relatively large by Norwegian standards. It currently consists of 5 professors, 1 associate professor (with a second associate professor to be appointed) and 3 adjunct professors. The number of postdoctoral researchers (11), doctoral students (18) and master's students (14) is substantial.

Assessment and grading

This is arguably one of the most internationally well-known and successful research groups in chemistry in Norway. They have recently published their work in the highest quality international journals (i.e. Nature, Physical Review Letters, Applied Physics Letters) and are known internationally for their research on proton ion conductors. They can reasonably be considered as one of the best groups in the world working in this important area. In addition to their work in proton conductors, they have made important contributions in the materials chemistry of other important materials classes such as multiferroics and functional oxides, indicating that they display both excellent problem selection and high research quality. Their current excellence in research in the defect chemistry of oxides is the continuation of a decades-long tradition of first-rate work in that field. The programme integrates thin film synthesis (important because many electronic devices use materials in thin film form), exploratory research and characterisation of new materials, and computer modelling of electronic structures of solids, promoting cross-fertilisation. It is a well diversified group that encompasses many of the subspecialties that are needed to formulate a high-quality, coordinated effort in materials physics and materials chemistry.

The group has been highly successful in obtaining external funding to support their research programme. They have extensive involvements with national and university-based collaborative research efforts and centres such as SMN, inGAP, FERMiO, FUNMAT, and MiNa and in the EU-projects MOFCAT, NanoHY, and NOVELOX. They also have good research connections with the applied research centres SINTEF and IFE. The range of research equipment available to this group is outstanding.

Scientific Quality and Productivity	5/4*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,4,5**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

This group publishes many papers, some in journals of the highest international quality. Their work is highly cited. They actively pursue external research funding and are generally successful in securing it both as individuals and in focussed research groups. Their work on proton conductors, important materials in a potential alternative energy economy based on hydrogen rather than petroleum, is highly relevant to society. This is a large group with strong leadership. Their research strategy is very good, but the group may be working in too many areas in parallel (see recommendations). The research infrastructure (equipment, clean rooms etc) is outstanding and located in very good laboratories. There appeared to be a shortage of technical staff supporting the experiments and the Committee was told that much of the equipment is not supported by maintenance contracts. They collaborate with high-quality research groups in Europe, Japan and the US. They are on the whole focussed and productive with a positive view towards scientific research.

Recommendations

The Committee recommends that this excellent group should continue along current research directions and follow their described plans for the future. Their work should be well-supported by the RCN. One danger they face is that by being involved in so many different areas of research that they find interesting and important they may become over-extended and therefore less productive. The Committee recommends that they should be mindful of this potential problem and scale back efforts in some areas they believe to be less important if this situation develops.

Although in large part things are going very well for this group, the connection between the materials physicists and chemists in this group and the Centre for Theoretical and Computational Chemistry (CTCC) is not as good as it could be. This group would benefit from increased interactions with theorists and computational chemists, and therefore plans for increasing interactions between the computational chemists and materials chemists should be encouraged. If the group expands their interests into the area of molecular materials chemistry, such computational chemists can be extremely valuable in aiding the interpretation of physical properties such as hydrogen production and photoconversion, photoluminescence, and electroluminescence. In the best case, that expertise should be firmly established within the group itself through an internal staff member. Given that they have other priorities for hiring in the near future, however, they may want to explore whether one of the faculty in the computational chemistry group might want to switch into their group.

This group informed the Committee that in the future they would like to better integrate polymer science into their activities, as a soft-matter component within the Centre for Materials and Nanoscience. “Soft materials” are a very important branch of functional materials science that this group is currently lacking, and so increased activities in this area would be of interest. The Committee believes that the integration of an organic chemistry-based programme directed towards the synthesis of polymers or molecules with attractive electronic or optical properties into this dynamic group would be beneficial to the group’s work. However, given the current extensive activities of this group in other areas, a new faculty member would be needed to expand into this new field. Given that this might be an appealing opportunity for some organic chemists who might have a secondary interest in physical chemistry, the Committee recommends that this group should actively seek organic chemists from other groups to ask whether they might be interested in joining.

6.1.1.5 Catalysis

The Catalysis Group is relatively small (3 professors, 1 associate professor), with, however, a unique position in Norway. It is involved in two research fields in catalysis: (i) the synthesis of metal-organic complexes and their use in homogeneous processes; and (ii) heterogeneous catalysis, especially microporous materials, such as zeolites and, more recently, metal-organic framework (MOF) structures, and also traditional metal/support catalysts. Applications of the research are mainly in natural gas conversion. The group has several joint projects with SINTEF, especially through the CATMAT Gemini Centre (Catalytic Materials and Absorbents). The group plays a leadership role in the SFI Centre for Innovative Natural Gas Processes and Products (inGAP). Other joint research activities, at the national (in materials science and nanotechnologies with SMN) and international (European Centre of Excellence in Catalysis, IDECAT) level, also provide structure for the research in the Catalysis Group.

The number of postdoctoral fellows (6) and Ph.D. students (11) is high when compared to other research groups in chemistry. This is an indication of the good dynamism of the staff members.

Assessment and grading

Research on chemical catalysis in Norway is essentially performed by this group and the Catalysis Group at NTNU. Some research topics (particularly on natural gas conversion) are closely related in the two groups, even though the problems are treated using different approaches and techniques. The research activities in the group rest on two pillars: homogeneous catalysis mediated by transition-metal complexes, and heterogeneous catalysis. There is considerable cross-fertilisation between the two, in particular through the recently developed chemistry of metal-organic frameworks.

The first research area in catalysis is “synthesis and characterisation of metal complexes and their use in homogeneous catalysis processes”. This field of research has excellent international visibility and recognition, with high-level publications.

The second research area (“heterogeneous catalysts using microporous and mesoporous solids such as zeolites or MOF”) has been developed more recently and has now reached a high scientific level. It takes advantage of the scientific knowledge developed in the first research area and displays very good cooperation among the different members of the group. Although this field of research leads to more applied projects, the fundamental aspects of the work, through mechanistic and modelling studies, remain one of the objectives of the group. Some of the recent work on the characterisation of porous materials is particularly interesting, and has given rise to excellent publications. Quantum chemistry modelling of catalytic processes is performed in this group by an adjunct professor.

Publication indices are reasonably good and even excellent in the first research area. The staff members involved in the second research area (metal-zeolites/MOF catalysts) share part of their time between the Catalysis Group of the Department of Chemistry and different Technical and Innovative Centres. This gives them access to very interesting facilities and personnel resources but also increases their research (and for one of them administrative) duties, which has its downside as well.

Scientific Quality and Productivity	5/3 *)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,4,5 **)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The publications of the senior members of the group are of excellent quality. The youngest should be encouraged to follow the track of their senior colleagues. The great number and very good quality of publications is in line with the number of Ph.D. students and postdoctoral fellows.

Even though the group keeps in mind the maintenance of a high level of fundamental research, there is little doubt that the applied research activities are very well linked to industrial strategy and national priorities. Close contact between this group and the inGAP centre reflects their willingness to translate fundamental findings into concrete achievements and to initiate applied projects with the best chance of success.

The organisation of the group is excellent, with a good balance between members mainly concerned with applications of metal complexes in homogeneous catalysis and those working to support or incorporate catalytic metal complexes on or in mesoporous materials. This latter aspect is well-adapted to applied projects.

Recommendations

The group is very well organised both in the national and international catalysis community. It has developed a research activity of high-quality, well equilibrated between fundamental and applied projects. The presence in the same group of specialists in molecular catalysis, in organometallic compounds, and materials able to host tailored active phases provides an excellent opportunity for performing very good research. However, the group is weakened by its low number of staff. The Committee recommends making every effort to recruit a new member in the near future.

The level of publication of the senior staff members is excellent. To maintain the high level of publication in the group, the younger members are encouraged to improve their track record by publishing their work.

In the context of rapid changes of the economical environment in Norway and in the world, this group has the correct expertise to provide answers to problems and crucial advancements important to society.

To take opportunity of the gradually decreasing resources of fossil oil and gas, the position of the group in the field of alternative energy resources should be strengthened. Due to the threat of the decline of traditional chemistry in Norway, developing new projects in nanomaterials and bioresources through national and international cooperation should be considered if the group has the opportunity to recruit another member. The group should take advantage of inGAP to develop these new projects.

Cooperation with other catalysis groups in Norway is encouraged and should be strengthened. In a similar way, cooperation with groups specialised in nanomaterials chemistry, through MiNaLab, or other research structures, should be strengthened. The Department of Chemistry at UiO benefits from a high potential in this field, and the Catalysis Group is invited to take advantage of this close proximity.

Finally, collaborations with computational chemists through the CTCC should also be developed.

6.1.1.6 Polymers – Organic Materials

The group consists of 5 professors, 5 postdocs, 9 Ph.D. students and 5 master’s students; however, 4 postdocs, 4 Ph.D.s and 5 master’s students are associated with a single professor. It supports a range of “soft-matter” activity, and has responsibility for teaching in polymer, surface and colloid chemistry, delivering the only comprehensive polymer education in Norway. There is a wide range of technical expertise within the group and the infrastructure to support a comprehensive range of experiments within this field. The level of coordination and cooperation within the group and with other groups in the Department of Chemistry is anomalously low.

Assessment and grading

Compared to other groups within Chemistry at Oslo, there are significant areas of weakness within this group, and signs of poor coordination and demoralisation. Although there is some high-quality work, there appear to be significant missed opportunities that could arise from interaction with members of other strong groups within the Department of Chemistry. For example, self-assembly is an important aspect of nanoscience and nanomaterial preparation and there is considerable potential for use of solid-state NMR methods elsewhere in the department, but these opportunities do not seem to have been followed. Interaction with research organisations outside the university in colloids and gels is quite extensive and the work of some of the professors is closely linked with industry and institutes.

Scientific Quality and Productivity	5/3[*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	1,1,3[**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

One of the professors runs a large group with a high level of activity. Elsewhere, the number of researchers and publication rates are low, though a reasonable proportion of the papers do appear in good quality journals. Much of the activity is related to industrial concerns, and the group has a special role in providing the only broadly based educational programme in polymers and colloids in Norway. Furthermore, this is the only colloid/surface chemistry university research in Norway related to land-based industries; the activity in other universities is narrowly focussed on the petroleum industry and oil recovery. As commented above, the level of strategic planning within the group seems very poor, and is confined to individual group members. However, the basic infrastructure for experimental work and the laboratory conditions seem to be good. The pattern of external collaboration is mixed. Within Oslo it seems that numerous opportunities for collaboration are being missed.

Recommendations

The recent strategic organisation of research groups within the University of Oslo has largely been very successful, but this group appears to be an exception. It does not seem that bringing this group together has led to significant benefits and, indeed, it seems to have created problems with some of the members not responding to opportunities for funding and collaboration in new research areas. It seems that reassessment of this research group and reassignment of its members should be a priority.

Despite the obvious risks of building on a poor foundation, there is a great deal of potential for developing work of the type carried out in this group along numerous strategic directions in association with other groups in Oslo. It is clear that a programme of work in polymers, textured interfaces and gels must be maintained and strengthened. There are strong overlaps with nanoscience (self-assembly, nano-bio, hybrid nanoparticles) and with pharmacy (drug delivery, gels). Much progress has been made around the world in developing a theoretical and experimental framework to support these developments. This might be an area for targeted new appointments to bring in new expertise in forefront areas such as soft-matter statistical mechanics, optical tweezers and confocal microscopy, and single-molecule spectroscopy. As the Committee has commented elsewhere, such activities have a high degree of prominence in universities internationally that have comparable reputations to Oslo’s, and the Committee believes that they should be part of the research portfolio at Oslo as well. Given the reduced opportunities for working with industrial organisations in colloids and polymers, the development of this new science should be seen as an opportunity to refocus.

The difficulty of recruiting Ph.D. students to this area was commented upon and, looking at the group as a whole, the number of Ph.D.s is low. The Ph.D. training programme should be examined to see if it provides a sufficiently rounded training in this subject area to be attractive. This, of course would depend on retaining a recognisable “soft-matter” group in the future.

6.1.1.7 Quantum Mechanics, Structure and Dynamics

The group consists of two parts. There is a Theory/Computational subgroup containing two professors, two recently appointed adjunct professors and the pending appointment of an associate professor. The second subgroup is experimentally based and includes four professors, two in gas phase structural chemistry, one in atmospheric chemistry/spectroscopy, and one in mass spectrometry/chemical reactivity. The group is associated with one arm of the CTCC (together with the theory group at Tromsø), of which all professors are members or associate members. This has enabled co-location of all members in recently refurbished laboratories of very good quality. Within the Theory subgroup, one professor has been Dean of Mathematics and Physical Sciences for several years, with consequences for his research output.

Assessment and grading

The Theory subgroup is strong and firmly founded. The CTCC has enabled new appointments and an influx of postdoctoral workers into the Theory subgroup. The Theory subgroup (aside from the professor who is Dean) is highly active, as evident from the bibliographic survey, and very well regarded at the international level. It is responsible for the Dalton suite of quantum chemistry codes, which is widely used, and this has drawn the group into extensive international collaborations. Overall this is one of the strongest groups, worldwide, in developing quantum chemical methods and this has been recognised by awards etc. The group also hosts international summer schools in quantum chemistry and is a very active centre for visiting students and researchers. The computing infrastructure is outstanding. The group could support more Ph.D. students but, as the Committee has commented elsewhere, recruitment problems are considerable. The group could profitably broaden its research interests if the scope for expansion exists. Computer simulation and condensed phase ab initio electronic structure methods are applied to a limited extent elsewhere within experimental chemistry groups at Oslo. The Theory group could provide a better focus for this type of work and perhaps enhance the quality of the work which is done. Equally, there is no expertise in statistical mechanics or soft-matter, which could be very beneficial to other groups and provide a more rounded approach. In all cases, this broadened activity would enable profitable interaction with very strong experimental groups which could suggest wholly new problem areas and facilitate grant applications to sustain this level of activity.

The microwave and electron diffraction labs have been badly affected by the difficulties of funding and recruiting Ph.D. students and postdocs, which have prevented the development of new and innovative activities. The current effort is supported at a low level with little new money for equipment or maintenance. Furthermore two of the professors are approaching retirement, and it is believed that these areas of activity will be terminated at that time under the strategic plans of the Department of Chemistry. The Committee has commented elsewhere on the crisis for quantitative spectroscopy in Norwegian chemistry which will ensue, as these have been the leading Norwegian labs in the subject for many years. Of the remaining spectroscopy groups, one is focussing on vibrational spectroscopy with an applied (environmental/atmospheric) orientation and the other on mass spectrometric studies of clusters and chemical reactivity. These have been relatively well equipped.

Overall then the two subgroups are on different trajectories; the Theory group is growing in strength and resources, whereas the experimental groups are facing a reduction in their activity levels and a need to focus on *applications* of spectroscopy. Despite these differences there is a high level of activity in the application of computational quantum chemistry to chemical reactivity, structure, spectroscopic observables, etc. This forms a strong collaborative link between theoreticians and experimentalists within the group.

Scientific Quality and Productivity	5/4*)
Relevance and Societal Impact	3
Strategy, Organisation and Research Cooperation	3,4,4**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The best work within the group is at the “internationally leading” level. The overall publication rate is quite high, and the citation levels are admirable. Publication rate is high even in the experimental groups which have suffered from limited resources, and many of the publications are in highly respected journals. This attests to a good level of morale and general activity within the group as a whole. The bulk of the work is on basic problems in chemistry and the level of activity is well represented by the normal indicators (publications etc.) without special Norwegian relevance. An exception is the work on applications of spectroscopy in atmospheric chemistry, which represents a significant contribution to Norway’s internationally recognised strength in the area.
The group is well located, has good resources for its current activities, and is sustaining a high level of activity. These testify to the success of the previous reorganisation to form this strategic group. The Theory subgroup is very well engaged with the groups doing similar work at other Norwegian universities, and there is promise of resolving the Ph.D. problem by these means. A forward looking strategy for the experimental groups is urgently required. The Committee was concerned that there is a gap opening between the Theory subgroup and the condensed phase computational work being undertaken in Functional Materials, in particular. Opportunities for symbiosis may be being lost. There is considerable evidence for a healthy level of international collaboration.

Recommendations

This is currently a strong group, which has made good use of the resources offered through the CTCC. As the Committee has discussed elsewhere, the National Research Training Network is a realistic proposal for addressing the weakness in graduate recruitment and training in theory and could form a model for how research training can be offered in a small country. Further appointments could be very profitably used to strengthen the effort in computational studies of condensed phases.

A strategy is urgently required for the development of experimental chemical physics and spectroscopy in view of the impending retirements, poor level of funding and the sub-critical level of activity. In our view this is a matter for national attention as the Committee observed little innovative work anywhere in the country in the use of lasers, quantitative spectroscopy etc. This suggests a long-standing shortage of research workers with skills and interests in this area.

6.1.1.8 School Laboratory

The School Laboratory is a group of very small size. One professor and one lecturer are fully involved in the education of teachers in chemistry. The group did not supervise any Ph.D. students during the last years. The School Laboratory acts virtually as a service organisation, and research projects are not carried out at all.

In view of this, the School Laboratory has to be evaluated by applying another standard. A grading of the research output is not possible. However, the group has a responsibility to train chemistry teachers. This is a task of national interest.

Considering the service role of the group in the department and the age distribution of its members, the department needs to develop a strategy for the School Laboratory.

One perspective could be to turn the group from a research group into a service group (which it is de facto) and to install two lecturers for carrying out the training programme.

Another alternative could be to invest in the group and turn it back into a research group with the strategic task to increase the interest of society – in particular young people – in the field of chemistry. In the long run, this could have a significant impact on the recruitment of young scientists.

In order to optimise the limited resources in Norway for research in chemical education the Committee strongly recommends coordinating any future activities in the field with the Department of Chemistry at NTNU.

6.2 NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

6.2.1 Department of Materials Science and Engineering (DMSE)

DMSE at NTNU was established in 2002 after a merger of three former departments: Department of Metallurgy, Department of Electrochemistry and Department of Inorganic Chemistry. Today DMSE is organised in four research groups “Physical Metallurgy”, “Process Metallurgy”, “Inorganic Chemistry” and “Electrochemistry”. Only the two latter groups are included in the evaluation. The main reason for dividing the department into four research groups is due to their education and teaching responsibilities, taking into consideration the historical origin of the groups. DMSE is co-located with several research groups in SINTEF and collaborates very strongly with those groups. In general, strong collaboration across the borders of the four formal departmental research groups and with researchers at other departments, SINTEF, and industry, is quite common.

The research carried out at DMSE fits into two of NTNU’s strategic research areas: “Materials” and “Energy and Petroleum – Resources and Environment”. Key areas for “Materials” are light materials, materials for energy technology, materials for oil and gas, and materials for electronics and sensors. The second area of research is related to hydrogen production by membranes and water electrolysis, gas separation membranes, fuel cells and solar energy cells. The electrochemistry group is also a key player in the Centre for Renewable Energy, which is a joint effort by NTNU, SINTEF and the Institute for Energy Technology (IFE). The DMSE at NTNU has been the guiding force in the establishment and construction of the national nanoscience laboratory (“NTNU Nanolab”), which is designed to house the electronics patterning and characterisation equipment that is required to perform state-of-the-art research in the fabrication and characterisation of materials at the nanometer length scale. The NTNU Nanolab, under construction at the time this report is being written, is physically connected to the materials science building at NTNU.

The organisational and leadership structure of the department involves a department head, a deputy head, a management group, research group leaders, and an advisory board. Students, Ph.D. students, administrative, scientific and technical staff are represented in both the management group and the advisory board, which is headed by an external member (SINTEF) and is consulted with regard to the annual budget, new faculty positions and other strategic issues. Meetings on the scientific staff level are carried out regularly.

The staff key data are summarised in Table 4 (detailed information on the research group level is given in the respective chapters).

	Total	
Positions	**Univ.**	**Extern**
Professor	9	0
Associate professor	1	0
Professor II	5	0
Postdoctoral research fellow	1	6
Doctoral students	6	29
Technical/administrative positions	9	1
	31	**36**

Table 4: Numbers taken from the factual information provided by the Department

”Univ.” = persons financed by the university

”Extern” = persons financed by external research grants

Hiring of new faculty members is one of the most important strategic decisions in the years to come, e.g., hiring of two associate professors, one in nanoscience and one in corrosion and surface science. The age distribution among professors in permanent positions is summarised in the following table.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
1	0	2	2	2	1	1	1

Table 5: Age distribution among professors in permanent positions

The recruitment of doctoral and postdoctoral fellows to DMSE over the past five years has changed in terms of increasing numbers of master’s students. Foreign doctoral and postdoctoral candidates are mainly recruited from European countries and Asia.

Graduates	**2005**	**2006**	**2007**	**Total**
Dr. ing./Dr. scient. graduated	11	7	3	21
M.Sc. graduated	14	16	22	52

Table 6: Number of graduates

Special attention is paid to the education of competent master’s and Ph.D. students in solar cell research, since DMSE feels that it has a national responsibility to meet this emerging field in Norway. Accordingly, the department wants to meet the rapidly increasing number of graduates needed by the Norwegian solar cell industry.

As to future and strategic planning, the evaluation of engineering science performed in 2004 has had a large impact on DMSE. In particular, interdisciplinary initiatives involving mechanical engineering, metallurgy/materials science and chemistry, e.g., fields such as light metals, solar cells and nanotechnology, are in the focus.

Assessment and recommendations

The evaluated portfolio of this department includes one of the two large inorganic and materials chemistry research groups in Norway. These are specialties in the larger chemistry community that have increased in activity and importance in the past decade. This is due both to the emergence of nanoscience as a large and active discipline, and the realisation by chemists that the design of molecular and non-molecular solids with specific physical properties can be both challenging and rewarding. This department clearly approaches these chemical specialties from the viewpoint of materials science – as their emphasis is strongly on developing the chemistry of materials to improve the processing of important technological materials and to discover and develop new materials that have the potential for applications in important technologies. These qualities of their approach to materials chemistry research are greatly enhanced through their very close collaborations with SINTEF and other industrially-based organisations. In some areas of research, this close collaboration with non-academic research organisations has resulted in somewhat more emphasis on development-oriented rather than basic-oriented research than is generally found in academic materials science departments internationally. The department as a whole has been very successful in funding its research, and seems to have a very healthy research culture.

DMSE moved into a completely renovated chemistry building in 2006. The laboratories in the renovated building are excellent both in the areas of basic building infrastructure, and availability of research equipment. DMSE has received several grants for high-quality high cost research instrumentation in recent years and the positive impact of this instrumentation was apparent to the Committee during the tour. It was noted by the researchers, however, that funding for smaller equipment, for consumables, and for maintenance and technical support of the equipment has been difficult to attain.

DMSE stands to be the primary benefactor from the new infrastructure that will be available in the NTNU NanoLab when it is completed. This new laboratory, which represents a major national investment, is expected to establish a cross-disciplinary framework for research in nanotechnology. Future plans for large-scale infrastructure improvement also include a building for solar cell research, which will be occupied together with SINTEF and other NTNU departments. In conjunction with the expanded activities of this department in nanoscience, which are presently very limited, plans are currently in place to hire a new faculty member in that specialty area. Other plans are to add another in the area of corrosion/surface science. This would serve to reinforce their already major focus in that research area.

Overall, this is a strong department with an applied focus. They have good funding for their work through their industrially funded projects and institute associations, and their leadership is strong. The labs visited were busy and had a good feeling of productivity. Much of the work is presently oriented toward local Norwegian industry and technology, in part due to the materials science and engineering core interests, but also due to the relatively good availability of funding for applied research in this field compared to funding for basic research. Substantial capability exists in this department in terms of infrastructure, experience, and intellectual resources that would potentially allow them to perform basic research that would have significant impact in the international scientific community. To do that, however, the department would have to acquire the financial support necessary to expand or redirect their research in new directions. This would require that they very actively seek support from current limited resources available for basic research in Norway or compete internationally for EU-funded basic research projects. Given their excellent record of success in applied areas, this group may be an effective voice arguing to increase the funding available from national Norwegian funding sources for basic scientific research: the researchers in this department would no doubt be very productive in any basic research programme they undertake if further investment is made in that area.

At first it may be considered unconventional for strongly chemically oriented groups such as ”Inorganic Chemistry” and “Electrochemistry” to be subgroups in a materials science department rather than in a chemistry department. The very strongly properties-oriented and materials-processing oriented characters of these groups, and the nature of their interactions and collaborations, however, makes their intellectual home much more suitable in the materials department rather than the chemistry department. This arrangement is clearly working very well for these groups, and the Committee recommends that the current inclusion of these groups in DMSE be maintained.

6.2.1.1 <u>Electrochemistry</u>

The electrochemistry group involves 3 full professors, 1 associate and 3 professor II. There are three research teams, in electrolysis, corrosion, and electrochemical energy technology. There are currently 19 Ph.D. students, which is high by Norwegian standards for a group of this size, and three postdocs. Although this is labelled an electrochemistry group, its research activities are more narrowly focussed in several applied activities. There is a significant overlap between the group’s activities and those in the Inorganic Chemistry Group (to which the same remark about breadth of focus could be applied) and the two groups coordinate their planning through the DMSE organisational structure. The group has recently moved to a completely renovated building, where the facilities are excellent.

Assessment and grading

The Electrochemistry Group has strong links to Norwegian industries (aluminium and offshore). This connection may, in the past, have encouraged too narrow a focus on industrial concerns for good internationally recognised and publishable work to have been a major priority. The group has great potential for addressing scientific issues due to new technologies arising from the energy crisis and the infrastructure and the expertise they have accumulated due to the range of problems they have historically addressed. The group has strong links with institutes (SINTEF and IFE) which further strengthens the available infrastructure and the possibilities for major research collaborations. It is clear that new directions of research are being targeted, stimulated in part by the reorganisations at NTNU and strategic research directions identified within NTNU and the EU. There was evidence of rapid development of work on new energy technologies, e.g., significant and growing activity in the fuel cells and hydrogen economy areas (though not yet substantial publications), and on the electrowinning of other materials (e.g., the avoidance of CO_2 in Fe production and Ti electrowinning). This group is benefitting from strategic thinking following reorganisations and new recruitments.

It is clear that the recruitment of students to do Ph.D.s in this group has been problematic; though there has been a strong increase in the number of externally funded Ph.D. positions recently. As discussed in general comments, steps could be taken to improve the attractiveness of a Ph.D. programme (i.e. to generalise its educational base). The master's programme has been very busy, and the numbers of students graduating seems to be increasing rapidly. There was evidence in the laboratories of many international visitors (students and postdocs) supported on external grants. On the other hand, the staff is mostly local and appears to have worked in Norway for most of their careers.

Scientific Quality and Productivity	3/2[*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,4,3[**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

The level of research activity visible from publications in internationally recognised journals is not high, though it is on a steeply rising trajectory - especially the work associated with new energy technologies. The citation rate of much of the work is low, which is what might be expected for work that has been primarily motivated by local concerns of Norwegian industries.

The work consequently scores relatively highly for its relevance. The group is also very active in educating master's and Ph.D. students with appropriate training to participate in new technologies. The laboratories were very busy with master's students and overseas Ph.D. students.
The research infrastructure is very good. There are extremely well equipped and spacious laboratories, excellent technical (workshop) support and very good access to libraries. The group now appears to be responding well in its strategic thinking to several external stimuli, and moving away from heavy reliance on its traditional sources of support from the aluminium and offshore industries.

Recommendations

Overall this is a group with first class, relevant expertise for a range of highly topical problems, and excellent infrastructure. Following the upheavals of restructuring and moving, the group seems to be moving away from its traditional relationships with industry and repositioning itself to take advantage of the new opportunities.

Attention is drawn to the very significant opportunities for a group of this type that are presented by new technologies especially in new methods of metal extraction and in electrochemical energy technologies. These technologies appear in the strategic plans of NTNU and at the national and EU level, so there are major opportunities for funding new research directions. However, to fully exploit these opportunities, more staff are required and this is also indicated by the age profile of the current members. Apparent threats were the lack of internal support for research in the form of technician support for instruments, funds for small items of equipment etc. Attention is also drawn to the amount of time spent on teaching as a consequence of improved undergraduate recruitment and the reductions in staff levels. To improve the international visibility of this group, incentives to publish in leading journals should be considered.

The group should address whether it is presenting an attractive Ph.D. training programme, which will encourage its master's students to remain in the university. Suggestions have been made in the general sections of this document.

6.2.1.2 Inorganic Chemistry

This is a group of reasonable size (5 professors, 1 adjunct professor and 1 chief scientist) working in a broad field of research topics: carbons for electrodes in aluminium electrolysis technology, ceramic materials for metallurgy (e.g., oxides, silicides, nitrides, borides, and glasses), perovskites as ferroic materials, oxygen permeable membranes, and various nano-materials technology related topics. At present, two additional research topics are pursued in the group: molten salts and polymerisation catalysts. During the interview, it was announced by the head of the group that these two topics will be given up in the near future. The group also comprises 5 postdoctoral fellows and 16 Ph.D. students. This is in good accordance with the number of staff members, and reflects a significant research activity.

Assessment and grading

This group performs high-quality research in materials chemistry as it applies to materials science, particularly as it is related to applied topics. They are well equipped to perform their research. The research group is very active and is well connected to industry. They perform a substantial amount of industry-related research that is of value to the development of technologies in Norway.

The group occupies a unique position in Norway in the field of aluminium production and in other fields of metallurgy. Research topics are closely related to industrial problems, and thus in this area the group appears to be well-funded by industry, with research highly relevant to Norwegian society. The visit to the laboratory by members of the Committee largely confirmed this impression of an applied research at a high-quality level.

Investigations of carbon electrode materials within the framework of application to aluminium electrolysis technology are important parts of the group's work. New considerations of the need for energy savings during aluminium extraction, addressing environmental problems, and of purity of products and by-products are expected to dominate future actions in this field of research. Their research on ceramic, membrane and ferroic materials, while largely distinct from the above, is related at the most fundamental level as many of the applications of such materials of interest to the group are in the energy sector. These materials, though the details of their relevant physical properties and applications are different, fit well into the expertise of this group and with each other, as their basic solid-state chemistry, preparation, and characterisation are strongly related. The wide range of topics studied, however, may hinder interactions between the staff members, as they must concentrate primarily in their specialties to most effectively obtain high-quality results in their specific areas of interest. As a consequence, some of the synergies that arise from concentrating efforts of several staff members in one area are sacrificed.

This group has had strong input to the development of the NTNU NanoLab, the national nanoscience laboratory that is located very close to the laboratory housing inorganic chemistry. If this group does expand into the area of nanoscience in a substantial way, then the synthetic methods employed to prepare nanoscale oxides and other materials via sol-gel or micelle techniques may be applicable broadly to many of the materials of interest, and interesting new collaborations among group members could emerge on the basis of these new techniques.

Scientific Quality and Productivity	4/3*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	3,5,3**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The overall level of publication in international journals is good, but could be improved. Efforts in that direction have been made by various members of the group, reflecting a good progression of scientific quality and increased focus on publishability. This group is capable of publishing more in basic research in the future and could redirect their work in that area if they obtain funding. The relevance of the work is high, in that it impacts current technologies important to the Norwegian economy, especially in the field of electrochemical metallurgical processing, and in the field of metallurgy in general.
The organisation of the research is very good. The leadership is very strong. However, cooperation between staff members is limited. The level of outside collaboration is high, both with other groups and industrial concerns.

Recommendations

Like the Electrochemistry Group, overall, this research group is quite strong. Particularly strong is their work related to the chemistry of metallurgical processing, and the Committee recommends that this work should continue along its current directions. They have good funding for that work through their industry and institute connections, and the work is clearly valuable to Norwegian national interests. The visit to the laboratory showed a good level of research activity and positive attitude of the young researchers, which the Committee would like to commend. The Committee is also happy to commend this group's teaching strategy of offering a good choice of summer schools for their Norwegian and international students. Their remarkable efforts in terms of student education should be maintained and even strengthened.

The Committee recommends that this group consider a change in balance between applied and fundamental research over the long-term. This can be accomplished by expansion of the group to include new staff members focussing on basic research, but could also be facilitated by abandoning some of the current applied topics and finding the funding to work on new, more basic problems. The very good equipment, the intellectual resources present, and the excellent possibility of recruiting students through having them perform work in a combination of both basic and applied areas would likely allow basic research to thrive in this group, improving their productivity in terms of high-level publications and increasing their visibility in the international research community. Some of this may come along with an increasing emphasis on nanoscience, which by its nature is more of a basic research field. They are already working toward those directions in the area of fuel cell studies, which, given the importance of energy research in the coming decade, the Committee hopes that they will be able to expand in basic as well as applied directions. Their work in ferroics is perhaps the most forward-looking of the current research programmes, and would be one area where increased funding for basic research could have a substantial benefit. Funding basic research areas of mutual interest will also help to strengthen internal group research cooperation.

This group has been the prime motivating force, it appears, for the establishment of the NTNU Nanolab. Nanoscience as it is practiced at the current state-of-the-art level internationally is not, however, one of the primary strength areas of the current researchers in this group, nor is it very strong in other chemistry groups in Norway. The establishment of the NTNU Nanolab as an important resource in Norway is a significant step toward joining the international research community in this important area of science. It should now be considered a very high national priority to bring strong leadership in nanoscience from outside of Norway into the Norwegian system. Investment in an internationally recognised expert with a good modern overview of the field, and giving that person the opportunity to hire several very early career professors from international research groups to create a critical nucleus of researchers would jump-start an international-class effort in this important area. Because daily access to facilities such as those that are envisioned to be part of the NTNU Nanolab will be critical to the success of such an effort, this group may best be sited at NTNU.

6.2.2 Department of Chemistry

The Department of Chemistry at NTNU has emerged from four chemistry departments at the former University of Trondheim in 1999. Today the department consists of three sections, “Physical Chemistry”, “Organic Chemistry”, and “Analytical and Environmental Chemistry”.

The main focus of the Department of Chemistry, different from the rest of chemistry departments at NTNU, is more basic research and less technology oriented. The members of the department are split across two buildings, with the organic chemistry section mostly remaining in the old chemistry building.

The department’s organisational structure involves an elected head and three section leaders, appointed by and advising the head of the department. The head is responsible for the administration of the department and also for teaching and research. The head is advised by the council, which comprises elected representatives from the permanent scientific staff, the research assistants, the administrative and technical staff and students. The head directly communicates with staff in terms of performance and project applications.

Recently, a considerable number of faculty members have retired and there were three more due to retire in 2008.

	Total	
Positions	**Univ.**	**Extern**
Professor	13.2	0
Associate professor	10	0
Professor II	3	0
Postdoctoral research fellow	1	2
Doctoral students	11	19
Technical/administrative positions	4	0.3
	42.2	**21.3**

Table 7: Numbers taken from the factual information provided by the Department

”Univ.” = persons financed by the university

”Extern” = persons financed by external research grants

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
0	1	4	1	2	2	2	2

Table 8: Age distribution among professors in permanent positions

In particular, teaching seems to be regarded as the main criteria for the level of staffing and future appointments due to the strong involvement of staff in teaching duties. In this regard the reduction of the number of NTNU-financed research assistants from 13 to 5 in 2007 apparently resulted in a serious shortfall in teaching capacity. Both external financing and recruiting postdoctoral fellows as well as doctoral students remain problems to be solved. In particular, the department wants to attract female M.Sc. and Ph.D. students through goal-oriented recruitment drives.

The situation at the master's and Ph.D. level is represented in following table:

Graduates	**2005**	**2006**	**2007**	**Total**
Dr. ing./Dr. scient graduated	8	5	7	20
M.Sc. graduated	16	15	20	51

Table 9: Number of graduates

Future planning is part of the Department Strategic Plan for research, which is effective for the period 2006-2010.

Assessment and recommendations

The reorganisations at NTNU have created chemistry groups in two departments, Chemical Engineering and DMSE, which are well configured to take good advantage of the strong industrial and institute links which are a feature of NTNU and which contribute to outstanding infrastructure for research. As described elsewhere, these groups are either very strong, or on strong upward trajectories in their research output.

The remainder of Chemistry (which includes much of the basic core of the subject, and many of the people responsible for teaching it) is grouped into the Department of Chemistry, to which these considerations about access to resources do not, *a priori*, apply. Without this external/industrial support, the NTNU-funding model leaves a department very dependent on finding external funds in order to pursue research and, as commented elsewhere, unless the research effort is matched to the strategic programmes of the Research Council of Norway, such funding is very difficult to come by. The department is under severe financial constraint. This has affected the technical support for research quite seriously and means that there are no residual funds to help with incentivisation and prioritisation. The staff reported high teaching loads and a heavy time penalty associated with bureaucratic processes. Overall, the Committee felt that morale was low with a sense that the reorganisations and resource allocation model at NTNU had not worked in favour of this department.

Since, to a large degree, the current research targets of the workers in the Department of Chemistry might be described as basic chemistry, many are struggling to generate the necessary resources (including research students as well as support for equipment) to operate at even close to the internationally recognisable level, which is well below the internationally-leading institutional aspiration. It is simply not possible, for example, to run a recognised laboratory in organic synthesis on the level of resources available to the workers in this department. On an international level an organic synthesis professor would supervise ten graduate students and have two postdoctoral research assistants and an attempt to recruit such a person on the international stage would fail unless running a group of this type was a possibility.

Within the department, there have been some moves to adapt activity to meet this challenge. The merger of analytical and environmental chemistry has created a group that is more relevant to industry and this has enabled collaboration with StatoilHydro. Several other individuals have reconfigured their research objectives to participate in highly active funded programmes elsewhere in NTNU, for example, in catalysis. Others, especially in theory where resources are less important, have been able to continue research on topics of current interest which have a substantial fundamental aspect. However, a substantial number of disenchanted researchers remain, whose area of research activity has not adapted to changing times, who are apparently content to do research at a relatively low level.

The department displays no strong internal scientific collaborations or convincing synergies. Its different sections are even located in different buildings and there is no vision or agreement on a collaborative future development of the department. Even within one unit, such as the section of organic chemistry, networking is underdeveloped.

NTNU and RCN should undertake a serious evaluation of the state of this department, in full consultation with the members of the department themselves. The department - charged with maintaining a centre of basic chemistry at an internationally leading level - appears to have been placed in an extremely difficult position by the funding model within NTNU and the RCN, and the division of the subject of chemistry between different departments at NTNU. To achieve this level of research there would have to be new appointments of research active staff pursuing new areas of activity. However, the department itself does not appear to have a vision of a credible research agenda and a substantial shift of focus amongst many of the existing members would be necessary before the additional investment could be expected to produce the hoped for uplift in activity.

6.2.2.1 Physical Chemistry

This is a group of reasonable size (6 professors, 3 associate professors and 1 adjunct professor). However, two professors retired in 2008. Of the remainder, three professors and one adjunct professor could be considered as doing theoretical/computational work. This means that the number of groups doing experimental physical chemistry is low and probably sub-critical, from the viewpoint of coordinating basic resources and infrastructure and deciding on strategy. A further retirement is due in 2013. Strengthening the T/C section has been a priority in recent years resulting in the appointment of two new professors in his area. There are 12 Ph.D. students in the group and four postdocs which are small numbers for a group of this size.

Assessment and grading

The Physical Chemistry Group consists of a theory/computation section and several experimental researchers. The T/C section has good scientific quality, reflected in a good number of publications in international journals and an appropriate spread of activities. There is a good level of collaboration between the T/C groups and other similar groups in Norway and elsewhere. The activity level of the experimental subsection is not so high and, overall, falls below what might be regarded as the internationally expected norms. The activities of the experimentalists do not appear to be coordinated and do not appear to reflect any research strategy in physical chemistry *per se*. Apart from distinctive work in chemometrics, the active experimental projects could be characterised as applications of spectroscopy and synchrotron techniques in inorganic chemistry and catalysis. There are far fewer connections with the industrial and research institute sector than in other NTNU departments. The group is not well placed to take advantage of the more accessible Norwegian funding opportunities and needs a research strategy that more closely matches national priorities or opportunities within NTNU, especially for its experimental activities, where the resource requirement is higher. Although the level of external funding is listed as strength, it seems to be diminishing quite rapidly in the year-on-year returns. Promising opportunities are presented by the development of the NTNU Nanolab.

It is clear that the recruitment of students to do Ph.D.s and also master’s students has been problematic. The number of Ph.D.s and postdocs is low by international standards, and it is difficult to see how the necessary degree of continuity to run experimental research laboratories can be maintained with these numbers. The number of internally funded positions is very low, and has diminished rapidly.

The theory group is somewhat easier to sustain, and the computational section is able to make use of the excellent high-performance computing facilities in Norway. At least two of the members have taken advantage of collaboration opportunities within NTNU, and somewhat reconfigured their activities to match the priorities of experimental groups in Chemical Engineering, where they have found challenging and distinctive research opportunities. The T/C group would be viable and even strong with an easier access to responsive-mode funding, though the balance of the subjects covered is threatened by retirements that will reduce the strength in statistical mechanics/thermodynamics. There are opportunities for collaboration and symbiosis with Chemical Engineering in the latter area through modelling work on porous materials and confined systems, soft-matter etc. which could be addressed with a strategic appointment. The T/C group had a collective sense of identity and strategy and would be a suitable base for investment in new developments. Their links with other T/C groups in Norway is good and they would be well-placed to take advantage of a national training network.

The group appears to have very heavy teaching commitments, since it is engaged in a large number of classes at the undergraduate level. It was not clear to the Committee whether the group was holding onto this teaching load in order to maintain its university funding streams or whether it really had no option. It does appear that these activities and the associated administrative tasks have had a negative impact on research.

Scientific Quality and Productivity	4/2 *)
Relevance and Societal Impact	3
Strategy, Organisation and Research Cooperation	2,2,3 **)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The research activity indicated by publication rates is somewhat uneven, with the best at a very good level while the poorest appear to be almost research inactive by this measure. The pattern of supervision of Ph.D. students presents a similar picture. The level of publication is good and even excellent for some senior members. Some young members should improve their personal data in terms of publication and contracts. The group has international visibility in several fields of theory.

The topics of the group are not very close to applications. However, the group contributes to the improvement of basic knowledge useful for several national (and international) groups working in more applied research.
The work carried out in the group is largely directed at fundamental problems, so the activity should be fairly reflected by the normal measures of publication rates etc. However, some of the group members have matched their activity to programmes in Chemical Engineering where the research directions are more directly attuned to national priorities.
As commented above, it appears that there has not been any strategic thinking about how a basic chemistry group like this one is supposed to function successfully within a technologically focussed university like NTNU and with the funding opportunities presented by the Research Council of Norway. Much of the “strategy” is reactive to the pressures of a substantial teaching load and limited funding. There was no evidence of a concerted effort to lay out a programme of experimental research development, new appointments etc., which might attract strategic funding at the university or national level.

Recommendations

The theory group has good quality and has maintained a good level of activity with modest resources. It would certainly be helped by an improvement in funding for basic science. It seems that there are good prospects for symbiosis with more application-oriented work in Chemical Engineering, which throws up a number of basic problems of considerable interest. Some of this is already happening, but an appointment to facilitate simulation work on confined fluids, complex fluids, and porous media could be enormously beneficial to both Chemistry and Chemical Engineering and would build upon a strong tradition in Statistical Mechanics.

To be successful and achieve an internally recognisable level the experimental physical chemistry effort needs some new focal points and an increase in the number of workers to a critical size; these might be associated with the NTNU NanoLab development.

The group must address the problems caused by the shortage of young researchers, either as graduate students or postdocs. It should work to improve training opportunities within the Ph.D. programme and also give the creation of positions a higher budgetary priority in order to stimulate further research.

The group (and also the department) should review its contributions to the chemistry teaching programme. It was reported that these commitments were a significant dampener on research. Is the group’s contribution really excessive? Are there poorly attended courses which should be dropped?

6.2.2.2 Organic Chemistry

The Section of Organic Chemistry consists of three full professors and three associate professors. Two of six faculty members are female. The spectrum of research topics is broad and divergent and ranges from mechanistic studies to supramolecular chemistry, catalysis and synthesis of lipids, heterocyclic chemistry, fluoro-organic chemistry and the isolation and investigation of natural products. Currently 12 Ph.D. students are working in this section. There is a strong complaint about a lack of graduate students and an overload of teaching duties. Two master's programmes within chemistry studies at NTNU have not led to a sufficient increase in the number of Ph.D. students for the organic chemistry section; however, there has been an increase in the number of master's students.

Assessment and grading

The Section of Organic Chemistry at NTNU, consisting of six professors, does not appear as a unified whole. Possibly due to its history, it is further subdivided into groups, some of which know each other well and some of which even have their labs in a different building. There is little collaboration within this section and hardly any with other research groups in the Department of Chemistry. Structural future planning is inadequate and not driven by collaborative endeavours. The group has suffered from staff shortages; however, in this situation it is even more important to develop a strategic plan for the group, rather than to spread its research activity thinly. There did not appear to be any well-defined priority areas. During the evaluation process several desirable research areas for a new appointment have been mentioned such as organometallic chemistry, organic synthesis, catalysis and mass spectrometry. These plans to hire new professors are inconsistent.

The fundamental instrumentation for organic synthesis is largely old and insufficient, except the NMR equipment. Surprisingly, even though there is a new chemistry building at NTNU, only a small part of the Organic Chemistry Section moved into it.

Scientific Quality and Productivity	3/2*)
Relevance and Societal Impact	2
Strategy, Organisation and Research Cooperation	1,2,3**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The number of publications coming from this section is partly good, however, publications are often in level 1 journals and of little international visibility. Heterocyclic chemistry and work on lipids, vitamins, carotinoids and antioxidants currently has the highest impact in this section. There are isolated contributions with high international visibility. Overall, however, the publication rate and effort of the Organic Chemistry Section in Trondheim is not more than fair and often not internationally competitive. In its current condition research in this group is of little societal relevance and impact. Except for some work on vitamins and antioxidants that holds potential for various applications, a societal impact is not clearly visible. In terms of a future strategy, organisation, and cooperation, the section has fallen behind the Norwegian standards. There is neither observable strategy nor leadership that governs the group and few internal collaborations exist; these could help to favourably combine the existing resources. Basic experimental equipment is often in poor condition and the scientific communication within the section is not broad enough. There are, however, some national as well as international collaborations that are administered by a minority of the section's members. These collaborations are good and suited to improve the quality of the section's research.

Recommendations

The Section of Organic Chemistry at NTNU is the weakest representation of organic chemistry in Norway. It is essential to work on the scientific profile of the group, putting emphasis on a consistent strategy and up-to-date research projects. Establishing collaborations within the Department of Chemistry and other related institutes at NTNU appears to be more important (for example, with the Catalysis Group) for future success than maintaining less important projects. The most successful members in the section should take a leading position in this improvement process. This section needs one or two leading researchers who are active in a research area of international importance. Professors with no scientific output and no external funding should not significantly participate in the institutional funding. It should be considered whether such professors should focus their efforts essentially on teaching. In addition, a new professor position should not be arranged without a clear strategy. It is essential for this section to move into new laboratories based on an efficient infrastructural plan. The current premises are totally inadequate and, in addition, appear to be rather empty. The mass spectrometry equipment is totally insufficient and has to be replaced, or an effective collaboration with the Section of Environmental and Analytical Chemistry has to be established, where modern mass spectrometry equipment is available.

6.2.2.3 Environmental and Analytical Chemistry

The Section of Environmental and Analytical Chemistry consists of three professors and one adjunct professor, four associate professors, one postdoctoral researcher and one additional researcher. There are 14 Ph.D. students and approximately 25 M.Sc. students. In the general comments on Environmental Chemistry in Norway it was noted that a substantial fraction of the research work focusses on the opportunities and threats presented to Norway through its geographical location. The profile of environmental chemistry at NTNU is a good example of this focus with a substantial and highly regarded programme of trace metals and especially mercury research and a focus on pollutants in the arctic. The sensor research, while appearing quite different has similar geographical motivations. The section is well integrated into international research projects, including EU framework programmes. This integration is very important, especially as the issues have a substantial international and transboundary dimension.

Assessment and grading

The strengths presented by the section are reasonable as far as they are stated, but are rather brief and several key strengths have been omitted or understated. The greatest strengths are the key staff, who have a solid publication record with reasonable citation rates. This is not a large research group, but given the scale of resource available, the involvement in some of the most important emerging issues relevant to Norway shows a good strategic vision. This section could not be expected to be involved in all issues, the skill base and scale of the team preclude such a strategy. Instead the approach of a quite narrow specialisation is a solid strategy as long as the output of high-quality publications is maintained. The focus on specific emerging areas including mercury chemistry in the arctic and the long range transport and pathways of persistent organic pollutants again with a focus on the arctic are important examples of the innovation and search for exciting new avenues. The links with international research groups is very important to the section.

The self assessment of the weaknesses is fair; the section is too small in the absence of more postdocs to develop a larger programme of innovative research. There is a logical link between the lack of postdocs, links with highly rated university groups and the scale of the innovative research activity. Postdocs funded by research grants/contracts in collaboration with the leading teams especially where there are associated Ph.D. students provide an effective mechanism for collaboration between groups.

This section has maintained a focus on relevant issues and within this area they have developed topical new projects which clearly have a strong future. The past research has brought a reasonable level of output, as evidenced through the publications. The publication rates are intermediate relative to other parts of the Department of Chemistry and by comparison with other environmental chemistry research groups under review. So there is clearly room for development of publication rates. It is not fully clear whether there is a substantial quantity of unpublished material and that the individuals lack the time to pull the data together, analyse and write up the findings, or whether there is a deficiency in the supply of new data. The evidence of an overload of teaching and administration in the absence of an adequate postdoc community, to get on with the research with little distraction, suggests that again the lack of postdocs is an important bottleneck in the group's productivity.

Scientific Quality and Productivity	4/3*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,3,4**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The grading reflects the levels of publication output in quality and quantity; there are some important papers in good journals and the overall productivity is reasonable given the demands on the section, however it could clearly be improved. The societal impact is higher given the main focus on environmental chemistry of pollutants. The strategy of maintaining a focus in the core areas, given the section's skill base and equipment and associated infrastructure is entirely logical. The organisational approaches appear less strategic and more a collection of individuals with broadly similar interests. Clearly the teaching and administration requires a more rigid organisation. The cooperation is patchy with examples of excellent collaboration at international levels, but in other areas as the section notes, the links with the best university groups are missing, and thus the overall score reflects these aspects.

Recommendations

The most important recommendation for this section is that the overall team should be enhanced by a number of postdoctoral research staff. This is the missing ingredient in the team, and if provided it would allow the productivity of the section to increase substantially, and provide more balance between research and teaching, more effective links with high-quality research groups elsewhere, both nationally and internationally, and increase the research income. The question then is how to achieve this result, given that there are several different solutions. The research ideas generated can be funded from national, EU or industry sources, all of which can be utilised to support postdocs and Ph.D. students, some, where possible, in collaboration between NTNU and partner organisations. The most important result for this group is the securing of additional postdocs, so it would seem appropriate to develop specific projects within the broad range of experience of the existing team to achieve this result, using the infrastructure of NTNU and with PIs from the existing staff. It is unclear to the Committee whether the Research Council of Norway and other sources of funding lack the opportunities for these new project ideas, or whether the section has made the applications but that the success rate of research proposals has been to low to secure the additional positions.

6.2.2.4 Chemistry Dissemination Group

The group is of very small size (1 professor, 1 associate professor). There are currently 2 Ph.D. students supervised.

Assessment

The amount of research performed by the group is rather limited due to the heavy servicing load to schools and to the Institute of Teacher Training Education in addition to the normal teaching load in the department. The research addresses areas of rather diverse character like developing electrochemistry experiments on the one hand and the chemical analysis of Coptic art treasures in Ethiopia on the other hand.

The group maintains a good collaboration on the national and international level. The research results are published on a regular basis in the Journal of Chemical Education, edited by the Division of Chemical Education of the American Chemical Society. In addition, the group shows good international visibility due to various collaborations not only in Europe (Belgium and Denmark) but also in Africa (Ethiopia, South Africa). Projects performed are of cross-disciplinary nature.

This group differs significantly from regular research groups as it performs numerous services leading to less research output. Therefore, for the grading of the scientific quality and productivity another standard must be applied. In addition, the bibliometric analysis does not contain separate information about the publication record. The research activity of one member of the group is good whereas other group members need to establish their scientific output, based on the CVs provided.

Encouraging young talented pupils is a task of high relevance and societal impact for Norway. However, the Chemistry Dissemination Group does not cope with this demand as the research focusses on other issues.

The group needs focus and a clear research strategy for the future. Although cross-disciplinary collaborations with other departments like history, education and art exist the strong embedment in the Department of Chemistry seems to take away flexibility in setting research targets and setting up cross-departmental collaboration.

Recommendations

In view of the diversity of the research and the very limited research resources available the group's size appears to be sub-critical. On the other hand, raising the interest of pupils in chemistry is an issue of nation-wide relevance. Currently the group cannot satisfy this demand of national interest for Norway. It could however contribute significantly to overcoming the problem of recruitment of students if the resources would be adapted adequately along with a focus of the research topics. In this regard, the field of chemistry and its didactics may offer huge potential for challenging research. This field covers a variety of research questions starting from "teaching" chemistry in kindergarten and ending with web-based chemical experiments (E-Labs). Moreover, cooperation with social science departments could easily be set up. If the department wants to expand into this area, a strategic appointment of an internationally recognised researcher in the field is strongly recommended.

In order to optimise the limited resources in Norway for research in chemical education the Committee strongly recommends coordinating any future activities in the field with the Department of Chemistry at UiO.

6.2.3 Department of Chemical Engineering

In 1999 the Department of Chemical Engineering obtained its present structure as a result of a reorganisation process in the previous years. The department is organised in six research groups, “Catalysis and Petrochemistry”, “Colloid and Polymers”, “Process Systems Engineering”, “Reactor Technology”, “Separation and Environmental Technology” and “Paper and Fibre Technology”. There are close links with SINTEF, in particular for the catalysis group and the reactor group.

A major new focus of the department research is on CO_2 capture and removal. To strengthen this area the two groups “Reactor Technology” and “Separation and Environmental Technology” are to be merged. In addition, the CO_2 activity is supported by SINTEF and other departments at NTNU. The main ambition is to firmly establish the department as the “National Centre for Research on CO_2 Removal.”

The department is housed in the chemistry buildings K5 (partly renovated in 2007) and K4 (to be renovated in 2009), and partly in the PFI building, and has two large experimental halls. The department has acquired a substantial amount of small to medium-sized instrumentation.

Organisationally, the research groups are split into subgroups. In terms of day-to-day leadership of the department, leader group meetings take place regularly. The department has a head of the department, who represents the department within the faculty and the NTNU. The head is supported by an advisory committee.

The main tool for long-term leadership of the research is seen to be the allocation of positions and choice of research areas for new faculty.

The department has been through a major and successful replacement of its academic staff over the last 10 years. 15 out of 19 of the current full-time staff were hired in that period (8 of the new staff hired were from their *own* M.Sc./Ph.D. graduates).

The staff key data are given below (detailed information on the research group level is given in the respective chapters).

	Total	
Positions	**Univ.**	**Extern**
Professor	15	0
Associate professor	5	1
Professor II	2	8
Postdoctoral research fellow	1	22
Doctoral students	7	71
Technical/administrative positions	5,5	4
	35.5	**105**

Table 10: Numbers taken from the factual information provided by the Department

”Univ.” = persons financed by the university

”Extern” = persons financed by external research grant

Age distribution has been considered as a factor during the hiring process (professors and associate professors) preventing an “age plug” for the next 30 years. The present numbers are given in the following table.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
2	5	2	1	5	2	1	2

Table 11: Age distribution among professors including associate professors in permanent positions

The number of Ph.D. students/postdocs joining the department is about 20 annually. Due to the low number of master’s students in the department, recruiting of new researchers on an international level is increasing. Funding is mainly provided by grants or based on RCN applications or industry, in particular, since four NTNU Ph.D. positions used as teaching assistantships have been eliminated in 2008.

Graduates	2005	2006	2007	Total
Dr. ing./Dr. scient. graduated	13	15	15	43
M.Sc. graduated	23	18	27	68

Table 12: Number of graduates

The Department’s Strategic Plans were based on the 1997 RCN evaluation (Weitkamp report) and changes were made possible through a Strategic Reorganisation Project 2003-2006 financed by the RCN.

Assessment and recommendations

This is a fundamentally strong department, with, overall, an excellent research climate, good funding, high-quality staff, and a positive outlook for future success. Their research groups are of substantial size, a reflection of their overall success and quality. Their research is highly recognised by the international research community. This is reflected by their field citation index of 147 which means that the articles they publish have received almost 50 % more citations than the average articles in the fields the groups are active in.

The department has a pivotal role in chemical engineering research and education in Norway. It has a unique position in the matter of CO_2 sequestration processes and a predominant role in petrochemistry, natural gas upgrading, polymer, and paper technologies. Strong interactions with SINTEF and many other industrial research centres play a very important positive role in the overall picture of the research in the department. Further, it is the primary location for high-level education in many of the fundamental areas of chemical engineering valuable for the Norwegian economy.

From the fundamental point of view, the department's expertise in reactor and process design are nationally and, in certain fields, internationally recognised. From the experimental point of view, the department has taken good advantage of a ten-year effort in equipment renewal, laboratory renovation and improvement of infrastructure, and is benefitting from the impact of those developments on its research quality. The quality of the equipment and, generally speaking, of the technologies developed in the department, along with the expertise of the staff make it such that some of the groups are often asked to participate in European projects.

In general, the department has satisfactory conditions for research at its disposal. There has been a significant improvement of the laboratory infrastructure over the last 10 years.

Overall, the Committee was very favourably impressed by the research in this department, and further believes that the close interactions with SINTEF and other research entities are highly beneficial. The Committee can therefore make no major general recommendations for changes, other than that the Committee is in favour of maintaining current directions and plans. Recommendations concerning specific groups' efforts are outlined in the following sections.

6.2.3.1 Catalysis

This is a large group (4 professors, 1 associate professor and 2 adjunct professors, 24 Ph.D. students, 4 postdocs), largely involved in a Gemini Centre with SINTEF (KinCat Centre). In addition to the university group, the KinCat Centre comprises 9 researchers from SINTEF.
Research activity covers a wide range in catalysis: conversion of natural gas (e.g., Fischer-Tropsch, partial oxidation, after-treatments of methane conversions: CO_2 capture), upgrading of oil fractions (reforming, isomerisation), biofuels (e.g., reforming, gasification, H_2 production), environmental catalysis (sulphur removal).
The group is also concerned with more fundamental approaches in catalysis (surface science, characterisation of porous catalysts, kinetic modelling), with some aspects of catalytic materials synthesis (carbon nanofibres, zeolites, etc.) and with reactor engineering (e.g., membranes).

Assessment and grading
The group has a pivotal role in applied catalysis and chemical engineering in close relationship with industrial problems. Undoubtedly, the group takes advantage of the very good level of equipment in catalytic reactors provided by the presence of the KinCat Centre with SINTEF.
SINTEF projects and NTNU projects are both separate and intimately mixed. KinCat is the leader in Norway as far as applied research on natural gas and biofuels is concerned. It has very good recognition by the international catalysis community. More fundamental aspects in microkinetics, modelling, and surface science are also at a good level even though the strategy is always (or almost always) to apply these studies directly to practical problems.

Cooperation with the Catalysis Group of the University of Oslo is evoked but not detailed. Links seem rather important with the inGAP Centre. It would have been interesting to specify how the research projects (especially those in cooperation with SINTEF on natural gas conversion) are shared between the two groups.

Publication indices are good and even excellent for certain members of the group. The youngest members have a good opportunity to follow in the senior members' footprints.

Scientific Quality and Productivity	5/3*)
Relevance and Societal Impact	5
Strategy, Organisation and Research Cooperation	4,5,4**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The group benefits from a significant number of Ph.D. students and postdoctoral fellows, which leads to an intense scientific production in terms of Ph.D. theses, contract reports and publications in journals. The productivity is very good for the leaders, and should be improved for the youngest members. It would be in the staff members' advantage to vary the journals in which they publish their works.

The research topics are fully in accord with strategic priorities of Norway and in close connection with industry.

The internal organisation is clear, with a very good cooperation with SINTEF through a Gemini Centre. Cooperation with other national and international laboratories could be strengthened so as to offer new opportunities for the group.

Recommendations

The group has very good recognition for its excellent expertise in the chemical engineering aspects of catalysis. Links with SINTEF through the KinCat Centre are very strong and allow the group to benefit from substantial help in personnel, equipment and funding. Undoubtedly, the group takes advantage of this intimacy with SINTEF staff members to develop projects having a high economical impact in the fields of energy, petrochemistry, and environmental catalysis. It seems necessary to see to it that these strong links do not hinder the emergence of exploratory individual projects.

The group is invited to publish its work in multidisciplinary journals when possible. Although their publication indices are already good and even excellent for the group's leaders, young members should make additional efforts to improve their personal data.

Cooperation with other groups working in catalysis should be strengthened. Common projects may be developed in the framework of inGAP or other research structures.

Cooperation with groups specialised in nanomaterials and inorganic chemistry should be strengthened. Although some aspects of catalyst preparation are developed in the group, it could benefit from the expertise of inorganic chemistry and materials groups in Norway. Conversely, the group could help these teams in developing models including chemical engineering steps of the synthesis of new materials.

National and international cooperation in reaction modelling and microkinetics should also be strengthened to reach a very high level.

6.2.3.2 Colloid and Polymers

The Colloid and Polymers Group was heavily restructured and reorganised following the Weitkamp report. The current group consists of one full professor and two associate professors all of whom have been appointed since 2002 through the restructuring process, which has been achieved in part with a Strategic Reorganisation Project from RCN. The group is currently split between two buildings, but will be co-located when the latest round of building refurbishments is complete. The group is now organised into three subgroups, each led by one of the professors: Crude Oil Technology (surfactants, emulsions etc.), Materials Science/Nanotechnology (functionalised colloids, sol-gel etc.) and Polymer Science/Nanotechnology (drug delivery, self-assembly etc.). The group is strongly involved in numerous industrial projects, especially those connected with enhanced oil recovery.

Assessment and grading

The reorganisation has resulted in the creation of a very dynamic and strategically focussed research group. The research topics include areas that directly address traditional issues from the petroleum recovery industry, but also new areas suggested by this industry, and wholly non-oil related activities that build upon the expertise gained in handling complex fluids, polymers and functionalised colloids. The spread of research interests is broad and covers ongoing activities in the field with an applied focus. The group has successfully mixed the applied work with more basic work on developing techniques for creating new functional materials, and this has resulted in an engagement with the up-to-date aspects of the field and its new techniques. The success of the industrial work is attested by the good level of industrial support and collaboration. The more basic work has resulted in a substantial number of publications, including a significant amount in leading journals, and these are distributed across the subgroups. The subgroups are involved in extensive collaborations both within Norway (UiO) and internationally.

Scientific Quality and Productivity	4/4*)
Relevance and Societal Impact	5
Strategy, Organisation and Research Cooperation	5,4,4**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

Research activity is uniformly very good across the subgroups, with a good number of publications, appearances at conferences and collaborations. The group is very well configured to perform basic work in support of key Norwegian industries and the success of these associations is confirmed by the high level of joint projects with industry and institutes. The strategy following the recent reorganisation is well-thought out and is producing a good mix of applied and basic work. The group has good infrastructure, which will be further improved by consolidation into a single building.

Recommendations

This group has only just been formed and appears to be on an excellent track with good potential for growth in the funding environment at NTNU; thus, “leave alone” seems appropriate advice. The group could clearly benefit from increased technical support and the provision of more places for graduate students. The group would also benefit from the emergence of a good simulation group elsewhere in NTNU, which would enable better contact with the rich developments in the theory of complex fluids that are developing on the world stage and an even broader focus. Equally, strength in structural studies of complex fluids or optical manipulation would be beneficial. A continued and closer link with the Paper and Fibre Technology Group is recommended. It would be a pity if this connection were diminished by the reorganisation, especially given the new technologies emerging from bio-processing of lignin where the expertise of this group would be welcome.

6.2.3.3 Process Systems Engineering

This is a relatively large research group (2 professors, 2 associate professors) active mainly in the field of process modelling, operation, control and optimisation. Currently there are two postdocs and 14 Ph.D. students in the group.

The majority of the projects deal with advanced control systems. The concept of “self-optimising control” links economic optimisation and control. Design aspects become important in those projects which deal with controllability (design for control). The group operates experimental equipment starting from laboratory size up to medium-size pilot plants (e.g., for integrated distillation system in Kaibel or Petlyuk design or for anti-slug control).

The modelling activities focus on the development of the object-oriented simulation tool MODELLER which applies a multi-scale modelling approach. The key idea is to free process engineers from coding equations into standard dynamic simulation tools. Based on a selection of concepts and mechanisms the tool automatically assembles the necessary equations.

As models need information on the physical behaviour of the components in the system normally equations predicting activity or fugacity coefficients are normally implemented in a simulation tool. The Process Systems Engineering Group follows a different strategy. In order to improve the computational performance of the model methods have been developed based on structured equation sets allowing, e.g., automatic generation of gradients.

Very recently the group entered the area of systems biology by hiring a new faculty member. The key idea is to apply modelling approaches to protein synthesis and regulation. The activity is part of a larger effort at the faculty which involves another 2 faculty members by the year 2009, one in the Department of Biology and one in the Department of Biotechnology.

Assessment and grading

The international visibility of the Process Systems Engineering Group can be regarded as excellent. International cooperation is very strong enabling the group to take over a leading position in European projects (like PROMATCH). Cooperation between the members of the group is fair, as demonstrated by some joint projects. Entering the new area of systems biology offers the opportunity to improve internal cooperation. Extensive cooperation with SINTEF and companies like StatoilHydro and Gassco obviously enables the group to operate very good state-of-the-art laboratory and pilot plant equipment.

The overall publication indices of the group are excellent. However, the performance of the individual group members differs significantly, as witnessed by, e.g., the number of Ph.D. students supervised. One member of the group supervises 11 out of 14 students.

Scientific Quality and Productivity	5/3[*)]
Relevance and Societal Impact	5
Strategy, Organisation and Research Cooperation	5,5,4[**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

Individual activity of the group members differs significantly leading to an inhomogeneous publication output. One member of the group covers 90 % of all publications demonstrating an excellent publication record. Other members of the team could improve.

The Department of Chemical Engineering is the only one in Norway where chemical engineers are educated. As Norway needs to build and operate manufacturing processes the department takes over a national responsibility in training engineers who are prepared to take over these jobs. Process simulation and control is an indispensible element in the training of chemical engineers.

International and national cooperation is very good and even excellent for certain members of the group.

Recommendations

Currently the core competence of the Process Systems Engineering Group is modelling and the application of models to control and optimisation problems. The group focusses on research questions dealing with process analysis and optimisation rather than with process synthesis. It seems that the department's strong history in conceptual design received a lower priority in the recent past. Reactivating the strong activity centred on process systems engineering PROST as envisaged by the group could provide a chance to reinvest in this research area. Any future strategic appointments of new professors should then target at getting the best scientists in this field.

Entering the new area of systems biology should be regarded as a first step towards transferring research results from chemical industry into the field of biotechnology. Modelling and simulation of biotransformation processes including the downstream section would offer a variety of new research topics for the group, of which modelling and simulation of solids handling processes is most challenging.

6.2.3.4 Reactor Technology

The rather large group (3 professors, 22 Ph.D. students) has a long successful history in single- and especially multi-phase reactor modelling. The group covers the full range of scientific areas needed to model chemical reactors and to validate the models against experiments.

One basis for reactor modelling is a reliable description of the physical and chemical behaviour of the molecules in the system. One other basis is the reasonably correct description of the hydrodynamics of a multi-phase reactor system. Here, the group recently introduced population balance frameworks which describe the dynamic size changes inside the heterogeneous systems. These population balance equations are coupled with models for bubble or droplet breakage and coalescence.

The models developed are used for various applications of technical relevance like steam reforming or Fischer-Tropsch reactors, droplet removal from high pressure gas streams and CO_2 capture processes. The latter is at present the largest activity in the group (in cooperation with SINTEF) and has attracted considerable EU funds.

The group has a large amount of technical equipment even up to pilot scale available enabling to validate the models and assess them against experiments on different scales.

To include reliable physical property prediction methods in the reactor models the group cooperates with the Process Systems Engineering Group in the field of thermodynamics.

Assessment and grading

The group is highly visible inside the international scientific reactor engineering community. This leading position enabled the researchers to take over leading positions in various EU-funded FP6 and FP7 projects.

Recently, the decision was taken to merge the Reactor Technology Group with the Separation and Environmental Technology Group to implement a structure which demonstrates the already exiting close collaboration between the two groups.

Cooperation with industrial companies must be regarded as excellent on the national as well as on the international level. To supervise such a large number of Ph.D. students in view of the experimental facilities needed is only possible due to the strong link of the group to SINTEF and its extensive support.

Scientific output is good and even very good for certain members of the group.

Scientific Quality and Productivity	4/3*)
Relevance and Societal Impact	5
Strategy, Organisation and Research Cooperation	5,5,5**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The group overall shows a good scientific productivity with some members performing very well. Due to the strong interaction with SINTEF it seems to be difficult to maintain a good balance between applied and fundamental research.

Holistic modelling of chemical reactors is a key task necessary for process development. The group at NTNU is the only one in Norway using this tool up to the technical reactor level. The chemical reactions in focus are highly relevant for Norwegian economy.

Cooperation and merger with the Separation and Environmental Technology Group demonstrates a strategic vision of the group. In the department's CO_2 activities the group will play an important role.

Recommendations

The strategy of the group to focus on reactor modelling and the validation of the models against experiments on industrial processes relevant for Norwegian's economy is clearly formulated and thoroughly implemented. The need of especially technical support provided by SINTEF is obvious. This strong interaction with SINTEF however might limit the scientific output of the group to some extent. This issue should be considered when setting up future projects.

6.2.3.5 Separation and Environmental Technology

This relatively large group (1 professor, 1 associate professor, 2 adjunct professors, 2 scientists, 5 postdocs) performs research in the areas membrane separation and crystallisation. Currently 9 Ph.D. students are supervised.

In the field of membrane separations, the Memfo group focusses on the material development, modelling, and simulation of gas separation processes. Applications are CO_2 capture from flue gas, natural gas sweetening and biogas upgrading and the recovery of H_2 from various mixed gas streams. In addition, membranes for chlorine separation are developed. Most of the projects are performed in close cooperation with industrial partners. Therefore, all research efforts account for the future application of the membranes in production processes.

The crystallisation subgroup was established in 2003 by employing an associate professor. Currently two different projects are running. One deals with the precipitation of calcium carbonate in glycol loops. The other one is performed in cooperation with the Norwegian institute Tel-Tek (Department of Powder Science and Technology, POSTEC) and focusses on the effect of crystal properties on the downstream filtration step.

Assessment and grading

The Memfo subgroup shows a very good scientific output with several patents and a reasonable number of international publications leading to a high visibility of the group. The scientific quality of the research enables them to play a major role in a large number of European projects.

Having finished the start-up procedure, the recent publication record of the crystallisation group appears to follow this model.

Internal as well as national and international cooperation of the Memfo subgroup can be regarded as excellent. The recently established crystallisation group could very much benefit from the cooperation experience accumulated in the Memfo group.

Scientific Quality and Productivity	4/3*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,3,3**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The scientific performance of the group is good on average and even very good for some members of the group. However, the high industrial relevance of the research seems to somewhat limit the publication of the results.

The processes in focus are of high relevance for the Norwegian industry. Gas separations based on membrane processes offer huge energy savings compared to other technologies like absorption or adsorption.

The Separation and Environmental Technology Group appears to work in two separated subgroups with rather limited internal cooperation. Whereas the strategic focus on membrane development for gas separations of the Memfo subgroup is clear the crystallisation subgroup needs some improvement in research focus.

Recommendations

The internal cooperation of the Memfo subgroup is well developed in the department. There is a clear strategy visible focussing on material development and modelling for membrane-assisted gas separations. The subgroup will certainly strengthen due to the future merger with the Reactor Technology Group and the joint CO_2 activities on the department level. In the department an internal cooperation with the Catalysis Group in the field of carbon nanotubes could accelerate research in the field of material development.

The crystallisation subgroup would also benefit from more intense internal cooperation. The field of membrane-assisted crystallisation processes might be an area for future collaborative research. After having finalised the infrastructure for the new group there is a clear need for a research strategy as well as for the definition of the future position in the upcoming large group Environmental, Reactor and Separation Technology. The role of the subgroup in the department concentrating on CO_2 activities will be difficult to identify. Focussing on the separation effect of crystallisation processes (e.g., in biochemical processes) rather than on manipulating solids' properties might provide an angle to define a research focus different from POSTEC.

6.2.3.6 Paper and Fibre Technology

This is a very small group (1 professor, 1 associate professor) having a unique position in Norway. Research projects cover all the main topics in paper and pulp technology: industrial processes of paper fabrication, paper bleaching, paper quality, and inks. New projects are being developed, for example, with the Catalysis Group for the production of bio-oils and, more generally, biofuels. These new projects deal with wood, lignin or ligno-cellulose delignification and the chemistry of carbohydrates.

In spite of the low number of staff, there are a significant number of Ph.D. students (6) and one postdoc. The group benefits strongly from a close cooperation with the Paper and Fibre Research Institute (PFI), which is located in the same building.

Assessment and grading

This is a rather broad spectrum of activity for such a small group even though the staff members appear as very dynamic. It seems extremely important and vital for the group to develop good cooperation with other research groups. This is already the case with the NTNU Catalysis Group in bio-energy projects. Ligno-cellulose and carbohydrate chemistry may obviously lead to cooperation with research teams in organic chemistry.

Publication indices are only fair. This is essentially due to the very nature of the topics, studies on paper and pulp technology being published in specific journals with a limited impact.

Scientific Quality and Productivity	2/2[*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,3,4[**)]

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The scientific quality is good in terms of Ph.D. training but the publication policy should be revised. Even if the group is concerned primarily with applied research, there should be many more opportunities to publish work in good journals than are now taken.

This group has a pivotal role in research in the field of paper and pulp industry: it is the only group in Norway working in this field, with exception of certain projects related to wood chemistry and biofuels that are also pursued by other groups.

The group is extremely fragile (2 staff members). Nevertheless, it consists of a young staff with a good long-term strategy. The collaborations established engaged in the field of bio-energy are a good index of this strategy.

Recommendations

The group is encouraged to increase its level of publication. Although the group works in a highly specialised research field, efforts should be made to publish some of its studies in multidisciplinary journals.

The Committee is conscious of the fact that the group has to maintain a substantial expertise in terms of teaching. However, the group is too small to maintain the teaching of a high number of classes linked to the traditional paper industry.

Due to the small size of the group, good projects should be developed through cooperation with other groups. The staff members should take advantage of their very good knowledge in ligno-cellulose and lignin chemistry to develop new cooperative projects in bio-energy. The willingness of the group to go further in that direction is strongly encouraged.

6.3 UNIVERSITY OF BERGEN

6.3.1 Department of Chemistry

The Department of Chemistry is one of eight departments organised under the Faculty of Mathematics and Natural Sciences at the University of Bergen (Fig. 2). At the Faculty of Mathematics and Natural Sciences a reorganisation took place during the years 2002-2004. The Department of Chemistry is organised in the three research sections “Organic, Biophysical, and Medicinal Chemistry”, “Inorganic Chemistry, Nanostructures and Modeling”, and “Physical-, Petroleum- and Process Chemistry”. In particular, the department interacts with the Centre of Pharmacy and the Centre for Integrated Petroleum Research (CIPR) at the University of Bergen. The Centre of Pharmacy was established through a cooperation between the Faculty of Medicine and the Faculty of Mathematics and Natural Sciences with the Department of Chemistry as a key partner.

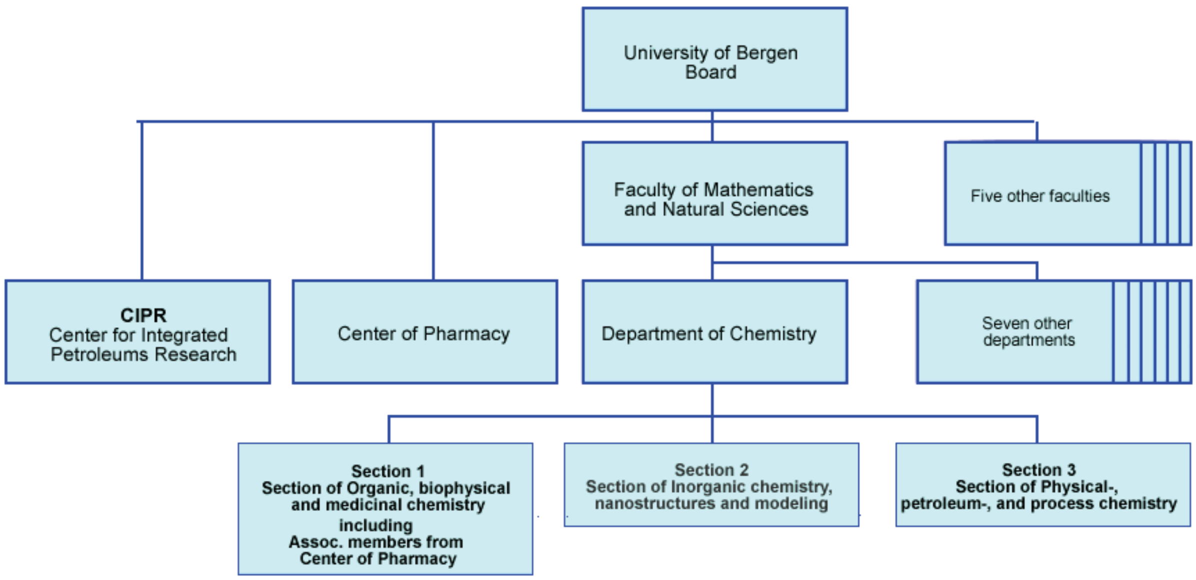

Fig. 2: Departmental structure

According to the previous recommendations from the national evaluation, the department has strengthened research in organic and inorganic chemistry, in particular in organic synthesis and catalysis. In general, the department’s research focus is building on previous experience in promising areas such as nanosciences, including heterogeneous catalysis and modelling, organic synthesis, chemistry of natural compounds, surface and colloid chemistry, chemometrics, and biophysical chemistry. Furthermore, the department is a key partner in two research programmes of importance for the University of Bergen, the petroleum programme, centred on CIPR, and the nanoscience programme.

The Department of Chemistry has a wide range of scientific equipment installed, e.g., important techniques such as NMR, MS, IR, Raman and X-ray, and many of the major instrument laboratories have been newly installed or upgraded during the last few years. Furthermore, the department is involved in the university's planning of a new technology building "Teknologibygget" at the campus of the University of Bergen. The building is expected to house various kinds of large-size equipment for a series of institutes.

As a result of the previous RCN evaluation and the implementation of the Quality Reform in higher education, the department has changed its organisational structure. Thus, the appointed head of the department is given full responsibility for the personnel and financial matters of the department, including salaries, and may function as head in a non-permanent position for up to three four-year periods. The head selects his/her deputy. The previous board of the department was replaced by an advisory council of elected staff members. The sections are headed by sections leaders, with whom the head of the department collaborates.

Since the last evaluation in 1997 the permanent staff members employed at the department have been reduced from 25 to 18 in 2008, which has apparently led to a critical situation both in achieving above-the-critical-mass research groups and staff members available for teaching. The staff situation per 15th of April 2008 is given in Table 13.

	Total	
Positions	**Univ.**	**Extern**
Professor	18[1)]	1[2)]
Associate professor	7[3)]	-
Professor II	-	1
Postdoctoral research fellow	-	6
Researcher	1	3
Doctoral students	14	15
Technical/administrative positions	3.8[4)]	-
	43.8	**26**

Table 13: Numbers taken from the factual information provided by the Department

"Univ." = persons financed by the university

"Extern" = persons financed by external research grants

[1)] Professors include also 3 professor emeriti

[2)] Employed at Centre for Integrated Petroleum Research, but closely associated with the Department of Chemistry

[3)] Two associated professors are employed at the Centre of Pharmacy, but closely associated with the Department of Chemistry

[4)] The numbers are the numbers of man-labour years of technical activity, directly supporting research. No administrative positions are directly supporting research.

Due to the age of academic staff and retirements, a major challenge will be to keep all the groups above a critical mass in terms of personnel, including plans for better use of technical staff in the various research groups. An age distribution is given in the following table.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
0	0	1	3	3	3	2	4

Table 14: Age distribution among professors in permanent positions

In general, the recruiting situation reflects the Norwegian picture. During recent years, the annual recruitment of doctoral students has been in the range of 5-13. In order to counteract the lack of local candidates, the available positions have been announced internationally, leading to 55 % non-Norwegians admitted to the Ph.D. programme.

Graduates	**2005**	**2006**	**2007**	**Total**
Dr. ing./Dr. scient. graduated	4	12	9	25
M.Sc. graduated	4	14	14	32

Table 15: Number of graduates

The department’s strategic plan for the years 1997-2007 matched to large extent the recommendations from the previous national evaluation. A new strategy was to be worked out in 2008.

Assessment and recommendations

The Department of Chemistry at the University of Bergen has responded very positively to the calls to reorganise into strategic groups. The Committee observed a surprisingly high level of morale, considering the recent reductions of staff numbers and limited resources directed towards chemistry, and a clear sense of direction within the research groups. As detailed above, the department is now quite small and there are additional imminent retirements, so further resignations of key staff would pose a major threat. The number of Ph.D.s and postdocs is also low, and it does not seem likely that these numbers could be increased sharply, though indications are that numbers are beginning to climb.

We observed good instrumentation for research, especially in X-ray, mass spectrometry and NMR, and there were realistic plans for further bids for improved instrumentation. This was one department that seemed to have thought through the benefits of charging for the use of instrumentation. Where resources had been made available, they had been well used. Laboratory space seemed good, though the basic equipment level of some of this space was old. Technical support for instrumentation seemed to have sunk to a low level, as a consequence of budgetary constraints, with the department’s technicians largely involved in the teaching laboratory. Due to the reduction in size, a great deal of staff time is being taken up by teaching. However, it was recognised that supporting the master’s programme was a key to regaining the strength of the department by increasing the number of young research workers. The faculty described the difficulties they have accessing scientific databases (e.g., SciFinder). This is considerable disadvantage, and should be solved at the university/faculty level as a basic provision necessary for the functioning of any successful department in science at a university.

Unlike NTNU and Oslo, the University of Bergen does not have the advantage of proximity to research institutes. The university (with support from RCN) has created Centres in Pharmacy and in Integrated Petroleum Research at a high level in the organisational structure. The Department of Chemistry has responded well to the opportunities created by these initiatives, and the research strategies of two of the groups reflected these opportunities well. Consequently, the research infrastructure and opportunities for collaboration in targeted research programmes have increased considerably. A knock-on consequence in a small department is that the research activities have become strongly polarised, since pharmacy and petroleum research reflect activities on the extremes of chemistry. There is a threat to the sense of cohesion across the department (there did not appear to be a seminar programme or teaching programme for Ph.D.s or a common meeting area) and the teaching activity in the mainstream undergraduate course could suffer.

The department does not seem to have an input into the planning of the two Centres themselves, as they are coordinated at a higher level in the university’s structure. This must be a potential weakness as a good deal of the department’s own planning is predicated on relations with these Centres. For example, the relocation of all members of the Centre of Pharmacy away from chemistry would be a major blow to cohesion. The department does not seem to have a way of influencing such decisions.

Although this department must be regarded as being in jeopardy, due to its small staff, limited budget, and the threat of further reduction, it has evolved a good structure which would be a sound base for reinvestment to return to a viable size. The number of graduate students is small. The department is targeting this issue by increasing the strength of its master's programme and also by engagement with national programmes for strengthening graduate training. Rebuilding a broad-based chemistry programme by appropriate appointments and by revitalising the undergraduate and postgraduate provision is clearly necessary to sustain an internationally recognisable chemistry programme at Bergen. This will require a significant investment.

*6.3.1.1 **Section of Organic, Biophysical and Medicinal Chemistry***

In the Section of Organic, Biophysical and Medicinal Chemistry within the Department of Chemistry two professors have retired since 15^{th} of April 2008 and currently the faculty members comprise 9 professors, of which 6 are full professors and 3 are associate professors, one having been appointed in August 2008. In addition, there is one adjunct professor and three staff members of the Centre of Pharmacy - all associate professors - who are associated with this section. Two of these latter professors are fully integrated in the section's research programme. One of the professors of Organic, Biophysical and Medicinal Chemistry is active in science education.

Research is dedicated to synthetic organic chemistry, method development and work on molecules of medicinal interest. There is a natural product chemistry subgroup and three professors, emphasising NMR spectroscopy. A start-up company has emerged from this section.

Assessment and grading

This section has a good size and an attractive research profile. Research topics cover classical organic synthesis projects and method development together with more interdisciplinary areas such as natural product isolation and characterisation, medicinal chemistry and environmental chemistry. NMR research has a strong visibility within this section, although the publication record of this subgroup is not completely convincing. Spectroscopy in Bergen has the potential to expand, however, given that there are adequate premises for a high-end NMR machine, together with enough suitably qualified technical staff.

Association with at least two professors affiliated with the Centre of Pharmacy is critical to this section, both in terms of size and research projects. The company Fluens Synthesis AS runs its labs within this section. This is beneficial because these activities on continuous flow organic synthesis may attract students and strengthen the interaction between organic chemistry and industry, which is weak throughout Norway.

There are not enough graduate students to fully exploit the potential of the section's research. Initiatives to attract more students have been started.

The premises for this section are appropriate, as is the instrumentation, which is quite impressive in part. Once student numbers go up again, the section will need more space.

Scientific Quality and Productivity	4/3*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	2,3,4**)

*) first number leading scientist(s)/second number the average of the section

**) separate numbers for strategy, organisation, research cooperation

The leading groups in this section have a very good publication output, with an above-average number of level 2 publications. The publication record of the majority of the section is less convincing, with less visible contributions in level 1 journals. Overall, this rather large section should publish more. There has been the successful setup of a company, Fluens Synthesis AS, which raises the societal impact and relevance of the section. Unfortunately there is no current strategic plan and consequently the section's overall organisation is not optimal and needs improvement. International contacts and collaborations are working and very good at this section.

Recommendations

The Section of Organic, Biophysical and Medicinal Chemistry has a good size and promising research profile. To further develop the research profile and output it seems necessary to find a way of integrating the work of the associated colleagues at the Centre of Pharmacy into the section's structure. The Committee encourages the faculty to start a parallel synthesis laboratory, as planned by the Department of Chemistry, as it supports and strengthens several particularly successful activities within this section. It is critical, however, to agree on a collaborative plan for how to fully utilise such a laboratory, including other universities and companies. Organic chemistry research, where it is beneficial for environmental topics, especially those of relevance for Norway, should be included in this strategic plan. The NMR subgroup has the potential to expand its activities, however, it needs more space and technical staff. Again, for this subgroup it will be critical to set up regulations to govern the balance of self-user, service, and collaborative offers and projects, together with a valid concept for charging for analytical services. The Committee recommends that this section should set up a strategic plan, to evaluate the above-mentioned activities. The plan should address the following aspects: (i) Strengthening organic synthesis by focussing on biological-medicinal and environmental chemistry; (ii) Supporting existing collaborative efforts and identifying new ones, both internally, nationally and internationally; (iii) Identifying room and staff for new instrumentation and investments and planning its organisation and financing; and (iv) Evaluating how these initiatives can help to attract more graduate students and funding.

6.3.1.2 Section of Inorganic Chemistry, Nanostructures and Modelling

As reported, this is a section of reasonable size (5 professors, 1 associate professor, 1 emeritus professor). However, the section is moving into a new structure. Two members retired in 2008 while another one has left the section after having been appointed to a position in Germany (1 Oct 2008); he will be associated with the section as adjunct professor. Research projects cover three fields: (i) structural studies (crystallography) and spectroscopy of molecules and ions in solution or in adsorbed phase (XPS, collaboration with Lund and with California for access to specific equipment); (ii) computational chemistry and molecular modelling; (iii) inorganic synthesis and catalysis. The section's activities appear to be well-thought out and strategically selected with a view to what is possible within a relatively small chemistry department. The areas of activity have significant overlap and benefit from interactions with research activity in other departments in Bergen. The number of postdoctoral fellows (4) and of Ph.D. students (11) is low by international standards.

Assessment and grading

The well-thought out strategy presented in the self-evaluation was supported by our observations of a strong sense of coherence and shared purpose within the section, evident both at the presentation and the site visit. The Committee was impressed by the level of interaction and mutual understanding among the different section members, together with the evidence of joint projects. This section does not have the advantage of the other chemistry sections of proximity to the research centres (Pharmacy and CIPR) which bolster their overall level of activity. On the other hand, this does enable them to develop a more independent research strategy.

This coherent structure is threatened by two recent retirements and by the departure of another professor to a post elsewhere (whilst retaining a 20 % position in Bergen). The latter is a specialist in surface organometallic and nanostructured materials chemistry, with applications in catalysis. The reputation and equipment base for this latter area are now particularly strong, with a full range of characterisation techniques within the laboratory.

The computational chemistry is strong and has an impressively wide range of activities, from biological systems to materials. It seems to be very well integrated with the other (experimental) research activities within Bergen, both inside and outside chemistry, and thereby able to engage in a number of interesting projects. The computational chemistry effort makes very good use of the national facilities for high-performance computing. There is good coordination with other theory/computation groups in Norway and an application for a National Graduate School in Quantum Chemistry was coordinated by Bergen to address the difficulty of providing adequate training in this area.

Structural chemistry has an excellent equipment base, much of which has been developed locally. In particular, the Committee saw unique capabilities for studying low-temperature phase transitions.

The lack of technical support for equipment is likely to be a particular problem for this section as they must continue to use the equipment base effectively in a time when academic staff is changing.

Scientific Quality and Productivity	4/4*)
Relevance and Societal Impact	3
Strategy, Organisation and Research Cooperation	4,4,4**)

*) first number leading scientist(s)/second number the average of the section

**) separate numbers for strategy, organisation, research cooperation

The remaining section members (after the retirements of 2008) have uniformly good publication indices, with a good level of activity and publication in quality journals. Interestingly, these indices are relatively homogeneous among the different members, attesting to the good morale within the section.

The members of the section are largely engaged in curiosity-driven research and their activities are well reflected by the normal publication indices. There are no special Norwegian factors.

There are many interesting aspects in the research strategy and organisation of the section, which should be encouraged. They presented an interesting triangular structure with individual disciplines, like structural chemistry and crystallography at the apices, and the links between them populated by section members engaged in collaborative activity. Analysis of this structure had led to clear priorities for future requirements and to an understanding of how the difficulties posed by retirements should be addressed. This strategy encouraged the belief that new appointments would be strategically planned and brought into a supportive environment. The equipment stock and laboratory infrastructure is very good, though there is a weakness in the provision of maintenance and technical support for equipment. This infrastructure could support a larger number of master's and graduate students, which would benefit the activity levels. Overall, the section is making a well-thought out, spirited and successful effort to deal with the problems of working in a small chemistry department in Norway. The section members participate in numerous collaborations both internally and externally.

Although strategy, organisation and cooperation are all given appropriately good scores, these somewhat overestimate the actual strength due to the rapid decrease in the number of staff without firm commitments to replacement.

Recommendations

This is a successful section, which is threatened by reduction in size due to recent retirements; apart from a loss of particular research strengths, this increases the teaching burden on other members of staff and reduces the amount of time available for research. New appointments are urgently required to maintain the section's profile and a balanced portfolio of activities. The development of a new team specialised in organometallic chemistry and catalysis is a particular priority, as this has been a pivotal activity in generating collaboration within the section. Since this has become an area of internationally recognised strength, it is important that the section should be enabled to make a new appointment soon. The expertise and infrastructure relevant to this area of activity should not be lost. To maintain strength in the longer term, further appointments will be necessary, especially as a further retirement is not too far away.

In common with other groups, a shortage of graduate students is a major impediment and the measures that have been planned to encourage graduate recruitment should be encouraged.

6.3.1.3 Section of Physical-, Petroleum- and Process Chemistry

This is a section of 4 professors and 2 associate professors. In addition there is one professor employed at CIPR associated with this section. Research topics are strongly related to the concerns of the petroleum industry and cover several fields in petroleum and physical chemistry: enhanced oil recovery by surfactants, gas hydrates and biofuels, processes in oil refinery, chemometrics and process optimisation. The group is in close interaction with the Centre for Integrated Petroleum Research (CIPR), which contributes strongly to the available infrastructure and sense of purpose within the section. The number of postdoctoral fellows (2) and Ph.D. students (9) is quite good, but the available infrastructure, laboratory space etc. could support a larger number of graduate workers.

Assessment and grading

The section is fully involved in research projects funded by CIPR, in which enhanced oil recovery dominates all the other activities. Some of the experimental facilities are highly distinctive, including the rigs for examining the interactions of oil-recovery chemicals with rocks and for measuring sound speeds in suspensions. These support unique capabilities with major significance for the petroleum industry. The group has a very good expertise in chemistry and thermodynamics in solutions and at micelles and interfaces. The formation of gas hydrates in pipes for oil recovery is also a problem of the greatest interest.

Owing to a large number of analytical tools (NMR, IR, Raman, GC-MS, LC-MS), the section has developed an excellent expertise in chemometrics with a very good reputation throughout the world.

Although the individual activities within this section are at a high level, they are largely aimed at particular concerns of Norwegian industry. The types of research that would currently be expected under the label “physical chemistry” in universities across the world are not found. This can be seen as a strategic response to the situation of a small department in Norway. However, being exposed only to this narrow range of topics must have consequences for the nature of the graduate experience, amongst other things.

Scientific Quality and Productivity	4/2[*)]
Relevance and Societal Impact	5
Strategy, Organisation and Research Cooperation	3,3,4[**)]

[*)] first number leading scientist(s)/second number the average of the section

[**)] separate numbers for strategy, organisation, research cooperation

For the most part, the members of the section have only moderate publication indices, with a high proportion of these appearing in highly specialised journals. Research programmes in basic topics and journal publication did not appear to be a priority within this section. Research topics are largely linked to problems in petroleum chemistry and oil recovery and within certain areas of specialisation there is significant international collaboration. The section is in close contact with industry and has a high societal impact. The creation of the CIPR has created an excellent opportunity for strengthening the petroleum-related research and the group has restructured around this opportunity. However, the problems (e.g., for the Ph.D. programme, and the teaching of basic chemistry) that arise from having such an industrially-oriented activity at the centre of the section should be addressed. There did not appear to be a strategy to improve these situations.

Recommendations

The section has three activities in which it is strong, though these are not core chemistry activities. There is therefore a danger of becoming separated from the rest of chemistry within Bergen and from mainstream chemistry worldwide. In some sense, the more successful these activities are, the more this concern will be exacerbated. Whilst recognising the difficulties caused by the small size, it seems important to develop strategies to avoid fragmentation and the loss of a viable identity as a chemistry department. In a similar vein, it should be questioned whether a sufficiently general training for Ph.D. students can be provided within this section.

It seems mandatory to maintain a good expertise in chemometrics in the section. The University of Bergen should remain the leader in this discipline and maintain its excellent international recognition. Chemometrics has been an area of strength for Norway, with activity in several universities, but with the effort at Bergen particularly prominent – though threatened by a recent retirement. It remains a subject of considerable interest for industrially-related research activity. As such, it is a field in which research can become overly focussed on particular local concerns, and lose its basic and internationally recognisable dimension. It is suggested that the activity in chemometrics be reviewed at a national level with a view to identifying new research priorities and targeting future activities.

Given the reduced size of the academic staff (and the extra amount of time individual staff members spend on teaching etc.), and the large amount of experimental infrastructure, increasing the amount of technical support for research should be cost effective.

It seems clear that a close cooperation with the group of inorganic chemistry in chemometrics would be helpful to maintain a high level in this field at the University of Bergen.

The long-term strategy of the section for other activities should be clarified, there appear to be areas of potential overlap with the inorganic chemistry group, for example, which are being overlooked.

6.4 UNIVERSITY OF TROMSØ

6.4.1 Department of Chemistry

The Department of Chemistry at the Faculty of Science is organised as 4 research groups: “Theoretical Chemistry”, “Structural Chemistry”, “Organic Chemistry”, and “Inorganic and Materials Chemistry”. The department is the host of national platforms/centres: the CoE “Centre for Theoretical and Computational Chemistry” (CTCC) and the “Norwegian Structural Biology Centre” (NorStruct), and is a partner in a large national platform of the RCN’s Functional Genomics initiative, and “MabCent – Centre for Marine Bioprospecting”, a Centre for Research-based Innovation. Valuable collaboration exists with faculty members in biomedicine, marine research and biology.

The research profile of the department is chemical biology-oriented. The expertise of the department spans a wide range including synthetic methods, chemometrics, theoretical and computational chemistry, structural chemistry and biology, protein chemistry, biomolecular modelling, and transition metal chemistry. These will also be the key areas of competence in the future for pursuing more applied projects in the fields of materials science, medicinal chemistry, drug discovery and design, development of industrially applicable enzymes, and marine biotechnology. The department has considered the initiation of a programme of research on functional materials and nanoscience in collaboration with the Department of Physics.

The department is housed in the Science Building, which is the oldest building at the university campus. The premises of the Department of Chemistry do not meet modern standards and also do not provide sufficient laboratory and office space for the current activities, in particular since the establishment of the CTCC. The Department of Chemistry has replaced many of the larger pieces of equipment in recent years, and has initiated a process of organising central research facilities and techniques into service units, e.g., for NMR, MS, X-ray, etc. The department has access to the national and regional supercomputing facilities (“Stallo”), the technology platform in proteomics, and the European Synchrotron Radiation Facilities.

Due to the new structure for the scientific and administrative leadership at the University of Tromsø the department leadership is in the form of a head, who is engaged for four-year terms of office and has been given extensive executive power. The department board focusses on core activities such as long term strategies, annual budgets and the hiring of staff members. Since the research group structure of the department is mainly an administrative construction, there is no leadership at this level. Time-limited larger initiatives, such as CTCC and NorStruct, have their own decision-making and steering structures.

An overview on the organisation is given in Fig.3.

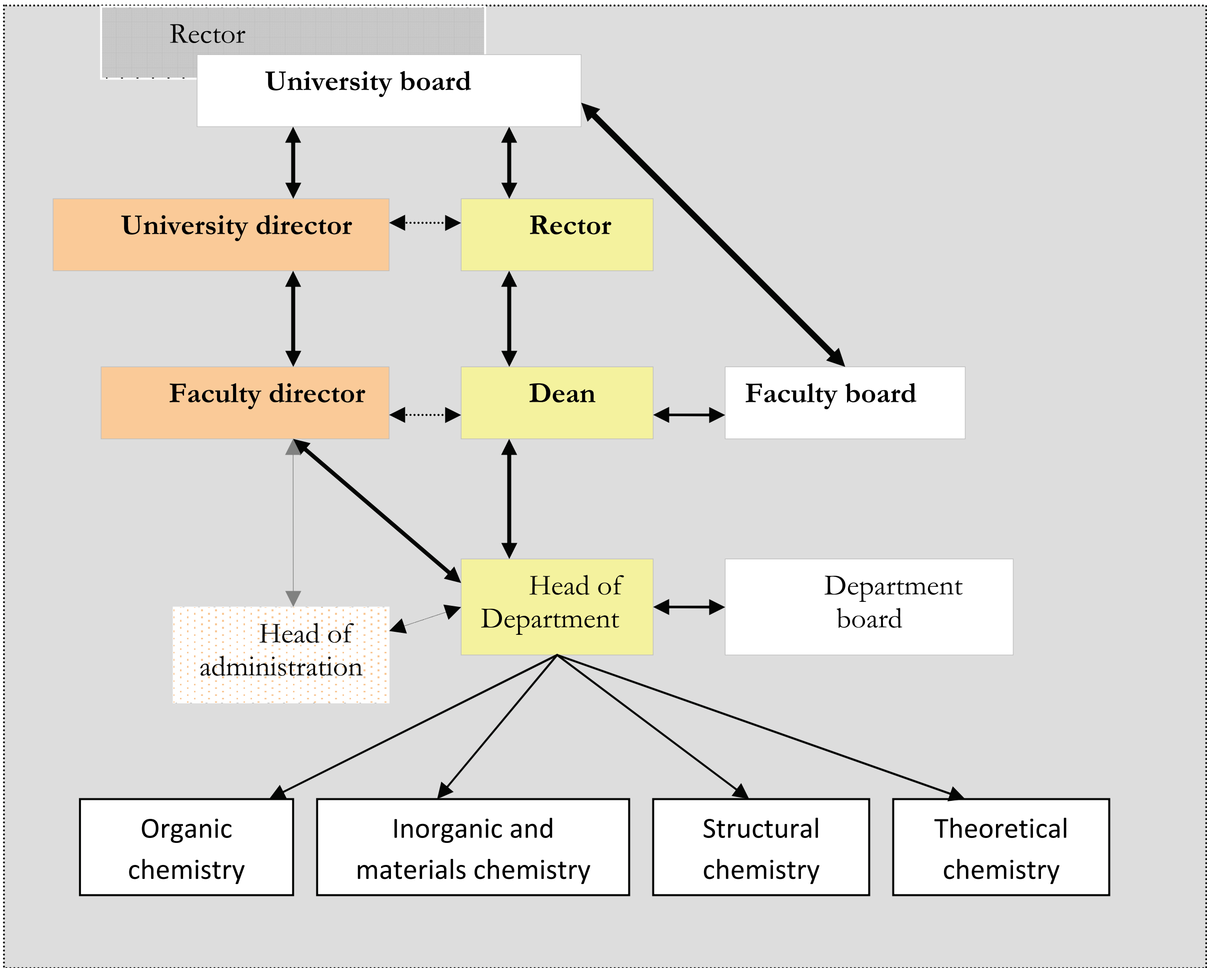

Fig. 3: Organisation chart

The Department of Chemistry has become increasingly international in recent years. Six of the 12 faculty members are non-Norwegian, and postdoctoral and doctoral fellows have been largely recruited internationally. The staff situation is given in the following table:

	Total	
Positions	**Univ.**	**Extern**
Professor	7[1)]	0
Associate professor	5	0
Professor II	0.2	0.4
Postdoctoral research fellow	3	12
Doctoral students	9	9
Technical/administrative positions	7[2)]	5
	31.2	**26.4**

Table 16: Numbers taken from the factual information provided by the Department

”Univ.” = persons financed by the university

”Extern” = persons financed by external research grants

1) Salary for one person covered by CTCC

2) 30 % of the administrative position is supporting research

Among the faculty members, only one is female, whereas there are two women at the postdoctoral level. The technical staff consists of 7 technicians, who divide their time between services to research activities and teaching laboratories.

The age distribution of professors in permanent positions is given in Table 17.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
0	1	1	3	0	0	2	-

Table 17: Age distribution among professors in permanent positions

The department reports that recruitment of qualified postdoctoral researchers is relatively easy. However, they report that, on the Ph.D. level, evaluation of the qualifications of applicants coming from abroad is difficult, and they would prefer a better balance between Norwegian and foreign students in their programme. They have therefore concluded that the number of potential Ph.D. candidates educated internally has to be increased to address this issue, and spend significant resources on outreach activities to increase the number of undergraduate and master-level chemistry students and to improve the poor recruitment of students for their Ph.D. programme.

The numbers of graduated Ph.D. and master’s students is given in Table 18.

Graduates	2005	2006	2007	Total
Dr. ing./Dr. scient. graduated	3	2	4	9
M.Sc. graduated	3	0	2	5

Table 18: Number of graduates

The department benefits from the graduate school “Ph.D. School in Molecular and Structural Biology”, which is a joint effort between the Faculty of Science and the Faculty of Medicine led by NorStruct.

A long term strategic plan for the department was worked out in 2006 for the period 2006-2012. This plan is now the main directive for the head of the department when annual plans and budgets are worked out.

Assessment and recommendations

Taken as a whole, this department made a very positive impression on the Committee during their presentation and subsequent discussions. They are a small group, but are quite dynamic. The goal of favouring interdisciplinary research in the department is an admirable one, and the faculty appears to be more internationally oriented, with less intellectual in-breeding, than some of the departments interviewed, a situation that favours the infusion of new ideas. Like many of the other chemistry departments in Norway, this group has troubles recruiting Norwegian graduate students and would benefit from changes in national policy concerning Ph.D. programmes. The foundation for developing a first-rate chemistry department with further investment in personnel and infrastructure is clearly present.

This department reported to the Committee that they are not going to pursue new disciplines in the immediate future, according to their master plan, but rather strengthen the disciplines they currently have. Based on the quality of the present group and the good foundation it provides for further improvement, the Committee endorses this plan.

This department is performing better from a financial perspective than many of the departments interviewed by the Committee. This is due in part to the overall productivity of the group, but also in part is due to good management of their human resources. The Committee encourages continuation of careful financial control in future years. Although this department reported that basic research is poorly funded in Norway, as did all the other chemistry departments interviewed, they do appear to have a reasonable level of external (i.e. non-departmental) funding. However, they would benefit significantly from aggressively pursuing EU-funded projects: Some of the faculty are clearly competitive enough internationally to succeed in that venue.

The department reports that its policies encourage faculty to take sabbaticals, and that many of their faculty take advantage of this to visit international research and academic institutions. The Committee supports this policy.

This department and other chemistry departments in Norway currently have central instrumentation facilities that are fully financially supported by the department. This department reports that it will soon move to a system in which the costs of running the central facilities are paid in fees on a per-use basis by researchers from their research funding. The Committee supports such a policy, which is more in line with the international standard for facilities' funding, but at the same time encourages the department to provide some central cost subsidy as it benefits the most productive members of their department.

Finally, this department appears to be the most "space starved" of any department in the country. Further, currently occupying three buildings, it is very difficult to maintain the kind of synergy between researchers that encourages interdisciplinary collaboration and a sense of intellectual community. Finally, the quality of the space occupied is fully inadequate for current programmes, hinders growth, and decreases the international competitiveness of the research programmes. The Committee therefore strongly recommends, based on its very favourable impression of this department, that a new chemistry building should be built, a modern facility with space adequate for all current faculty and their research groups, and for future expansion.

6.4.1.1 Inorganic and Materials Chemistry Group

This is a very small group, based on the teaching and research of one professor. The group has diverse research interests in the general area of inorganic and materials chemistry, and encompasses both theoretical and experimental components. Major thrust areas are in synthesis, chemistry and modelling of functional materials, with a view towards increased research activity in renewable energy related topics. International aspects of the collaborative research programme are strongly emphasised. The number of Ph.D. and master's level students and postdoctoral fellows is small, but not unreasonable for the group of a single professor. This group is scheduled to hire an additional professor in 2011.

Assessment and grading

The Inorganic and Materials Chemistry Group is excellent. The group is dynamic and insightful, and is performing research at the international standard in the field. The group has diverse interests and presents an excellent case for combining both theory and experiment in a single programme. The current research thrusts and the plans for future research seem excellent. The group is ambitious and forward looking and could easily intellectually accommodate more researchers very productively if more personnel and funding become available.

The graduate students in this group are strongly encouraged to spend some time abroad during their graduate experience. This is a highly valuable activity, as it will bring new ideas and techniques into the group, and more broadly into Norway in general. The leader of this group displayed an excellent grasp of important issues in the international materials chemistry community, and the group overall has excellent connection to the field.

Scientific Quality and Productivity	4
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,4,5*)

*) separate numbers for strategy, organisation, research cooperation

This group has international and collaborative publications with some of the world-leading figures in inorganic chemistry. They have an excellent publication record, with recent papers in competitive journals such as JACS and Inorganic Chemistry. This group published 7 papers in 2007 and 8 in 2006, which represents a very good publication rate for the group of a single professor. Research in functional materials has the potential for substantial societal impact, especially in the area of sustainability and renewable energy. Finally, the very strong international research cooperation that this group has developed represents part of an excellent overall research strategy. Having both theoretical and experimental work in the same group is a very good strategy for success in this field when there are very limited opportunities available for collaboration with other research groups in the same field at the same institution.

Recommendations

This group should be encouraged to grow through increased investment in personnel and infrastructure. The current plan is for the group to obtain more research infrastructure in the form of a laser Raman lab. The Committee supports this increase in capabilities and further believes that any further investment will be well justified.

The group is clearly competitive in this area on an international level and should be encouraged to apply for EU programme grants.

The addition of a second faculty member in this area in 2011 is supported by the Committee. The Committee recommends that great care be exercised during the hiring procedure to find a person with complementary skills to those already present and at the same time a person with a broad international view of the field to further enhance the uniquely broad vision of the current group. It is recommended that the new faculty member should be recruited internationally, building on the excellent foundation already present, and that Norway should provide internationally-competitive start-up funding to attract an excellent international scientist to this group.

6.4.1.2 Organic Chemistry Group

This group consists of 4 faculty members, two of Swedish, one of German and one of Norwegian citizenship; one professor is female. Research in this group is dedicated to the development of synthetic methods and the synthesis of biologically active or otherwise interesting molecules. National and international collaborations are good and the connections within the department are very good. Recruitment of students is difficult and research has to be accomplished with a limited number of co-workers, thus this group is critically small. The group has an affiliated start-up company, Lytix Biopharma, and this interaction is beneficial for the department.

Assessment and grading

Given its small size and limited work space, the organic chemistry group performs rather well. However it suffers from inadequate premises and laboratories. Recruitment of national master's and Ph.D. students has to be improved in order to have enough personnel for the ongoing research programmes, which are up to the international standard in the field. Combined with the work on the development of synthetic methods are projects dedicated to the synthesis of compounds of medicinal and biological interest. Thus, there is some activity in the field of biological chemistry, which combines well with the Structural Chemistry Group at the same department. There are several international exchanges on the graduate student level, which are clearly stimulating for the group. All faculty members are ambitious, while one is currently suffering from an overload of duties due to maternity and her position as deputy head. The group has excellent intellectual potential and could be more productive with more personnel and lab space. Hosting Lytix Biopharma is beneficial for the group.

Scientific Quality and Productivity	4/3[*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,4,4[**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

In this small group half of the personnel have a good publication output with a good number of publications in level 2 journals, such as in Medicinal Journal of Chemistry, while the other half clearly has to improve their publication record. Currently this group has the weakest publication record within the department, however, from the ongoing activities improvement of the situation can be expected. The activity of the group has resulted in the establishment of a successful small company holding 5 patents since 2004. The research in the field of medicinal chemistry clearly has a societal impact and, furthermore, has a connection to some highly relevant projects in the Structural Chemistry Group. Some recent projects have been dedicated to environmental issues. The group combines its limited resources very well and benefits from its high cooperative and collaborative standard. The group follows a strategic plan that has been agreed on, reflecting good leadership as well as a very good colleagueship. The national and international connections and collaborations of the group are very good. To allow further optimisation of the group's standards, the premises are in urgent need of improvement.

Recommendations

The size of this group is at its lowest limit, and the group needs some release of its load in organisational and institutional work to be able to concentrate more on research. Improved premises are urgently needed and highly recommended as this will allow this active group to more effectively develop its interesting projects, which are at the international standard. Collaborations within the department should be further strengthened to improve the chance for grant applications and funding, and especially the in-house expertise in structural chemistry should be utilised in the future research programmes of this group. The high cooperative standard of the faculty members in the group and the good working atmosphere help to attract students from abroad (as well as nationally) and should be a guideline for future activities. Ph.D. mobility programmes are already working and need to be further developed and encouraged. The group is encouraged to continue the development of the current strategic plan according to their vision of the department. Strengthening the existing expertise and programmes should have priority before starting new areas of research.

6.4.1.3 Structural Chemistry Group

This group consists of 4 faculty members, three from Norway and one with US citizenship. This strong team is a major player in the Norwegian Structural Biology Centre (NorStruct) providing a high visibility both nationally and internationally and operating a large number of collaborations. The situation in terms of limited number of graduate students is less tense than at other places in the department and in Norway in general. The mobility of researchers in this section is high. The group appears rather homogeneous.

Assessment and grading

The structural chemistry group is excellent and performs up to the state-of-the-art research in the field. The publication record is very good throughout the group. The group is extensively collaborating within the department, within Norway, and internationally, without losing sight of its own specific aims. Research is dedicated to the investigation of different structure-function relationships and receptor-ligand interactions, which are of high relevance in life sciences and of broad interdisciplinary interest.

Scientific Quality and Productivity	5/4[*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	5,4,4[**)]

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

There is a relatively consistent and very good publishing activity in this group, with a very good paper production in level 2 journals. The leading publishing activities in the group can be regarded as excellent, especially due to their high international visibility and citation rate. Research on structure-function relationships is of fundamental importance for basically all areas of the life sciences, and is one of the prevailing areas of research with high societal acceptance. It is of importance for Norway's scientific landscape that there exist a department that is an expert in protein isolation, amplification and structure elucidation, which is a challenging combination of techniques. Accordingly, research in this group is organised so that students gain experience in all areas connected to protein structure elucidation, which is a Nobel-prize-awarded approach (cf. Robert Huber). However, the different logistic stages of this research are partly located in different buildings. This should be improved to increase efficiency and internal interactions. The group has very good national and international collaborations.

Recommendations

To maintain its high standard in the future, the group is dependent on adequate investment, a sufficient number of technical stuff, ample money to cover high running costs and appropriate infrastructure. The potential of this group to play the key role in structural chemistry and biology in Norway is very high. This group should be supported to maintain its excellence, and future investments should support the collaborative initiatives within the department as well as within Norway, as there is the opportunity for this group to become the leader of a national centre in structural biology with the highest international visibility. The collaborative network NorStruct should be continued and supported as well as the National Research School in Structural Biology. The financial background of the group needs consolidation in order to develop into *the* national centre in structural biology.

6.4.1.4 Theoretical Chemistry Group

The group involves one professor and two recently appointed associate professors. There are currently 5 postdoctoral workers and 5 graduate students. The group has been greatly strengthened by the award of the Centre for Theoretical and Computational Chemistry (CTCC) jointly with the University of Oslo, which has enabled a move to new office space together with the appointment of postdocs and creation of a visitors programme. The established strengths of the group are in new method development in the area of quantum chemistry, but one recent appointment is in (bio)molecular simulation which is very strategic given the strength of the Structural Chemistry Group in Tromsø. Further details are well summarised in the self-evaluation document.

Assessment and grading

In part, as a consequence of the recent appointment, the activities of the group over a broad molecular size range and their activities are well coordinated with experimental groups in inorganic chemistry and structural chemistry. The group has a range of activities that is well directed towards the opportunities for computational work in Norway and the opportunities for collaboration within Tromsø. In addition they contribute to highly specialised expert developments in quantum chemistry methodology and through this have excellent collaborations and involvement in international networks. The group consists of young, highly qualified staff members and a high degree of coherence and collaboration is evident from the self-evaluation and from the group interrelationships observed during the site visit. The group has outstanding access to high-performance computing. The principal deficiency of the accommodation is that the group is split up and in different buildings from the rest of chemistry. The group has benefitted considerably from the CTCC which has boosted their resources considerably and enabled a group of viable size to be created. This might otherwise have been problematic, given the limited opportunities for responsive-mode funding. EU funding opportunities are generally limited to applied work and this does not really present a viable source of funding for theoretical work *per se*. The lack of students coming through the undergraduate programme is a clear weakness and, given the small total numbers of master’s students in Tromsø, it would seem that making the Tromsø provision as attractive as possible to international students is the only option. The group has been involved with the other Norwegian theory groups in an attempt to create a joint training programme which would help this process considerably.

Scientific Quality and Productivity	5/4*)
Relevance and Societal Impact	4/3
Strategy, Organisation and Research Cooperation	4,4,5**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

Scientific quality and productivity: some aspects of the research conducted are at an internationally leading level and throughout the group there is a high level of activity and publication in leading journals in the field (especially considering the age of the new appointees). The number of postdocs and graduate students is consistent with a very good level of activity.

Relevance and societal impact: the activities of the group are in basic science, which is well reflected in the normal measure of scientific output; there are no special factors. The connection of the group to other theory/computation groups in Norway is very good and contributes to an externally perceived national strength in the subject.

Strategy, organisation, and research cooperation: appointments appear to have been made highly strategically to complement other activities in Chemistry in Tromsø and to take advantage of the funding and computing infrastructure available to this kind of work in Norway. Considering the extremely small numbers of students coming through the undergraduate programme in Tromsø, the group has achieved a remarkable level of strength and visibility.

Recommendations

This group has excellent infrastructure and strength at the academic staff and postdoctoral levels. This could support a much higher number of graduate and master's students and consequently an even higher level of activity, though this would exacerbate the space problem. As commented elsewhere, theory/computation does appear to be a Norwegian strength and there is a high level of mutual understanding between the groups at Tromsø, Oslo, Bergen and NTNU. So support for the proposed national initiative in Ph.D. training in the subject would certainly be well-used and could help to address the shortage of Norwegian students in the area.

6.5 NORWEGIAN UNIVERSITY OF LIFE SCIENCES

6.5.1 Chemistry Research Group

In 2005, the traditional “Agriculture University of Norway” (NLH) was reorganised and accredited as a university and “The Norwegian University of Life Science” (UMB) was established. UMB focusses specifically on biology, food, environment, land- and natural resource management. The UMB comprises 8 departments. Chemistry is an important scientific area at UMB, not only for chemistry as such, but as a basic discipline for sciences at other departments. The UMB research group in chemistry is split into two separate research groups organised within two different departments (see Fig. 4). The research group “Environmental Chemistry” is part of the Department of Plant and Environmental Sciences (IPM), and the research group “Natural Product Chemistry and Organic Analysis”[3] is part of the Department of Chemistry, Biotechnology and Food Science (IKBM). A joint forum (Faggruppe) for UMB chemistry is established to coordinate the research and education within chemistry.

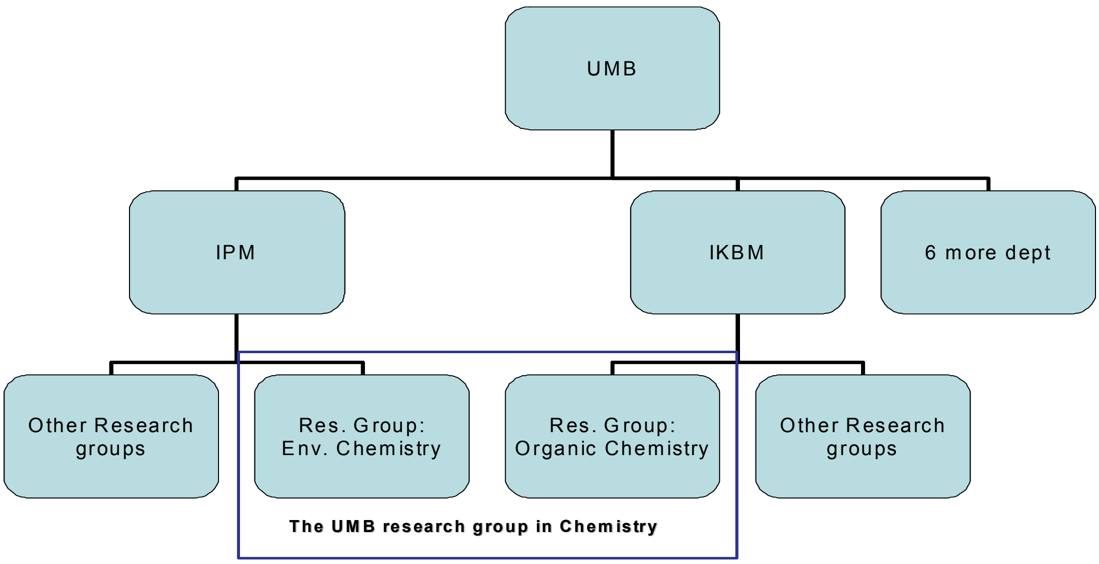

Fig. 4: Departmental structure at UMB

In the “Environmental Chemistry” group research areas include analytical chemistry, radiochemistry and environmental chemistry. The research group of “Natural Product

[3] The research group “Organic Chemistry” was renamed “Natural Product Chemistry and Organic Analysis” throughout this report as requested by UMB

Chemistry and Organic Analysis" group has a focus on natural product chemistry and bio-organic analytical chemistry.

In general, there is a need for improved facilities to handle high-quality chemical analysis. IPM has excellent equipment for radionuclide and trace element analysis, but some facilities are old and need improvement. Facilities and equipment at IKBM are sufficient to handle high-quality chemical analysis. IKBM has its own NMR facilities, but also has a good collaboration with NMR at UiO.

In chemistry, very few positions have been vacant in the last ten years. The staff situation is given in Table 19.

	Total	
Positions	**Univ.**	**Extern**
Professor	4*)	-
Associate professor	6	-
Professor II	-	4
Postdoctoral research fellow	-	2
Doctoral students	5	16
Technical/administrative positions*	9	1.5
	24	**23.5**

Table 19: Numbers taken from the factual information provided by the Department

"Univ." = persons financed by the university

"Extern" = persons financed by external research grants

*) Including two professors with 50 % positions

The age distribution among professors in permanent positions is summarised in Table 20.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
0	0	1	0	0	2	2	0

Table 20: Age distribution among professors in permanent positions

The recruitment of master's and Ph.D. students is different within the two research groups. In the "Environmental Chemistry" group recruitment of Ph.D. candidates is very good due to externally funded projects, while recruitment of M.Sc. students is limited due to late contact with the chemistry students in the B.Sc. programme. The "Natural Product Chemistry and Organic Analysis" group has many M.Sc. students due to its educational responsibility for UMB students in General Chemistry, while recruitment of Ph.D. students is limited due to a lack of funding. The number of graduates is given in Table 21.

Graduates	2005	2006	2007	Total
Dr. ing./Dr. scient. graduated	5	2	3	10
M.Sc. graduated	12	7	11	30

Table 21: Number of graduates

Assessment and recommendation

This university with its special history and location has a potential to develop further and focus on specialised areas in chemistry within the frame of environmental sciences, food science, biotechnology. The atmosphere of this rural campus is inspiring and there is a beautiful new building for teaching and research in which the organic chemistry group is also located.

The two research groups have different research areas and structure and are in different departments. There is a mechanism to allow the two groups to discuss issues and to integrate where appropriate, but it is not clear whether this process achieves the optimum level of cooperation or integration. Given the differences between the two research groups this evaluation considers each group in turn.

For the chemistry activities at UMB there is a great potential for focussed collaborations within the main areas of UMB research areas. Synthetic organic chemistry should deepen its internal UMB interactions in order to specialise on areas that are otherwise underrepresented in Norway, building up collaborations with the environmental sciences and with biotechnology, proteomics and protein engineering, and food science.

6.5.1.1 Environmental Chemistry at IPM

The Environmental Chemistry Group consists of six academic staff, and while there have been appointments over the last decade, the turnover has been very small. This has resulted in a stable research environment. The new appointments have mainly been achieved by appointing a guest professor and making professor II appointments. There has also been the appointment of two associate professors who had been departmental engineers and had completed Ph.D.s in the research of the department. Overall the group, while small, has a clear focus. Among the main subject areas, environmental radioactivity has been a core research subject in which the group has an international reputation and extensive research links through grants, contracts and individual links. The other subject areas include much that complements the environmental radioactivity work, including trace metal behaviour in the environment and the physiological effects of acidified freshwater and estuarian waters on fish, again with the speciation of metals being a key component.

Assessment and grading

The productivity of the group overall is satisfactory when publication statistics are reviewed, but the average performance overall conceals a broad range, with a few individuals contributing substantially more to the overall output than the rest of the group. The publication numbers have held up well over the last five years and the publication rates of the two chemistry groups are broadly similar.

Scientific Quality and Productivity	5/3*)
Relevance and Societal Impact	5
Strategy, Organisation and Research Cooperation	4,3,5**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The science quality is judged by the character of the research output in high-quality journals, which is very good and in some cases excellent. The lower score for productivity reflects the overall output, which is intermediate. Clearly there are a few individuals who drive the research agenda and output, and the group depends on them to maintain a satisfactory level of productivity. The work of the group is highly relevant across the spectrum of research, and, in the case of environmental radioactivity, this is the leading Norwegian group and is an important national asset. Given the likely global increase in nuclear generating capacity over coming decades it will be necessary in a strategic sense to maintain the capability in this important field. The research group is small and very sensitive to changes in staff, and in the not too distant future it will be necessary to appoint new staff from the wider international community to maintain the vigour of the research.

The strategy of the group is satisfactory in the short term in looking to enhance the measurement capability and instrumentation. However, given the size of the group and the age structure, the long-term development of the group requires a more strategic view of the staff profile to be internationally competitive in five or ten years time, which requires appointments of new staff in the next few years. The group has excellent international collaborative links.

Recommendations

The small research group is on the boundaries of critical mass, carries a substantial teaching and administrative burden, and the excessive work load has developed in part as a consequence of the success of the group in establishing this small centre of excellence. The capacity of the group to take on more work is limited by staff numbers and this must be limiting the overall scientific productivity and the ability of members of the team to take sabbatical leave and to develop new lines of research. The equipment available to the team is very good, although it is clear that the general infrastructure and especially the laboratories need to be improved. The improvements required are necessary to enhance both the teaching and research facilities. The student numbers at all levels have been maintained very effectively at UMB, and to maintain this success it is necessary to upgrade the infrastructure for the group. Specific items of equipment have been identified to enhance the research capability of the group. Clearly in this field progress at the leading edge of development requires access by the group to the best equipment, and the case for new investment in instrumentation for this group is supported by the Committee.

This team has maintained an important position in Norway as the centre for environmental radioactivity research and teaching. The wider research by the group complements this focus. Overall the team is too small and should be supported in the near future by junior academic staff, hopefully attracting new blood from the international community to bring in fresh ideas and to shape the team and UMB for the longer term. This injection of younger talent should include postdoctoral researchers to strengthen the core science of the group and Ph.D. students which the group seems able to bring in very effectively. This would substantially increase the output of high-quality science from the group and provide for the longer term development of the group.

There is a clear need to upgrade instrumentation and more importantly the general laboratory facilities for the group, which are not adequate, and are below the standard expected of a high-quality research group. In the absence of these developments, it is likely that the only centre for environmental radioactivity in Norway would decline in the not too distant future to sub-critical size and an unsatisfactory level of scientific productivity. The overall upgrading of facilities and appointment of new staff to this group is therefore a high priority given the unique status of this research group for national capability in environmental radioactivity

6.5.1.2 <u>Natural Product Chemistry and Organic Analysis at IKBM</u>

The Natural Product Chemistry and Organic Analysis Group at UMB is organised within the Department of Chemistry, Biotechnology and Food Science. It is a small, but well-focussed group dealing with modern research topics. Currently it consists of two associate professors and two full professors, one of which is leader of the group. While one of the professors is on leave, there has been an additional position announced very recently. The premises in which the Natural Product Chemistry and Organic Analysis Group is located are new and very good, however, the available space is limited even for a small group as this one. This group can be called a bio-organic group, more than the other organic chemistry groups in Norway, as its research emphasis lies in the chemistry of natural products and especially lipids and their biological activity, on enzyme mechanisms and analytical chemistry with a focus on mass spectrometry. The instrumentation of the group is mostly very good, however, a new standard NMR instrument is needed. There are an insufficient number of Ph.D. students and permanent technical staff.

Assessment and grading

This group does not appear as convincing as the premises in which they are located. The laboratories are new and much of the equipment is of high standard. While there are a very limited number of professors - currently there are only three colleagues active - there were not enough collaborative projects to increase the visibility of the group and only lately an emphasis has been put on lipid research. Analytical research is focussed on advanced MS methods and shows a reasonable level of output. The same is the case for biological chemistry, which has reported very interesting contributions on ligand-receptor interactions and enzyme mechanisms. Synthetic organic chemistry does not play a key role in this group, although it could make important contributions to collaborative projects within the two afore-mentioned fields. In addition, the interaction of the group with the other areas at UMB is limited, and there is little evidence of integration of research activity according to a convincing strategic plan. The spectrum of analytical capability available to this group and the issues available for joint research with the environmental chemists present opportunities for integration that have not been taken. It is clear, however, that the research interests of the two groups are quite distinct, and there is little common scientific ground to expect broadly based integration.

Scientific Quality and Productivity	4/3[*)]
Relevance and Societal Impact	3
Strategy, Organisation and Research Cooperation	3,3,2[**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

Regarding its research output, the group falls into two halves. While the publication record of the better half is very good, the other half has published very little during the last five years, sometimes only one paper per year. Overall the productivity of the whole group appears only moderate, while the proportion of papers published in level 2 journals is roughly at the Norwegian average. The publication record might improve once the new focus on lipids is better established. Much of the published work has analytical as well as biological applications and this might eventually have an impact on public health. Industrial collaborations are not documented. This group does not follow a strategic plan, which would be important for such a small group. Accordingly, the group is not well organised as a whole and its potential cannot be fully utilised without improved planning and leadership. The research cooperation within the group is fair but could be improved.

Recommendations

This group is located in new premises, which support close collaboration within the group. The activities of each professor require a specific focus; however, at the same time there is a need to work on common topics to increase the international visibility of this small group. With the common interest in biologically active natural products, the group's activities should follow two corresponding areas, synthetic and analytical bio-organic chemistry. There must be an agreement on the most important molecular targets in order to concentrate the available resources rather than to spread them too thinly. With the present status of the group, such a concentration of forces could well apply for the lipid field, as the group has started to establish such as focus, however, this is not the only possibility. Whatever the group selects as its main focus, it should have a stand-alone characteristic within Norway. Naturally such developments would need to be formally documented in, for example, a strategic plan. It is important in this process to map the various overlaps within IKBM and furthermore with UMB. The special location of the campus and the specialised scientific surrounding bear a great potential for focussed collaborations, and organic chemistry at UMB has to utilise this in order to differ from the other Norwegian universities and its bigger neighbour the University of Oslo. Research areas including biotechnology, proteomics and protein engineering represent possible collaborative research areas. The group has a focus on MS methodology and should strengthen it. High-field NMR spectroscopy can be done in collaboration with UiO, however, the group needs a good standard instrument for daily service measurements and also to allow for the respective collaborations within UMB. As the group is on the boundaries of critical mass it needs more personnel; however, any additional appointment should be consistent with a clear strategy for research with some common goals. Improved leadership could facilitate this process.

6.6 NORWEGIAN INSTITUTE FOR AIR RESEARCH

The Norwegian Institute for Air Research (NILU) was established in 1969 as an institute under the Royal Norwegian Council for Scientific and Industrial Research (NTNF) and became, from 1 January 1986, a private foundation. The foundation is led by the board of directors, consisting of five external representatives, and the director of the institute. The institute is organised with five operative departments. NILU's chemical research is organised as part of the Environmental Chemistry Department. The funding at NILU is provided by industry (ca. 12 %), public administration (ca. 32 %), Norwegian pollution control authority (ca. 15 %), Research Council of Norway (ca. 16 %), and EU + basic grant + UN + development projects (ca. 25 %). Thus, the primary research for the Norwegian Research Council of Norway is a small fraction of the funding base for NILU.

The Environmental Chemistry Department which is the only part of NILU taking part in this review, (but is not the only part of NILU engaged in chemistry research), comprises 14 researchers, 4 Ph.D. students, 4 engineers, 12 technicians, 2 secretaries and 1 trainee. There are, in addition, two part time researchers (20 % each), one professor at NTNU and one professor at UNIS. The department recruits researchers nationally and internationally. The Environmental Chemistry Department is headed by a director and the allocation of internal funding within NILU is decided by NILU's director.

Currently, NILU is in the process of establishing the institute's strategy for the period 2009-2012.

Assessment and grading

The Environmental Chemistry Department, with 14 researchers and other staff has in addition to the senior scientists who direct the projects and write up the research papers and reports a broad range of the technical skills necessary for research and monitoring, and the technical skills to support and operate the laboratory facilities. The group clearly has critical mass for its work in environmental chemistry; it has a clear focus and occupies a prominent position internationally in persistent and semi-persistent pollutants in the environment. The group has a range of state-of-the-art equipment including high resolution MS linked to GC, ICP and HPLC instruments. The team working and focussing on a narrow range of issues has enabled the group to become prominent in this field.

The group has its main base at Kjeller the NILU headquarters, and an important base for polar-orientated research and monitoring is at Tromsø. There are also important long-term monitoring stations on Ny-Ålesund and more recently in the Antarctic at the Troll station. The standard of the analysis of trace levels of a wide range of analytes is excellent and the high standards of the environmental chemistry at NILU have become widely recognised.

Scientific Quality and Productivity	5/4*)
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	4,5,5**)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The grading of this group comprises both an assessment of the scientific quality of the work, the productivity of the group and the scientific vision and development. The publication output overall is satisfactory in a simple comparison of papers produced per researcher; it is not a high publication rate as noted in the bibliometric analysis provided to the Committee. However, the number of researchers used as the denominator in the bibliometric analysis at 15 overstates the scientific staff engaged in publication. A more reasonable approach would be to use the number of Ph.D.s and senior academics associated with the output. In this case the publication rate per researcher would be closer to 7 and would be a high figure relative to the university research groups with which it is being compared. In addition the highest publication rate of individuals within the group is at the very high end of the entire range of individuals considered in this evaluation. The citation rates are also higher than the average in the review. Overall therefore the quality and quantity of the scientific output is excellent.

The societal impact of the NILU work is very high and the group is associated with leading international research in this field, including many EU collaborations and wider involvement in the assessment of global environmental change. The research group is highly organised and well managed. The strategy of working with the best techniques and on a highly focussed area has proved successful, as many of the key scientific developments in this field have been technology led, with the new techniques enabling many of the really new discoveries.

Recommendations

The review notes the threats, including the challenge of keeping up with the latest technical developments in instrumentation and the very high cost of replacing these instruments. However, the Committee notes that the strategy to date has been very successful, and expects that through research grants and Research Council of Norway initiatives the group will continue to stay at the leading edge of developments. The challenge of delivering more science from the work without diluting the clear focus and mission of NILU could be addressed by involving more of the domestic academic community in the large monitoring and data rich environment of NILU. The facilities, both in instrumentation and fields sites and monitoring data and expertise, show that there is much that could be achieved by greater involvement with the university research groups, who through joint Ph.D. students and postdocs could enable a wider range of science to be completed in collaboration with this group. This should not be seen as a major change in operation, rather it should be seen as harvesting more of the potential of the NILU activity through the provision of more pairs of hands and a slightly wider scientific vision and domestic collaboration

6.7 UNIVERSITY OF STAVANGER

6.7.1 Department of Mathematics and Natural Science

Since the establishment of the University of Stavanger in 2005, the Department of Mathematics and Natural Science is part of the Faculty of Science and Technology. The two chemistry groups of the department are assigned to “Biological Chemistry” and “Chemistry and the Environment” (C&E). In the field of “Biological Chemistry” a “Centre for Organelle Research” (CORE) is planned providing an environment for doing chemical, biological and biophysical research with a focus on cellular processes.

The “Biological Chemistry” group focusses on basic molecular research at the interface between chemistry and biology. Research activities in the C&E group are focussed on environmental engineering (water cleaning and water analysis), corrosion, as well as certain research areas in organic and biophysical chemistry.

During the last years major pieces of equipment could be purchased from external funds by both the biological chemistry group and the C&E group, i.e. confocal microscope, isothermal calorimeter, and imaging system.

The staff situation is given in Table 22. Presently, the technical assistance for research is unacceptably low, i.e. one 50 % technician position is allocated to two labs. The other 50 % position is allocated for teaching.

	Total	
Positions	**Univ.**	**Extern**
Professor	6	-
Associate professor	5	-
Professor II	-	7
Postdoctoral research fellow	5	5
Doctoral students	15	5
Technical/administrative positions	2.2	-
	35.2	**17**

Table 22: Numbers taken from the factual information provided by the Department

”Univ.” = persons financed by the university

”Extern” = persons financed by external research grants

The age distribution among professors in permanent positions is summarised in Table 23.

31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
0	1	1	0	2	1	1	0

Table 23: Age distribution among professors in permanent positions

Young promising researchers could be recruited in particular in Biological Chemistry. However, recruitment of master's and Ph.D. students has been difficult. Many Ph.D. candidates are now recruited from abroad. A Ph.D. programme has been established in "Biological Chemistry".

The numbers of graduates are given in Table 24.

Graduates	**2005**	**2006**	**2007**	**Total**
Dr. ing./Dr. scient. graduated	2	4	3	9
M.Sc. graduated	10	12	21	43

Table 24: Number of graduates

Assessment and recommendations

The maturing process of the former college into a university is difficult and not finished. The department had expected that the university would receive additional financial support when receiving university status, which apparently was not given. Thus, it was felt that the university has a financial disadvantage, a fact that the Committee could not verify.

In general, the department does not have a common infrastructure. There is no particular leadership at the departmental level; however, a new head of department was appointed recently. Decisions are as yet generally made at the faculty level.

Initially, the department consisted of one group, the Biological Chemistry Group. Only some time later, this setup has been changed as it was not compatible with the interest of all of its members. Thus today, the department has to distribute its forces between Biological Chemistry and C&E. However, the Biological Chemistry Group is the much stronger one, much more productive and the actual home of the university-style research in this department. In the very near future more lab space will be provided for the Biological Chemistry Group for the establishment of CORE (Centre for Organelle Research) which will further strengthen this area. The members of the C&E Group suffer from a too large teaching load and the lack of a scientific approach. The C&E Group basically has no scientific impact and hardly a fruitful overlap with Biological Chemistry at the same department. Thus, it is questionable whether the two groups will ever have a fruitful collaborative future within the same department.

Moreover, biological chemistry has no overlap with the offshore petroleum engineering, which dominates the local industry. In spite of lacking overlap with local industry, the Biological Chemistry Group has managed to set up a convincing programme, which promises effective future funding.

To further develop the already strong biological chemistry at this young university, this group should be supported in setting up suitable collaborations within the university and beyond (e.g., biochemistry and medicine).

The department seems to have no strategy in developing chemistry-related research. As some of the research aspects are linked to the university's strategy "Energy, Climate and the Environment", strong leadership at the departmental level would be urgently needed to encourage and coordinate collaboration between individual researchers in the C&E Group.

*6.7.1.1 **Biological Chemistry***

The research in this group is much more concentrated in the field of biochemistry than any other group that has been evaluated by the Committee. The biological chemistry topics are related to the molecular processes in cells, in particular in cell organelles and their influence on metabolism, development, and environmental adaptation. There is no synthetic chemistry dealt with and it is not needed. The group was formed already in college times by three professors, and expanded to five professors after the establishment of the University of Stavanger. Very lately a 6^{th} colleague has been appointed, supplementing the existing group very well. In addition, 4 adjunct professors II are associated with this group. There are more Ph.D. students and postdocs in this group when compared to many other chemistry groups in Norway of a similar size.

Assessment and grading

This group has made a successful attempt to form an internationally visible group, contributing significant research to the community. The individual researchers have focussed their activities towards a common strategy, to an extent that is rare in Norwegian chemistry departments. The future strategy that has been set up is attractive and realistic, and is still open for further development. Recent appointments have further confirmed the quality of this fine group, which can count on a respectable number of Ph.D. students and postdoctoral students according to Norwegian standards.

Research ranges from studies on DNA repair, flavonoid regulation, carbon metabolism in yeast, mechanism of chloroplast division and iron-sulphur proteins to biochemical clocks and biophysical analytical methods. Lately the group has gained expertise in proteomics in the field of plastids and their photosynthesis. All initiatives taken together make this group the only one of its kind in Norway with a high international reputation.

Scientific Quality and Productivity	5/3[*)]
Relevance and Societal Impact	4
Strategy, Organisation and Research Cooperation	5,5,5[**)]

[*)] first number leading scientist(s)/second number the average of the group

[**)] separate numbers for strategy, organisation, research cooperation

The publication record of this group is headed by a leader group whose output has been excellent during the last years, while the rest of the group displays a rather limited number of papers, however, often in very good journals. According to the bibliometric analysis, this group has the highest proportion of publications in level 2 journals among all the evaluated departments and this guarantee for a high international visibility.

To elucidate cell organelle function and its regulation is of high relevance for understanding the molecular basics of life and thus this work has a high societal impact and is important for the thriving of this young university. It is very positive that the group has decreed itself a clear strategy and thus indeed appears as a whole. The group holds regular joint group meetings, allowing to identify internal collaborations to lead to the highest possible impact. In addition this well-organised group has good international collaborations.

Recommendations

This group should be encouraged by the university to further develop its highly relevant and internationally competitive work. Starting the ‘Centre of Organelle Research’ will be helpful in this regard and attract funding from the RCN. Collaboration with synthetic chemistry could be very helpful and attractive for several of the group’s projects, however, the interactions with the chemistry group in the department do not seem to be very beneficial for either of the two groups. This situation should be changed on an organisational level, and in this strategic evolution process the future teaching profile of the faculty has to be taken into account as well. As an attractive study programme is a precondition for recruitment of students, it is essential for this group to agree on an appropriate study programme portfolio at the department level. Teaching and interdisciplinary research within the Biological Chemistry Group should be supported by the appointment of a chemist active in synthesis, who can collaborate within and participate effectively in the existing research programme. The Centre for Organelle Research should be supported because it offers excellent and unique possibilities in the country, and collaborations of this group within Norway should also be encouraged. Finally the position of this strong group at the University of Stavanger has to be further consolidated and beneficially embedded into a supportive collaborational network.

6.7.1.2 Applied Chemistry and the Environment

The Applied Chemistry and the Environment Group comprises six members of staff, one as full professor and five as associate professors. The fields of research are mainly on water treatment, water contamination and corrosion chemistry.

Assessment and grading

The group clearly has a focus, but this is not readily conveyed by the broad title - something along the lines of “applied water chemistry research group” would be closer. However, this would not be fully inclusive of all individuals. The character of the research is very applied and the work therefore contains much that is specific to industry, where the publications are often reports, not all of which are available to the wider community. The facilities and equipment for research appear to be limited to basic tools that are used for both teaching and research. There has been significant new equipment acquired by the Biological Chemistry Group, while the Applied Chemistry and the Environment Group has not been able to follow the same track. The reasons for the differences were not entirely clear but appear to be related to the vision and research focus of the two groups.

Scientific Quality and Productivity	2/1 *)
Relevance and Societal Impact	3
Strategy, Organisation and Research Cooperation	1,2,2 **)

*) first number leading scientist(s)/second number the average of the group

**) separate numbers for strategy, organisation, research cooperation

The assessment needs to be consistent across the departments and institutes evaluated, and in this case the same criteria for assessing the output rates and output quality of the publications from the group should be used. The scores reflect the low publication rate and limited citation of the papers produced by this group. In giving these low scores, the Committee is aware that the group has a very different focus to most of the research groups in the review. This group is in a very new university and has not developed with the same academic focus. Thus it will take time and some significant changes in group priorities before similar publication rates could be expected. The practical work of the team and industry focus of the work requires a different assessment process.

The work of the group is clearly relevant and has significant societal impact; the modest scores reflect the strength of the evidence provided for a group of this size. The strategy for the future is limited and the group appears as a collection of individuals in a broadly similar area rather than a focussed team. The CV details were much more informative of the potential of the group than the document outlining a strategy; clearly this group should have a clear strategy and a plan for delivery, but to date it has not emerged.

Recommendations

The group would benefit considerably by developing a clear research strategy. There is a broad focus and there are many issues that fit within the range of skills of the members of the group. This suggests a need for clearer leadership among the group and a process to develop an inclusive strategy for the next 5 (or more) years. Given this approach, it would then be possible to develop a delivery plan, but the group must first decide the direction of travel and the goal before that becomes possible.

7 CURRICULA VITAE OF THE COMMITTEE MEMBERS

Evamarie Hey-Hawkins (* 1957) is full professor of Inorganic Chemistry at the Faculty of Chemistry and Mineralogy, Universität Leipzig, Germany, since 1993.
She received her diploma (1982) and doctoral degree (1983) in chemistry at the University of Marburg. She was a guest researcher at the University of Sussex (1984/85), England, at the University of Western Australia (1985/86), Australia, and at the Australian National University (1986/87), Canberra, Australia and obtained the *venia legendi* in Inorganic Chemistry at the University of Marburg in 1988. From 1988 to 1990 she worked as research associate at the MPI for Solid State Chemistry in Stuttgart, Germany, and from 1990 to 1993 she was guest researcher at the University of Karlsruhe (Heisenberg Grant) and temporary lecturer at the University of Hohenheim, Stuttgart, and University of Heidelberg.
She is the author of more than 230 publications and 3 patents. She was awarded a Liebig Grant from the Fonds der Chemischen Industrie, Germany, in 1984-86, a Heisenberg Grant from the DFG, Germany, in 1990-94, Visiting Professorships at Pamukkale University, Denizli, Turkey (by TÜBITAK) and the Université de Rennes 1, France (2007), and a Visiting Erskine Fellowship, University of Canterbury, New Zealand (2007).
Among other activities she is the Coordinator and Speaker of the Excellence Graduate School "Building with Molecules and Nano-objects" (BuildMoNa) and Coordinator of an EU TEMPUS project between the Departments of Chemistry in Tetovo and Skopje, Macedonia, Cluj-Napoca, Romania, and Universität Leipzig.

Robert Cava is Chair of the Department of Chemistry at Princeton and the Russell Wellman Moore Professor in Chemistry and Materials. He began at Princeton in 1997 after working at Bell Laboratories for 17 years, where he was a Distinguished Member of Technical Staff. He received his Ph.D. in Ceramics from MIT in 1978, after which he was a National Research Council Postdoctoral Fellow at the National Institute of Standards and Technology. He is a Fellow of the American Physical Society and the American Ceramic Society, and a member of the US National Academy of Sciences. He has been recipient of the Matthias Prize in Superconductivity, the New Materials Prize of the American Chemical Society, the De-Shalit Memorial Lectureship at the Weizmann Institute, the Debye Lectureship at Cornell University, the R.J.P. Williams Lectureship at Oxford University, and the John J. Carty Award for the Advancement of Science from the National Academy of Sciences. At Princeton, he has been a recipient of the President’s Award for Distinguished Teaching, the Phi Beta Kappa Teaching Award and three teaching awards from the Princeton Engineering Council. His research is in solid state chemistry - emphasising the discovery of new non-molecular solids with interesting electronic and magnetic properties.

Daniel Duprez (* 1945) is Professor and Senior Researcher in the Department of Chemistry, Catalysis Laboratory (LACCO) of the University of Poitiers, France.

He received both his Diploma of Chemical Engineer and the M.Sc. at the Polytechnicum of Nancy in 1967. He got his Ph.D. in 1975. From 1976 to 1978, he stayed at the ELF-TOTAL Research Centre in Solaize. In 1978, he got a position as Junior Researcher and Assistant Professor, and in 1985 as Senior Researcher and Professor at Poitiers University.

His main scientific interests are in the field of metal catalysis, especially in oxidation and DeNOx reactions in automotive depollution, catalytic water treatments, H_2 production and purification from hydrocarbons and bioresources. On a fundamental point of view, he has developed the concept of surface mobility of active species in catalysis by means of specific techniques such as transient H/D and $^{16}O/^{18}O$ isotopic studies.

He is author or co-author of 220 publications in peer-reviewed journals and of 190 oral communications in National and International Conferences. He was Deputy Director of the Catalysis Laboratory of Poitiers (LACCO) from 1991 to 1999 and Director from 2000 to 2007. Since the beginning of 2008, he is Director of the Federation "REAUMUR" of Poitiers. He is coordinator of several research programmes of ADEME (French Environment and Energy Management Agency) and of several international cooperation programmes. D. Duprez is President of the Catalysis Division of the French Chemical Society and the French representative to the IACS council. He is member of different Committees of the National Research Agency. He is member of the editorial board of Applied Catalysis B: Environmental and of ChemSusChem and member of the International Advisory Boards of many congresses throughout the world.

David Fowler CBE, FRS, FRSE (* 1950) is Senior Scientist at the Centre for Ecology and Hydrology, based at the Edinburgh Laboratory and is a Professor of Environmental Physics at the University of Nottingham. He gained his BSc and PhD in Environmental Physics at the University of Nottingham. David moved to the Institute of Terrestrial Ecology in Edinburgh in 1975. His research at CEH focussed on emissions, atmospheric processing, deposition and effects of a range of trace gases and aerosols through the period to 1991. Since then his main focus has been on radiatively active gases, measuring fluxes of CH_4 and N_2O by micrometeorological techniques from towers and boundary layer methods using aircraft. The focus of the CH_4 research was on the peat wetlands of Northern Britain and in Finnish Lapland and rice paddies in Italy including the up-scaling of fluxes to country scales. Current research interests are in Biogeochemistry, and in particular the global cycling of carbon, nitrogen, sulphur and metals and the effects of atmospheric pollutants on terrestrial ecosystems. His specialist area is in the exchange of trace gases and aerosols between the atmosphere and terrestrial surfaces. The primary research is published in 205 peer reviewed papers, 164 other papers and book chapters and 150 contract reports and books.
David was appointed a special Professor of Environmental Physics at Nottingham University in 1991; elected as a Fellow of the Royal Society of Edinburgh in 1999, a Fellow of the Royal Society of London in 2002, and awarded a CBE in 2005 for services to atmospheric sciences. David has chaired review groups for UK government departments over the last 20 years in the support of policy development to produce effective control strategies for the major atmospheric pollutants.

Thisbe Kerstin Lindhorst (* 1962) is full professor of Organic Chemistry at the Faculty of Mathematics and Natural Science of Christiana Albertina University of Kiel since 2000.
She studied chemistry at the Universities of München and Münster, received her diploma in chemistry and biochemistry in 1988 and her Ph.D. in Organic Chemistry in 1991 at the University of Hamburg. After a postdoctoral stay at the University of British Columbia she worked on her habilitation and became Private Docent in 1998 at the University of Hamburg. In 1997 she was a Visiting Professor at the University of Ottawa in Canada. Since 2000 she holds a chair in Organic and Biological Chemistry in Kiel.
Her scientific interests are in the field of synthetic organic chemistry, natural products, biological chemistry and especially in glycochemistry and glycobiology. She is the author of over 100 publications and of the text book "Essentials in Carbohydrate Chemistry and Biochemistry" amongst others. Her most important awards are 'Förderpreis der Karl-Ziegler-Stiftung award', 'Chemiepreis der Akademie der Wissenschaften zu Göttingen award', and 'Carl-Duisberg-Gedächtnispreis award'. Her activities and professional responsibilities comprise of positions as institute director, head of chemistry department, representative of the Gesellschaft Deutscher Chemiker (GDCh) in Kiel, board member of Liebig-Vereinigung within GDCh and she is an elected member of the DFG Forschungsforum as well as a referee for numerous programmes and scientific journals. She is an Editorial Board member of *Carbohydrate Research* and *International Journal of Carbohydrate Chemistry* and Scientific Editor of *Carbohydrate Periodicals* within the Royal Society of Chemistry. She has two children (*1991, *1995) and lives with her family in Kiel.

Paul Anthony Madden (* 1948) is Professor and elected as Provost of Queen's College, Oxford. He got his BSc in Theoretical Chemistry at Sussex University in 1970. From 1970-1972 he obtained a predoctoral fellowship (Fullbright) at the University of California Los Angeles under the supervision of Prof. D. Kivelson in experimental and theoretical research on molecular motion in liquids. In 1974 he got the D. Phil at Sussex. From 1974-1982 he worked as a University Demonstrator and an SERC Advanced Research Fellow at the Department of Theoretical Chemistry at the University of Cambridge and continued at RSRE Malvern in the Physics Division as Principal Scientific Officer. From 1884-2004 he worked as a lecturer in the Physical and Theoretical Chemistry Laboratory, Oxford, and he was appointed as Professor of Chemistry at Oxford in 1996. In 2005 Paul Madden was appointed to Regius Chair of Chemistry, University of Edingburgh, and as Director of the Centre for Science at Extreme Conditions (CSEC). In 2006 he was elected as Fellow of the Royal Society of Edinburgh. Other honours include a large number of visiting professorships, i.e. Louis Néel Professor at Ecole Normale Supérieure de Lyon, Universitá di Milano, Debye Lecturer Utrecht, University of Sydney, Kivelson Lecturer at UCLA, CNRS, Miller visiting Professor at the University of California, Eli Burshtein Lecturer at University of Philadelphia, and a visiting fellow of the Japanese Society for the Promotion of Science. In 2002 he got the Mulliken Medal at the University of Chicago, and the Thermodynamics and Statistical Mechanics Medal of the RSC. Paul Madden is a member of the Executive Committee Molecular Physics Editorial Board of Chemical Physics and EPSRC College member.

Gerhard Schembecker (1963) is full professor in Plant and Process Design at the Department of Biochemical and Chemical Engineering, Technische Universität Dortmund, Dortmund, Germany, since 2005. He received his diploma (1988) as well as his Ph.D. (1992) in Chemical Engineering from Technische Universität Dortmund. During his habilitation he worked on computer aided process synthesis and developed the software PROSYN which is used in chemical industry for the conceptual design of chemical processes. In 1999 he received the *venia legendi* in Plant and Process Design.

G. Schembecker is co-founder of the consultancy firm Process Design Centre (PDC) having offices in Dortmund (D), Breda (NL) and San Diego (USA). As President and CEO of PDC he has worked in more than 100 industrial process synthesis projects. G. Schembecker holds several process innovation awards (Rudolph-Chaudoire-Award, Haltermann Innovation Award, Shell “Memento” Award for Generating Process Improvement Ideas). He is member of scientific advisory boards (VDI-GVC; CUTEC) and board member of various organisations (ProcessNet committees *Process Simulation, Synthesis and Knowledge Management* and *Process and Plant Technology*, ZEDO Centre for Technical Consulting Systems).

He has published 30 papers and 3 patents. His research interests focus on the conceptual design and simulation of (bio)chemical processes supported by experiments with special interest in chromatographic and crystallisation processes.

8 ADDITIONAL INFORMATION ON THE EVALUATION

- Letter to the departments announcing the evaluation
- Letter to the departments for preparing for the hearing meetings
- Time Schedule for the hearing meetings
- Site visits – The Committee Members participation

Forskningsrådet

Kjemisk institutt, Universitetet i Oslo
Institutt for kjemi, Universitetet i Tromsø
Kjemisk institutt, Universitetet i Bergen
Institutt for kjemi, NTNU
Institutt for kjemisk prosessteknologi, NTNU
Institutt for materialteknologi, NTNU
Institutt for plante- og miljøvitenskap, UMB
Institutt for kjemi, bioteknologi og
matvitenskap, UMB
Institutt for matematikk og naturvitenskap, UiS

Vår saksbehandler/tlf.	**Vår ref.**	**Oslo,**
Trude Dypvik, 22 03 73 10	2007/07186	18.2.2008
	Deres ref.	

Evaluering av forskningen innen kjemifagene i UoH-sektor

Vi viser til brev av 17. desember 2007 om Forskningsrådets forestående evaluering av forskningen innen kjemifagene ved universiteter og høgskoler og fellesmøtet med instituttlederne i Forskningsrådets lokaler den 23. januar.

Divisjonsstyret for Vitenskap har nå godkjent mandat og plan for evalueringen.

Plan for evalueringen
Tidsplan for evalueringen følger vedlagt.

Evalueringen vil bli gjennomført ved hjelp av en internasjonal ekspertkomité. Et viktig grunnlag for komitéens arbeid vil være innsendte egenvurderinger fra instituttene/forskningsgruppene (se under). Videre legges det opp til at evalueringskomitéen møter fagmiljøene i perioden 15. mai -20. juni, 2008. Nærmere informasjon om dette vil bli ettersendt når komitéen er på plass.

Når utkast til evalueringsrapport foreligger, vil instituttet/forskningsgruppen få tilsendt egen omtale for faktakontroll før den endelige rapporten offentliggjøres. Evalueringen begrenses til vurderinger og anbefalinger på institutt-/forskergruppenivå, og enkeltforskere vil ikke bli omtalt ved angivelse av personnavn.

Faktaark. Frist for innsendelse 15.4.2008
Hvert institutt/forskningsgruppe skal fylle ut et faktaark. Hensikten med faktaarket er å lette evalueringskomitéens arbeid med egenvurderingene, se vedlagte faktaark med veiledning. Faktaarket kan lastes ned fra Forskningsrådets nettside http://www.forskningsradet.no

Som det går fram av faktaarket og veiledningen, spørres det primært etter informasjon om stillinger/ansatte ved det aktuelle instituttet/forskningsgruppen. Personer som har sin stilling ved annet institutt/forskningsgruppe og som i stor grad er delaktig i enhetens oppgaver/ansvar knyttet til forskningen skal omfattes av evalueringen. Disse personene føres derfor også opp i faktaarket med en merknad om stillingens tilhørighet.

Navneliste **Frist for innsendelse <u>7.3.2008</u>**
I tillegg til faktaarket skal det settes opp en liste med navn og adresse (e-post og vanlig adresse) for alt fast vitenskapelig personale og postdoktorstipendiater (alle de personer som skal sende inn CV). Dette er for å kunne oppfylle Datatilsynets krav om å informere direkte de personer som omfattes av evalueringen.

Frist for innsending av faktaark til Forskningsrådet er **15.4.2008**. Frist for innsending av navneliste til Forskningsrådet er **7.3.2008**. Materialet sendes elektronisk til Bente Gjelsnes: bg@forskningsradet.no

Egenvurdering. Frist for innsendelse <u>15.4.2008</u>
Egenvurderinger fra instituttene/forskningsgruppene vil utgjøre viktig grunnleggende informasjon for evalueringskomitéen. Det er viktig at egenvurderingen, inklusive CV-er og publikasjonslister fra det vitenskapelige personalet, er utfyllende og kvalitetskontrollert, da disse vil ha stor betydning for komitéens vurdering av forskningen og dens rammebetingelser og for evalueringsrapportens samlede kvalitet.

Vi ber om at instituttene/forskningsgruppene utarbeider egenvurderinger i henhold til vedlagte disposisjon med beskrivelse.

Egenvurderingen inkludert alle vedleggene bes innsendt på papir.
Frist for innsendelse av egenvurderingen er **15.4.2008**.

Før egenvurderingen utformes anbefaler vi at vedlagte mandat leses igjennom. Videre minner vi om at evalueringskomitéen vil foreta vurderinger på både forskergruppe-, institusjons- og nasjonalt nivå.

Egenvurderingene vil bli gjennomgått av Forskningsrådet før materialet oversendes evalueringskomitéen. Som tidligere nevnt, vil møter mellom komitéen og fagmiljøene etter planen bli avholdt i løpet av våren 2008.

Nærmere informasjon
Forskningsrådet legger vekt på at hver enkelt forsker som omfattes av evalueringen, skal få god informasjon. Vi ber derfor instituttledelsen sørge for at hver enkelt vitenskapelig ansatt og post doc får nødvendig informasjon om evalueringen. Det vises også til Forskningsrådets nettsider hvor informasjon om evalueringen vil bli lagt ut.

Vi står foran et utfordrende arbeid og håper at fagmiljøene vurderer den forestående evalueringen som interessant og viktig, og at den vil være nyttig for faget og forskningen. Vi fra vår side, vil gjøre det beste for at arbeidet skal kunne gjennomføres så greit som mulig.

Ta gjerne kontakt hvis dere har spørsmål:

Kontaktpersoner
Spørsmål i tilknytning til fagevalueringen kan rettes til:

- Seniorrådgiver Trude Dypvik, Avdeling for naturvitenskap og teknologi, Divisjon for Vitenskap, tlf. 22 03 73 10, e-post: tdy@forskningsradet.no
- Spesialrådgiver Odd Ivar Eriksen, Avdeling for naturvitenskap og teknologi, Divisjon for Vitenskap, tlf. 22 03 70 23, e-post: oie@forskningsradet.no

Med vennlig hilsen
Norges forskningsråd

Ole Henrik Ellestad
Avdelingsdirektør
Divisjon for Vitenskap
Avdeling for naturvitenskap og teknologi

Trude Dypvik
Seniorrådgiver
Divisjon for Vitenskap

Vedlegg:
- Faktaark med veiledning
- Disposisjon for egenvurderingen
- Mandat
- Tidsplan

Kopi av brev: Rektor og universitetsdirektør, UiO, UiB, UiT, NTNU, UiS og UMB
Det matematisk-naturvitenskapelige fakultet, UiO/UiB/UiT
Fakultet for naturvitenskap og teknologi, NTNU
Teknisk-naturvitskapleg fakultet, UiS

Deadline April 15, 2008

e-mail:bg@forskningsradet.no

FACT SHEET

Department of …………

Organisation – Organisation chart

Personnel

	Research group/unit		***Research group/unit***		***Research group/unit***		***Total***	
Positions	***Univ***	***Extern***	***Univ***	***Extern***	***Univ***	***Extern***	***Univ***	***Extern***
Professor								
Associate professor								
Professor II								
Post-doctoral research fellow								
Doctoral students								
Technical/adm. position*								
Total								

”Univ” = persons financed by the university ”Extern” = persons financed by external research grants
* Technical/adm.position: Positions supporting research

Professors, associate professors and professors II

Name and title	***Born***	***Research group/unit***	***Name***	***Born***	***Research group/unit***

Graduates

	2005	***2006***	***2007***	***Total***
Dr. ing./Dr. scient graduated				
Research group				
Research group				
Research group				
M.Sc.graduated				
Research group				
Research group				
Research group				
Total				

R&D expenditures by main source of funding (1000 NOK)

Type of expenditures	*2005*	*2006*	*2007*
University funding*, salaries			
University funding, other costs			
University funding, instruments and equipment			
University funding, total			
The Research Council, grants			
Other national grants (public or private):			
International grants(incl EU)			
External funding, total			
Total expenditures			
External funding as % of total expenditures			

* University funding: This refers to the institutions input of own resources such as salaries for scientific personnel (including social costs), other costs, and infrastructure.

…………………………………………………….
Date and contact person

Fact Sheet

Do not deviate from the template for the fact sheet!
Make sure that the personnel and organisation in the Fact Sheet corresponds to the self-evaluation.

- ***Organisation – Organisation chart***
  Present a brief, concise description of where the department/research group fits into the university structure. Make a simple organisation chart in Word or Power Point, for example. Additional comments should not exceed five lines.

  It is important that individual research groups should not be identified by the name of the group leader but rather by the scientific activity of their fields of research.

- ***Personnel***
  List the number of the different types of positions per department or research group, if the size of the groups suggests that this would be useful. Persons who have their positions in other departments but who take part in the department's responsibilities regarding research and the education of chemists, should be included. Please give a comment regarding the number of such persons and to which departments their positions belong.

  The abbreviation "Univ" refers to positions funded over a university's basic budget, while "Extern" refers to positions funded by external sources.
  The term "Technical/adm. positions" refers solely to positions that provide support services for the research.

  Make sure that the name and number of the research groups are in accordance with the organisation chart.

- ***Professors, associate professors and professors II***
  This table should include the name, title and year of birth of all the professors, associate professors and professors II who participate in the research at the department, as well as the research group to which they belong, if the size of the group suggests that such a division would be useful.

- ***Graduates***
  In the table "Graduates", list the number of doctoral students and M.Sc who completed their degree over the past three years (2003 to 2005). List the numbers under the different research groups to which they belong. Make sure that the name and number of the research groups are in accordance with the table named Personnel.

- ***R & D expenditures by main source of funding (NOK 1000)***
  This table is intended to furnish an overview of the department's basic grants (University funding) and external funding over the past three years (2003 to 2005). Overhead expenses financed by the University should be listed under University funding, other costs.

- ***Date and contact person***
  The fact sheet should be dated, and name of person responsible for completing the sheet should appear ("faglig ansvarlig kontaktperson").

17.02.2008

SELF-EVALUATIONS

Introduction

The department's self-evaluations provide essential information for the Evaluation Committee. Accordingly, ensuring the high quality of this material, including CVs and lists of publications by the scientific staff, will have a deep impact on the overall quality of the evaluation.

The deadline for submitting the self-evaluations is April 15, 2008.

Please submit self-evaluations, including all attachments, on paper (one copy) and in a format that can be copied directly and forwarded to the Evaluation Committee.

We recommend that you read the mandate before you fill in the self-evaluations.

All self-evaluations will be reviewed by the Research Council before the material is forwarded to the Evaluation Committee. Meetings between the Evaluation Committee and the research units are scheduled to take place in the period 15.05-20.06, 2008. Once the Evaluation Committee has completed the draft report, the relevant sections will be sent to each department to check the facts before the final report is published. The evaluation is limited to assessments and recommendations at the department/research group level, and individual researchers will not be mentioned by name.

Fact sheet

In addition, a fact sheet for the institute/unit should be submitted electronically by **April 15, 2008** to Bente Gjelsnes at the following email address: bg@forskningsradet.no . The fact sheet form can be downloaded from the Research Council's website.

Please use the following outline. You will find a more detailed description of the content required under the various points.

Outline of the self-evaluation

A Department level
1. Organisation of the department
2. The recruitment of researchers
3. Leadership of the research
4. The strengths and weaknesses of the department
5. Previous evaluation of basic research in chemistry
6. Strategy and plans for the future
7. Infrastructure (including major pieces of equipment)
8. General conditions for research
9. Other information of relevance to the evaluation

B Research groups
1. Description of research activities
2. Research collaboration (national, international, industry/public sector)
3. Strategy and organisation
4. Recruitment and mobility of researchers
5. Other information of relevance to the evaluation

Attachments to be included in the self-evaluation

- Brief CV and list of publications for all staff members in academic positions (professor I, professor II, associate professor) and all post-doctoral fellows, see p. 5
- Doctoral graduates, see p. 5

Details about the self-evaluation and the attachments

English is the working language for the evaluation. This means that **the self-evaluation and attachments must all be written in English.** Make sure that the self-evaluation and the fact sheet can be compared.

The self-evaluation should be 10 to 30 pages long, depending on the size of the department. The attachments come in addition. Use font size 12, Times New Roman.

A Department level

1. *Organisation of the department*
   Describe how the department is organised. Give a brief historical overview, with emphasis on organisational changes of significance. Include any ongoing reorganisation and planned changes, and the reasons they are being implemented.
2. *The recruitment of researchers*
   Describe the recruitment of doctoral and post-doctoral fellows to the department over the past five years (2003-2007).

   If the recruitment situation is difficult, discuss the reasons. Have any special initiatives been implemented? What strategy is the department pursuing in this context? Is there a strategy to obtain an equal balance between men and women in research?

   Do the doctoral students spend time at international research institutions and are researchers recruited internationally?

   Are doctoral students offered opportunities related to future oriented industrial research challenges?
3. *Leadership of the research*
   Describe briefly the steering structure, how the research is organised and led, and allocation of resources and decision-making responsibilities at the department.
4. *The strengths and weaknesses of the institute/unit*
   Give a brief evaluation of the professional, financial and organisational strengths and weaknesses of the department. List them as bullet points.
5. *Previous evaluation of basic research in chemistry*
   A previous evaluation of basic chemistry research in Universities and Colleges was performed in 1996/1997 and was followed up by a national strategic plan.

   Were the evaluation and the national strategic plan useful for the department and in which way? How has the previous evaluation and the strategic plan been used by the department in its own strategic plans?
6. *Strategy and plans for the future*
   Present the department's strategy and plans for the future (max. 2 pages).
   What are the department's visions and plans for research, and how are they expressed in the strategy for the years ahead? How does this perspective compare with the department's strengths and weaknesses? List the high-priority areas, scientifically speaking, envisaged for the future. Describe also the extent to which the future plans will affect how research is organised at the department. Please identify any needs associated with the equipment situation and major operating expenses.

7. *Infrastructure (including major pieces of equipment)*
   Describe major infrastructure and in particular investments made in recent years, including descriptions of items of equipment costing more than NOK 700,000 or major operating expenses. Report any need for upgrades or new equipment, including potential sources of funding, and discuss these needs in relation to section 7 ”Strategy and plans for the future”.
8. *General conditions for research*
   Discuss briefly the department’s resources (human, monetary, time), emphasising the latitude the framework offers for basic research. Compare the evaluation with the department’s ambitions. What is done to ensure that the rightful proportion of working time is spent on research?
9. *Other information of relevance to the evaluation*
   Include any other information you consider relevant to the evaluation, but which does not fit in as a natural part of the other sections.

B Research groups

1. *Description of research activities*

Describe the various research activities and the research profile of the group.

Discuss briefly the extent and output of the research activities in relation to the resources and the number of researchers in the group.

Does the group cover an adequate range of research activities in relation to its responsibilities as a university institution?

2. *Research collaboration (national, international, industry/public sector)*
   This section should describe the activities of the group with respect to formal national and international research collaboration, collaboration across faculty divisions, and collaboration with industry and public sector.

   The term ”research collaboration” refers to collaboration with a view to publication, project co-operation, staff researchers hosted by other departments and hosting guest researchers.

   The point is not to provide a list of partners, but rather to evaluate the impact of national and international collaboration on the research performed.
3. *Strategy and organization*
   Describe strategies for the research, and to what extent the strategies are implemented. Describe briefly how the research is organised and led, and decision-making within the research group.
4. *Recruitment and mobility of researchers*
   Do the doctoral students spend time at international research institutions and are researchers recruited internationally?
5. *Other information of relevance to the evaluation*
   Include any other information you consider relevant to the evaluation, but which does not fit in as a natural part of the other sections.

Attachments required for the self-evaluation

CV

For each tenured academic employee (professor I, professor II, associate professor) and for each post-doc fellow. *Max 4 pages excluding appendix!*

Please use the following outline:

Name:
Born:
Nationality:
Present position:
Degrees:
Work experience:
Membership in academic and professional committees:
Present doctoral students supervised:

Selected academic and professional publications 2003-2007 (max two pages)

- Peer-reviewed journals
- International conference proceedings

Fields of interests and present research activities (max one page)

Appendix:
The two most important publications 2003-2007 (enclosed copies)

In addition, please submit up to two pages of text that corroborate and complement the publication list, i.e. a brief discussion/evaluation of the thematic contents, scientific significance of the issues at hand and of the results brought to light.

Doctoral degrees

Please supply a list of doctoral degrees completed over the past five years (2003-2007). The list should include each person's name, title of doctoral thesis, and the name of his/her supervisor.

Review of basic research in Chemistry in Norway

Mandate for the evaluation committee

I INTRODUCTION

The Division of Science at the Research Council of Norway has decided to evaluate basic research activities in Chemistry in Norwegian universities and colleges.

The objective of the evaluation
The objective of this evaluation is to review the overall state of basic research in Chemistry in Norwegian universities and colleges.

Specifically, the evaluation process will:

- Offer a critical review of the strengths and weaknesses of chemistry research in Norway, both nationally and at the level of individual research groups and academic departments, and review the scientific quality of basic research in an international context.

- Identify research groups which have achieved a high international level in their research, or which have the potential to reach such a level.

- Identify areas of research that need to be strengthened in order to ensure that Norway in the future will possess necessary competence in areas of importance for the nation. And, as one aspect of this, enable the Research Council of Norway to assess the impending situation regarding recruitment in important fields of Chemistry.

The long-term purpose of the review
The evaluation will provide the institutions concerned with the knowledge they require to raise their own research standards. They will be provided with feedback regarding the scientific performance of individual research groups, as well as suggestions for improvements and priorities.

The evaluation will improve the knowledge base for strategic decision-making by the Research Council, function as a platform for future work on developing Chemistry and represent a basis for determining future priorities, including funding priorities, within and between individual areas of research.

The evaluation will reinforce the role of the Research Council as advisor to the Norwegian Government and relevant ministries.

Methods
An international Evaluation Committee will be appointed. The Evaluation Committee should base its assessments on self-evaluations provided by the departments/research groups as well as meetings with the various departments and research groups with oral presentations. The Evaluation Committee will decide a program for site visits to the institutions. A part of the self-evaluations will be information about the department's organisation and resources, development and future plans, as well as CVs and publication lists of the scientific staff. The Committee is requested to write a report with a set of specific recommendations. A preliminary report will be sent to the departments for comments. The Committee's final report will be submitted to the Research Council's Board of the Division for Science.

II MANDATE

Based on the self-assessments provided by the institutions and site visits the Evaluation Committee is expected to present the evaluation in a written report with a set of specific recommendations for the future development of the field, including means of improvement when required. The Committee is requested to evaluate scientific activities with respect to their quality, relevance and international and national collaboration. The Committee is further requested to evaluate the way in which Chemistry research is organised and managed.

The institutions are very different with regard to scientific staff, resources and research activities. The evaluation and the Committee's recommendations must take these differences into consideration.

The conclusions of the committee should lead to a set of recommendations concerning the future development of research in Chemistry in Norway.

Specific aspects to be considered:

1. General aspects

- Which fields of research in Chemistry have a strong scientific position in Norway and

- which have a weak position? Is Norwegian research in Chemistry being carried out in fields that are regarded as relevant by the international research community? Is Norwegian research in Chemistry ahead of scientific developments internationally within specific areas?

- Is there a reasonable balance between the various fields of Norwegian research in Chemistry, or is research absent or underrepresented in any particular field? On the other hand; are some fields overrepresented, in view of the quality or scientific relevance of the research that is being carried out?

- Is there a reasonable degree of co-operation and division of research activities at national level, or could these aspects be improved?

- Do research groups maintain sufficient contact with industry and the public sector?

2. Academic departments

- Are the academic departments adequately organised?
- Is scientific leadership being exercised in an appropriate way?
- Do individual departments carry out research as part of an overall research strategy?
- How is the balance between men and women in academic positions?

3. Research groups

- Do the research groups maintain a high scientific quality judged by the significance of contribution to their field, prominence of the leader and team members, scientific impact of their research?
- Is the productivity, e.g. number of scientific and Ph. D. thesis awarded, reasonable in terms of the resources available?
- Do the research groups have contracts and joint projects with external partners?
- Do they play an active role in dissemination of their own research and new international developments in their field to industry and public sector?
- Do they play an active role in creating and establishing new industrial activity?
- Is the international network e.g. contact with leading international research groups, number of international guest researchers, *and number of joint publications with international colleagues,* satisfactory?
- Do they take active part in international professional committees, work on standardization and other professional activities?
- Have research groups drawn up strategies with plans for their research, and are such plans implemented?
- Is the size and organization of the research groups reasonable?
- Is there sufficient contact and co-operation among research groups nationally, in particular, how do they cooperate with colleagues in the research institute sector?
- Do the research groups take active part in interdisciplinary/multidisciplinary research activities?

- How is the long term viability of the group evaluated in view of future plans and ideas, staff age, facilities, research profile, new impulses through recruitment of researchers ?

- What roles do Norwegian research groups play in international co-operation in individual subfields of Chemistry? Are there any significant differences between Norwegian research in Chemistry and research being done in other countries?

- Do research groups take part in international programmes or use facilities abroad, or could utilisation be improved by introducing special measures?

4. Research infrastructure incl. scientific equipment

- How is the status and future needs with regard to laboratories and research infrastructure?
- Is there sufficient co-operation related to the use of expensive equipment?

5. Training and mobility

- Does the scientific staff play an active role in stimulating the interest for their field of research among young people?
- Is recruitment to doctoral training programs satisfactory, or should greater emphasis be put on recruitment in the future?
- Is there an adequate degree of national and international mobility?
- Are there sufficient educational and training opportunities for Ph. D. students?

6. Future developments and needs

The Committee's written report is expected to be based on the elements and questions above. The assessments and recommendations should be at research group-, department-, institutional and national level.

7. Miscellaneous

Are there any other important aspects of Norwegian research in Chemistry that ought to be given consideration?

Evaluering av forskningen i kjemifagene – Tidsplan

Dato	**Milepæler**
17.12.07	Brev til institusjonene (innspill til komitémedlemmer, evt. kommentarer)
23.01.08	Møte mellom Forskningsrådet og institusjonene
06.02.08	Godkjenning av mandat og plan for evalueringen i Divisjonsstyret
15.02.08	Brev til institusjonene (egenevaluering, faktaark)
07.03.08	Innsendelse av lister med navn på vitenskapelig ansatt og post docs som omfattes av evalueringen
medio mars 08	Sammensetningen av komitéen er avklart
15.04.08	Innsendelse av faktaark og egenevaluering fra institusjonene
15.05.-20.06.08	Møter/*site visits*
01.09.08	Utkast til evalueringsrapport foreligger, til institusjonene for faktakontroll og kommentarer
10.09.08	Fagplanutvalg og opplegg for fagplan behandles i DSV
01.10.08	Tilbakemeldinger fra institusjonene
01.11.08	Endelig evalueringsrapport foreligger
12.11.08	Behandling av evalueringsrapporten i DSV
medio mars 09	Fagplanen for kjemi ferdigstilles og behandles i DSV

Separate letters sent by e-mail to the departments in June 2008

To the Head of Department

Evaluation of chemical research in Norway

Hearing meetings in Trondheim - Time schedule and guidelines for the departments/research groups preparations

We refer to the announced week of hearing meetings in Trondheim.

Enclosed you will find the time schedule for the meetings with the Evaluation Committee. Each department is responsible for checking out day and time for the meetings. As already announced, the meetings will be held from Monday September 1 to Thursday September 4 at Britannia Hotel in Trondheim.

The Departments` Preparation for the Meetings – SWOT-analysis
Each meeting will follow the same structure: introduction and presentation by the department or research group and questions by the Committee.

The ratio between introduction and questions should be about 20 – 80. If the time set for the meeting with the department is two hours, the introduction should take maximum 24 minutes of the available time (including the presentations of the different research groups). To secure enough time for questions, the Committee is entitled to interrupt speakers who do not keep the time schedule.

In the self evaluations the department/research groups have already described weaknesses and strengths. We suggest that the presentation concentrate on these and in addition on the strengths and weaknesses you see for your activity in a longer perspective. Together this will constitute a SWOT-analysis (Strengths and Weaknesses (to day), Opportunities and Threats (in the future).

In the presentations, do not repeat what the Committee already know from the self evaluations.

The presentation from the Head of department should not take too much of the available time, approximately 15 minutes would do. Please make sure there will be enough time for the presentations from the research groups and for questions from the Committee.

We recommend bringing presentations on a memory stick. Please bring also with you 10 handouts for the Committee during the presentation. The handouts should be copied in the Power Points format "Støtteark", with 3 slides per page. All presentations must be written and held in English.

Information from the meetings should be regarded as additional information to the written material that the Committee has already received, and which is regarded as the main material for the evaluation.

Summary, guidelines:

- Avoid repeating the written self-evaluation
- Focus on strengths, weaknesses, opportunities and threats (SWOT- analyses)
- The ratio between presentation and questions from the panel should be 20 -80 %

Participation
Please forward a list of the department's participations in the meeting (name and title) together with a plan for the presentations to Trude Dypvik, tdy@forskningsradet.no before **August 15**. Of practical reasons only a limited number of researchers can participate in the meeting with the Committee. The Research Council might require you to reduce the number of participants if the group is regarded to be too large.

The Research Council will cover travel cost for 6 participants from UiO.

The Committee chair asks you specifically to include a junior researcher among the participants. If necessary it might be possible to cover the travel cost for an additional participant to the meeting providing this is a junior researcher, this will have to be approved by the Research Council before you do the travel arrangements.

Practical matters
All meetings will take place at Britannia Hotel in Trondheim. The Air Shuttle Bus stops close to the hotel. All travel expenses in connection with the meeting will be reimbursed for the number of participants stated above. We do not expect that overnights in Trondheim will be necessary.

If you have any questions, please contact:

- Senior adviser Trude Dypvik, phone + 47 22 03 73 10 , e-mail tdy@forskningsradet.no
- Project coordinator Malena Bakkevold, phone + 47 64 97 28 72/95 75 05 33, e-mail: post@malena.no

For practical matters, please contact:

- Consultant Bente Gjelsnes, + 47 2203 , e-mail bg@forskningsradet.no

The Committee and The Research Council look forward to an important and hectic week and thank you in advance for your contributions.

Yours sincerely
The Research Council of Norway

Odd Ivar Eriksen Acting Director Division of Science	Trude Dypvik Senior Adviser Division of Science

Aug 20
2008

Evaluation of Norwegian research in Chemistry
Time schedule for the Hearing Meetings and Site Visits in Trondheim

Date	Time	Institution and Department	Participants and Research groups
Monday		The Norwegian University of Science and Technology (NTNU)	
Sept 1 **2008**	0830–1000	Department of Chemistry	• Organic Chemistry • Physical Chemistry • Chemistry Dissemination Group • Environmental and Analytical Chemistry
	1000-1015	Break	
	1015 -1130	**Department of Chemistry cont.**	
	1130 -1230	Lunch	
	1230 -1400	**Department of Chemical Engineering**	• Catalysis Group • Colloid and polymer Group • Proces Systems Engineering Group • Reactor technology group • Separation Group • Pulp and paper Group
	1400-1415	Break	
	1415-1530	**Department of Chemical Engineering cont.**	
	1530-1545	*Break*	
		Norwegian Institute for Air Research (NILU)	
	1545-1645	**Environmental Chemistry Department**	
	1645 -1700	*Break*	
	1700 –1730	Committee's 30 minutes	
	1930 -	*Dinner*	

Evaluation of Norwegian research in Chemistry
Time schedule for the Hearing Meetings and Site Visits in Trondheim

Date	Time	Institution/department	Participants and Research groups
Tuesday Sept 2 **2008**	0830 -0900	Committee’s 30 minutes	
		University of Oslo	
	0900- 1100	**Department of Chemistry**	• Synthesis and Molecular Structure • Analysis and Environment • Nuclear Chemistry • Functional Inorganic Materials • Catalysis • Polymers-organic Materials • Quantum Mechanics, Structure and Dynamics • School laboratory
	1100 -1115	Break	
	1115– 1215	**Department of Chemistry cont.**	
	1215- 1315	Lunch	
	1315-1515	Department of Chemistry cont.	
	1515-1530	**Break**	
	1530 -1730	Department of Chemistry cont.	
	1730 -1800	Committee’s 30 minutes	
	1930 -	*Dinner*	

Evaluation of Norwegian research in Chemistry
Time schedule for the Hearing Meetings and Site Visits in Trondheim

Date	Time	Institution/department	Research groups
Wed Sept 3 **2008**			
	0815-0845	*Departure for site visit at NTNU*	
	0845-1030	*Site visit: Department of Chemistry and Department of Chemical Engineering*	
	1030-1100	*Departure for interviews at the hotel*	
		University of Bergen	
	1100– 1300	**Department of Chemistry**	• Organic, Biophysical and Medicinal Chemistry • Physical-, Petroleum- and Process Chemistry • Inorganic Chemistry, Nanostructures and Modelling
	1300 -1400	Lunch	
	1400 - 1500	**Department of Chemistry cont.**	
	1500 -1630	**University of Tromsø**	• Organic Chemistry • Inorganic and Materials Chemistry • Organic Chemistry • Structural Chemistry
	1630-1645	Break	
	1645-1800	Meeting with PhD-students	
	1920 - 1930	*Departure*	
	1930 -	*Visit at Ringve National museum of music and musical instruments and dinner with RCN*	

Evaluation of Norwegian research in Chemistry
Time schedule for the Hearing Meetings and Site Visits in Trondheim

Date	Time	Institution/department	Participants and Research groups
Thur Sept 4 **2008**	0830 –0900	Committee's 30 minutes	
		NTNU cont.	
	0900- 1030	**Department of Materials Science and Engineering**	• Inorganic Chemistry • Electrochemistry
	1030-1045	Break	
		University of Stavanger	
	1045 –1145	Department of Mathematics and Natural Science	• Biological Chemistry • Chemistry and Environment
	1145-1300	Lunch	
	1300- 1330	**Departure for site visit at NTNU**	
	1330 –1430	*Site visit: Department of Material Sciences and Engineering*	
	1430-1500	*Departure for interviews at the hotel*	
	1500-1600	University of Life Sciences	• Environmental Chemistry • Organic Chemistry
	1600-1700	*Final meeting of Committee*	
		Departure for the Airport for site visits (Tromsø, NILU, UMB)	

Site visits – The Committee Members participation

September

September 3 and 4:

- **Norwegian University of Science and Technology, Trondheim**

- **Department of Chemistry:** David Fowler
  Thisbe Lindhorst
  Paul Madden

- **Department of Chemical Engineering:** Evamarie Hey-Hawkins
  Robert Cava
  Paul Madden
  Daniel Duprez
  Gerhard Schembecker

- **Department of Material Science and Engineering:** Evamarie Hey-Hawkins
  Robert Cava
  Daniel Duprez
  Gerhard Schembecker

September 5:

- **University of Tromsø:** Evamarie Hey-Hawkins
  Thisbe Lindhorst
  Paul Madden

- **Norwegian University of Life Sciences, Ås:** David Fowler

- **Norwegian Institute for Air Research, NILU, Kjeller:** David Fowler

October

October 6:

- **University of Bergen:** Evamarie Hey-Hawkins
  Paul Madden
  Thisbe Lindhorst

October 7:

- **University of Oslo:** Evamarie Hey-Hawkins
  Paul Madden
  Thisbe Lindhorst
  Daniel Duprez

- **Norwegian University of Life Sciences, Ås:** Thisbe Lindhorst

October 8:

- **University of Stavanger:** Evamarie Hey-Hawkins
  Daniel Duprez

BIBLIOMETRIC ANALYSIS

Evaluation of Chemistry in Norway

Bibliometric analysis

Dag W. Aksnes

NIFU STEP
Oslo

SEPTEMBER 2008

Preface

This report presents a bibliometric analysis of chemistry research in Norway and is a background report of the evaluation of the discipline. The report is written on the commission of the Research Council of Norway by senior researcher Dag W. Aksnes at the Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP).

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1 Introduction: Bibliometric indicators

Publication and citation data have increasingly been applied as performance indicators in the context of science policy and research evaluation. The basis for the use of bibliometric indicators is that new knowledge – the principal objective of basic and applied research – is disseminated to the research community through publications. Publications can thereby be used as indirect measures of knowledge production. Data on how much the publications have been referred to or cited in the subsequent scientific literature can in turn be regarded as an indirect measure of the scientific impact of the research.

This report presents the results of a bibliometric study of the institutions included in the evaluation of chemistry research in Norway. Both the institution/department level and the research group level are analysed. In addition the report contains a macro analysis of Norwegian chemistry research in international comparison.

The analysis is based on two data sources: Publication lists submitted by the researchers encompassed by the evaluation (i.e. self-reported publication data) and data provided by Institute for Scientific Information (ISI), the producer of the most important database for bibliometric purposes (now Thomson Scientific). In this first chapter we will provide a general introduction to bibliometric indicators, particularly focusing on analyses based on the ISI-database.[1]

1.1 The ISI-database

The ISI database covers a large number of specialised and multidisciplinary journals within the natural sciences, medicine, technology, the social sciences and the humanities. The coverage varies between the different database products. According to the website of the Thomson Scientific company, the most well-known product the *Science Citation Index* today covers 3,700 journals, and the expanded version of this publication database (Science Citation Index Expanded) 5,800 journals. The online product *Web of Science* covering the three citation indexes *Science Citation Expanded*, *Social Sciences Citation Index*, and *Arts & Humanities Citation Index* includes 8,500 journals. Compared to the large volume of scientific and scholarly journals that exist today, this represents a limited part. The selection of journals is based on a careful examination procedure in which a journal must meet particular requirements in order to be included (Testa, 1997). Even if its coverage is not complete, the ISI database will include all major journals within the natural sciences,

[1] This introduction is based on Aksnes (2005).

medicine and technology and is generally regarded as constituting a satisfactory representation of international mainstream scientific research (Katz & Hicks, 1998). With respect to the social sciences and humanities the coverage is more limited, and this issue will be further discussed below.

From a bibliometric perspective, a main advantage of the ISI database is that it fully indexes the journals that are included. Moreover, all author names, author addresses and references are indexed. Through its construction it is also well adapted for bibliometric analysis. For example, country names and journal names are standardised, controlled terms. It is also an advantage that it is multidisciplinary in contrast to most other similar databases which cover just one or a few scientific disciplines.

1.2 Citation indicators

Citations represent an important component of scientific communication. Already prior to the 19th century it was a convention that scientists referred to earlier literature relating to the theme of the study (Egghe & Rousseau, 1990). The references are intended to identify earlier contributions (concepts, methods, theory, empirical findings, etc.) upon which the present contribution was built, and against which it positions itself. Thus, it is a basic feature of the scientific article that it contains a number of such references and that these references are attached to specific points in the text.

This ISI-database was originally developed for information retrieval purposes, to aid researchers in locating papers of interest in the vast research literature archives (Welljams-Dorof, 1997). As a subsidiary property it enabled scientific literature to be analysed quantitatively. Since the 1960s the *Science Citation Index* and similar bibliographic databases have been applied in a large number of studies and in a variety of fields. The possibility for citation analyses has been an important reason for this popularity. As part of the indexing process, ISI systematically registers all the references of the indexed publications. These references are organised according to the publications they point to. On this basis each publication can be attributed a citation count showing how many times each paper has been cited by later publications indexed in the database. Citation counts can then be calculated for aggregated publications representing, for example, research units, departments, or scientific fields.

1.3 What is measured through citations?

Because citations may be regarded as the mirror images of the references, the use of citations as indicators of research performance needs to be justified or grounded in the referencing behaviour of the scientists (Wouters, 1999). If scientists cite the work they find useful, frequently cited papers are assumed to have been more useful than publications which are hardly cited at all, and possibly be more useful and thus important in their own right. Thus, the number of citations may be regarded as a measure of the article's usefulness, impact, or influence. The same reasoning can be used for aggregated levels of articles. The more citations they draw, the greater their influence must be. Robert K. Merton has provided the original theoretical basis for this link between citations and the use and quality of scientific contribution. In Merton's traditional account of science, the norms of science oblige researchers to cite the work upon which they draw, and in this way acknowledge or credit contributions by others (Merton, 1979). Such norms are upheld through informal interaction in scientific communities and through peer review of manuscripts submitted to scientific journals.

Empirical studies have shown that the Mertonian account of the normative structure of science covers only part of the dynamics. For the citation process, this implies that other incentives occur, like the importance of creating visibility for one's work, and being selective in referencing to create a distance between oneself and others. Merton himself already pointed out the ambivalence of the norms, for example that one should not hide one's results from colleagues in one's community, but also not rush into print before one's findings are robust. Merton also identified system level phenomena like the "Matthew effect": to whom who has shall be given more. Clearly, a work may be cited for a large number of reasons including tactical ones such as citing a journal editor's work as an attempt to enhance the chances of acceptance for publication. Whether this affects the use of citations as performance indicators is a matter of debate (Aksnes, 2003b).

The concept of quality has often been used in the interpretation of citation indicators. Today, however, other concepts – particularly that of "impact" – are usually applied. One reason is that quality is often considered as a diffuse or at least multidimensional concept. For example, the following description is given by Martin and Irvine (1983): "'Quality' is a property of the publication and the research described in it. It describes how well the research has been done, whether it is free from obvious 'error' […] how original the conclusions are, and so on." Here, one sees reference to the craft of doing scientific research, and to the contribution that is made to the advance of science.

The impact of a publication, on the other hand, is defined as the "actual influence on surrounding research activities at a given time." According to Martin and Irvine it is the impact of a publication that is most closely linked to the notion of scientific progress – a paper creating a great impact represents a major contribution to knowledge at the time it is published. If these definitions are used as the basis it is also apparent that impact would be a more suitable interpretation of citations than quality. For example, a 'mistaken' paper can nonetheless have a significant impact by stimulating further research. Moreover, a paper by a recognised scientist may be more visible and therefore have more impact, earning more citations, even if its quality is no greater than those by lesser known authors (Martin, 1996).

1.4 Some basic citation patterns

De Solla Price showed quite early that recent papers are more cited than older ones (Price, 1965). Nevertheless, there are large individual as well as disciplinary differences. The citation counts of an article may vary from year to year. Citation distributions are extremely skewed. This skewness was also early identified by Solla Price (Price, 1965). The large majority of the scientific papers are never or seldom cited in the subsequent scientific literature. On the other hand some papers have an extremely large number of citations (Aksnes, 2003a; Aksnes & Sivertsen, 2004).

Citation rates vary considerably between different subject areas. For example, on average papers in molecular biology contain many more references than mathematics papers (Garfield, 1979b). Accordingly, one observes a much higher citation level in molecular biology than in mathematics. Generally, the average citation rate of a scientific field is determined by different factors, most importantly the average number of references per paper. In addition, the percentage of these references that appears in ISI-indexed journals, the average age of the references, and the ratio between new publications in the field and the total number of publications, are relevant.

1.5 Limitations

In addition to the fundamental problems related to the multifaceted referencing behaviour of scientists, there are also more specific problems and limitations of citation indicators. Some of these are due to the way the ISI database is constructed. First of all, it is important to emphasise that only references in ISI-indexed literature count as “citations”. For example, when articles are cited in non-indexed literature (e.g. a trade journal) these are not counted. This has important consequences. Research of mainly national or local interest, for example, will usually not be cited in international journals. Moreover, societal relevance, such as contributions of importance for technological or industrial development, may not be reflected by such counts. Because it is references in (mainly) international journals which are indexed, it might be more appropriate to restrict the notion of impact in respect to citation indicators to impact on international or “mainstream” knowledge development.

There is also a corresponding field dimension. For example, LePair (1995) has emphasised that “In technology or practicable research bibliometrics is an insufficient means of evaluation. It may help a little, but just as often it may lead to erroneous conclusions.” For similar reasons the limitations of citation indicators in the social sciences and humanities are generally more severe due to a less centralised or a different pattern of communication. For example, the role of international journals is less important, and publishing in books is more common: older literature has a more dominant role and many of the research fields have a "local" orientation. In conclusion, citation analyses are considered to be most fair as an evaluation tool in the scientific fields where publishing in the international journal literature is the main mode of communication.

Then there are problems caused by more technical factors such as discrepancies between target articles and cited references (misspellings of author names, journal names, errors in the reference lists, etc.), and mistakes in the indexing process carried out by Thomson Scientific (see Moed, 2002; Moed & Vriens, 1989). Such errors affect the accuracy of the citation counts to individual articles but are nevertheless usually not taken into account in bibliometric analyses (although their effect to some extent might "average out" at aggregated levels).

While some of the problems are of a fundamental nature, inherent in any use of citations as indicators, other may be handled by the construction of more advanced indicators. In particular, because of the large differences in the citation patterns between different scientific disciplines and subfields, it has long been argued by bibliometricians that relative indicators and not absolute citation counts should be used in cross-field comparisons (Schubert & Braun, 1986; Schubert & Braun, 1996; Schubert, Glänzel, & Braun, 1988; Vinkler, 1986). For example, it was early emphasised by Garfield that: "Instead of directly comparing the citation counts of, say, a mathematician against that of a biochemist, both should be ranked with their peers, and the comparison should be made between rankings" (Garfield, 1979a). Moed et al. (1985) similarly stressed that: "if one performs an impact evaluation of publications from various fields by comparing the citation counts to these publications, differences between the citation counts can not be merely interpreted in terms of (differences between) impact, since the citation counts are partly determined by certain field-dependent citation characteristics that can vary from one field to another".

A fundamental limitation of citation indicators in the context of research assessments is that a certain time period is necessary for such indicators to be reliable, particularly when considering smaller number of publications. Frequently, in the sciences a three-year period is considered as appropriate (see e.g. Moed et al., 1985). But for the purpose of long-term assessments more years are required. At the same time, an excessively long period makes the results less usable for evaluation purposes. This is because one then only has citation data for articles published many years previously. Citation indicators are not very useful when it comes to publications published very recently, a principal limitation of such indicators being that they cannot provide an indication of present or future performance except indirectly: past performance correlates with future performance (Luukkonen, 1997). It should be added, however, that this time limitation does not apply to the bibliometric indicators based on publication counts.

1.6 Bibliometric indicators versus peer reviews

Over the years a large number of studies have been carried out to ascertain the extent to which the number of citations can be regarded as a measure of scientific quality or impact. Many studies have also found that citation indicators correspond fairly well, especially in the aggregate, with various measures of research performance or scientific recognition which are taken as reflecting quality. On the other hand, there have been several studies challenging or criticising such use of citations.

One approach to the question is represented by studies analysing how citations correlate with peer reviews. In these studies judgements by peers have been typically regarded as a kind of standard by which citation indicators can be validated. The idea is that one should find a correlation if citations legitimately can be used as indicators of scientific performance (which assumes that peer assessment can indeed identify quality and performance without bias – a dubious assumption). Generally, most of the studies seem to have found an overall positive correspondence although the correlations identified have been far from perfect and have varied among the studies (see e.g. Aksnes & Taxt, 2004, Aksnes, 2006).

Today most bibliometricians emphasise that a bibliometric analysis can never function as a substitute for a peer review. Thus, a bibliometric analysis should not replace an evaluation carried out by peers. First a peer-evaluation will usually consider a much broader set of factors than those reflected through bibliometric indicators. Second, this is due to the many problems and biases attached to such analyses. As a general principle, it has been argued that the greater the variety of measures and qualitative processes used to evaluate research, the greater is the likelihood that a composite measure offers a reliable understanding of the knowledge produced (Martin, 1996).

At the same time, it is generally recognised that peer reviews also have various limitations and shortcomings (Chubin & Hackett, 1990). For example, van Raan (2000) argues that subjectivity is a major problem of peer reviews: The opinions of experts may be influenced by subjective elements, narrow mindedness and limited cognitive horizons. An argument for the use of citation indicators and other bibliometric indicators is that they can counteract shortcomings and mistakes in the peers' judgements. That is, they may contribute to fairness of research evaluations by representing "objective" and impartial information to judgements by peers, which would otherwise depend more on the personal views and experiences of the scientists appointed as referees (Sivertsen, 1997). Moreover, peer assessments alone do not provide sufficient information on important aspects of research productivity and the impact of the research activities (van Raan, 1993).

Citations and other bibliometric indicators have been applied in various ways in research evaluation. For example, such indicators are used to provide information on the performance of research groups, departments, institutions or fields. According to van Raan (2000), “the application of citation analysis to the work – the oeuvre – of a group as a whole over a longer period of time, does yield in many situations a strong indicator of scientific performance, and, in particular, of scientific quality”. As a qualifying premise it is emphasised, however, that the citation analysis should adopt an advanced, technically highly developed bibliometric method. In this view, a high citation index means that the assessed unit can be considered as a scientifically strong organisation with a high probability of producing very good to excellent research.

In this way a bibliometric study is usually considered as complementary to a peer evaluation. Van Raan has accordingly suggested that in cases where there is significant deviation between the peers’ qualitative assessments and the bibliometric performance measures, the panel should investigate the reasons for these discrepancies. They might then find that their own judgements have been mistaken or that the bibliometric indicators did not reflect the unit’s performance (van Raan, 1996).[2]

In conclusion, the use of citations as performance measures have their limitations, as all bibliometric indicators have. But a citation analysis when well designed and well interpreted will still provide valuable information in the context of research evaluation. Performance, quality and excellence can also be assessed through peer review, but in spite of their widespread use, these have problems as well. A combination of methods, or better, mutual interplay on the basis of findings of each of the methods, is more likely to provide reliable evaluation results.

1.7 Co-authorship as an indicator of collaboration[3]

The fact that researchers co-author a scientific paper reflects collaboration, and co-authorship may be used as an indicator of such collaboration. Computerised bibliographic databases make it possible to conduct large-scale analyses of scientific co-authorship. Of particular importance for the study of scientific collaboration is the fact that the ISI (Thomson Scientific) indexes all authors and addresses that appear in papers, including country as a controlled term.

[2] Van Raan (1996) suggests that in cases were conflicting results appear, the conclusion may depend on the type of discrepancy. If the bibliometric indicators show a poor performance but the peer’s judgement is positive, then the communication practices of the group involved may be such that bibliometric assessments do not work well. By contrast, if the bibliometric indicators show a good performance and the peers’ judgement is negative, then it is more likely that the peers are wrong.

[3] This section is based on Wendt, Slipersæter, & Aksnes (2003).

By definition a publication is co-authored if it has more than one author, internationally co-authored if it has authors from more than one country. Compared to other methodologies, bibliometrics provides unique and systematic insight into the extent and structure of scientific collaboration. A main advantage is that the size of the sample that can be analysed with this technique can be very large and render results that are more reliable than those from case studies. Also, the technique captures non-formalised types of collaboration that can be difficult to identify with other methodologies.

Still, there are limitations. Research collaboration sometimes leads to other types of output than publications. Moreover, co-authorship can only be used as a measure of collaboration if the collaborators have put their names on a joint paper. Not all collaboration ends up in co-authorship and the writing of co-authored papers does not necessarily imply close collaboration (Katz & Martin, 1997; Luukkonen, Persson, & Sivertsen, 1992; Melin & Persson, 1996). Thus, international co-authorship should only be used as a partial indicator of international collaboration (Katz and Martin 1997). As described above there are also particular limitations with the ISI database, represented by the fact that regional or domestic journals, books, reports etc. are not included.

Smith (1958) was among the first to observe an increase in the incidence of multi-authored papers and to suggest that such papers could be used as a rough measure of collaboration among groups of researchers (Katz and Martin 1997). In a pioneering work, Derek de Solla Price also showed that multiple authorship had been increasing (Price, 1986). These findings have later been confirmed by a large number of similar studies (e.g. (Merton & Zuckerman, 1973; National Science Board, 2002). In the natural sciences and medicine the single-author paper is, in fact, becoming an exception to the norm. In the case of Norway, 86 % of ISI-indexed papers were co-authored in 2000, compared to 66 % in 1981.

Scientific collaboration across national borders has also significantly increased over the last decades. According to Melin and Persson (1996) the number of internationally co-authored papers has doubled in about fifteen years. In Norway every second paper published by Norwegian researchers now has foreign co-authors compared to 16 % in 1981. Similar patterns can be found in most countries. Bibliometric analysis thus provides evidence to the effect that there is a strong move towards internationalisation in science and that the research efforts of nations are becoming more and more entwined.

The move toward internationalisation is also reflected in the publishing practices of scientists: English has increasingly become the lingua franca of scientific research, and publishing in international journals is becoming more and more important, also in the areas of social science and the humanities.

As might be expected, nations with big scientific communities have far more collaborative articles than have smaller countries (Luukkonen, Tijssen, Persson, & Sivertsen, 1993), though one finds a trend to the effect that the proportion of internationally co-authored papers increases along with decreasing national volume of publications (see e.g. Luukkonen, Persson et al. 1992, National Science Board 2002), hence international collaboration is relatively more important in smaller countries. This is probably a consequence of researchers from small countries often having to look abroad for colleagues and partners within their own speciality. Size is, however, not the only factor with bearing on the extent of international collaboration; access to funding, geographical location, and cultural, linguistic and political barriers are other important factors (Luukkonen, Persson et al. 1992, Melin and Persson 1996).

Bibliometric techniques allow analysis of structures of international collaboration. For almost all other countries, the United States is the most important partner country; this reflects this country's pre-eminent role in science. In 1999, 43 % of all published papers with at least one international co-author had one or more U.S. authors. For Western Europe the share of U.S. co-authorship ranged from 23 % to 35 % of each country's internationally co-authored papers (National Science Board 2002). Generally, one also finds that most countries have much collaboration with their neighbouring countries (e.g. collaboration among the Nordic countries). Over the last decade we find a marked increase in co-authorship among western European countries; this probably mainly reflects the EU framework programmes.

2 Data and methods

This chapter gives an overview of the data and the methodology applied in the study.

2.1 Data

The study is based on two sources of data: Publication lists (provided by the researchers themselves) and ISI-data.

As part of the evaluation procedure the researchers submitted their CVs/publications lists to the Research Council of Norway. The tenured academic employees (professor I, professor II, associate professor) and post doc fellows included in the evaluation were asked by the Research Council (in letter dated 2 February 2008) to list their academic and professional publications for the past five years (i.e. 2003 – 2007) in the following categories[4]:

- Peer-reviewed journals
- International conference proceedings

Since this study has been based on the submitted publication lists we cannot provide a complete analysis of the publication output of researchers. Publications not covered by the above categories are not included (for example material such as popular science articles, reports, feature articles, book reviews are outside the scope of the categories given above). It appeared difficult to analyse the publications listed as conference proceedings. Based on the information given in the publication lists it was often impossible to determine whether a conference contribution had been published or not, or whether it had been published as an abstract or a full paper. Most of the listed publications were probably in the category of published abstracts/extended abstracts. We therefore decided to omit these publications/contributions from the analysis. Although an abstract may contain interesting original information, the value of an abstract is highly transient, and will usually be superseded by a more extensive report published in a journal (Seglen 2001).

This means that the analysis is limited to the journal articles. In chemistry, journals represent the channel were the principal and large majority of the original research results are published. In some of the analyses we have however also included other international contributions listed by the researchers (books, articles in edited books).

[4] In the original letter the Research Council requested a "selected" publication list of max two pages. However, later in a follow-up e-mail the researchers were asked to submit their complete publication list in the above mentioned categories. These publication lists have been used in the analysis.

It is common to apply a distinction between national and international journals. These literatures form distinct, yet partially overlapping worlds, each serving a different purpose. The international journals comprise internationally oriented, largely English language peer reviewed articles. National journals on the other hand, communicate with a local scholarly community. In chemistry, only a very small number of the publications represent items being published in national journals – at least in Norway. These publications have therefore been excluded. Thus the analysis only includes articles in international journals (and "international" books, and book articles with scientific content).

As described above the analysis is based on the self-reported publication data. Some publications were multiply reported. The reason is that when a publication is written by several authors it will appear on the publication lists of all the authors, and will accordingly occur more than one time. In order to handle this problem we removed all the multiply reported items, i.e. only unique publications were left.

Separate analyses were provided for the tenured (i.e. professor and associate professors) and the non-tenured personnel (i.e. post. docs and researchers). Persons who had retired during the period analysed were not included. We decided to exclude professor IIs (and associate professor IIs) from the publication analysis (persons with 20 % appointments), since their research for the most part is financed and carried out elsewhere. Their research papers co-authored with tenured staff would appear on the publication lists of the latter anyway.[5]

From the Research Council of Norway we obtained information on the name of the persons encompassed by the evaluation. We used each researcher's submitted publication lists as a reference standard for the inclusion and deletion of articles. Various search techniques had to be applied in order to identify the correct articles, although most of them were identified by simple searches based on author names. The bibliographic details of the articles were collected, including the number of citations. We considered only publications classified as *regular articles* and *reviews*. Editorials, meeting abstracts, letters, corrections are *not* included.

We applied ISI-databases which NIFU STEP has purchased from Thomson Scientific. One basic database is the *National Citation Report* (NCR) for Norway, containing bibliographic information for all Norwegian articles (articles with at least one Norwegian author address). Data for each paper include all author names, all addresses, article title, journal title, document type (article, review, editorial, etc.), field category, year by year and

[5] Since professor IIs are usually appointed on the basis of their scientific merit, they can be very productive, and may account for a major fraction of a group's scientific production if they were included.

total citation counts and expected citation rates (based on the journal title, publication year and document type). The 2008 edition of NCR, with data covering 1981-2007 was used.

In addition, the *National Science Indicators* (NSI) database containing aggregated bibliometric data at country and field/subfield level was used. This database was mainly applied for the purpose of creating reference standards.

A small fraction of the articles were not published in ISI-indexed journals. These articles are therefore not included in some of the analyses (analyses of citation rates and collaboration).

2.2 Methods

In the study the individual researcher represents the basic unit, and the data were subsequently aggregated to the level of departments/units. We have used the group/section structure described in the factual information reports the departments have submitted to the Research Council of Norway. Here the departments have listed the persons that are included in the evaluation and their group/section affiliations. In other words, we have applied a personnel based definition where a department or group is delimited according to the scientific staff included in the evaluation.[6] In should be noted that some of the "groups" represent more informal structures where other "groups" correspond to formal subdivisions within the departments. We have included all publications of the individuals examined, even if it included work done before they became affiliated at the respective departments. The scientific production of post doc. fellows and non-tenured scientific personnel (researchers) associated with the departments are analysed separately. We have not calculated productivity indicators for the latter group since these persons may not have been active (employed) as researchers during the entire period analysed.

2.2.1 Publication output

Scientific productivity can in principle be measured relatively easy by the quantification of published material. In practice it is more difficult, since a number of issues have to be faced. In particular the choice and weighting of publication types and the attribution of author credit are important questions to consider. Many publications are multi-authored, and are the results of collaborative efforts involving more than one researcher or institution. There are different principles and counting methods that are being applied in bibliometric studies. The most common is "whole" counting, i.e. with no fractional attribution of credit (everyone gets full credit). A second alternative is "adjusted counting" where the credit is divided equally

[6] Research assistants are not included. We have included professors with emeritus positions if these have been listed among the staff in the factual reports. We have not included persons who have retired.

between all the authors (Seglen, 2001). For example, if an article has five authors and two of them represent the department being analysed, the department is credited 2/5 article (0.4). One can argue that these counting methods are complementary: The whole or integer count gives the number of papers in which the unit "participated". A fractional count gives the number of papers "creditable" to the unit, assuming that all authors made equal contributions to a co-authored paper, and that all contributions add up to one (Moed, 2005). As described above in this study possible double occurrences of articles have been excluded within each unit. This means that papers co-authored by several researchers belonging to the same department are counted only once (but when fractionalised publication counts have been calculated, each persons is credited their publication share).

2.2.2 Citation indicators

It is the individual articles and their citation counts that represent the basis for the citation indicators. As described above citation counts are only available (at least in a systematic way) for the ISI-indexed articles. In the citation indicators we have used accumulated citation counts and calculated an overall (total) indicator for the whole period. This means that for the articles published in 2003, citations are counted over a 5-year period, while for the articles published in 2006, citations are counted over a 2-year period (or more precisely a 1-2 year period: the year of publication, and 2007). It is generally not advisable to use citation windows of only one or two years. Nevertheless, we have also included the recently published articles in the citation analysis. It is "expected" that the articles then are uncited or very poorly cited. It is worth noting that in the citation indicators the oldest publications will have relatively more weight than the recent publications. This is due to the fact that the 2003 publications, for example, will have assembled citations over a longer time period than articles published in 2007. Nevertheless, our method has some advantages compared to the alternatives. In particular, it reduces the problem of the poor reliability of citations as indicators when very short time periods are considered. It is, however, important to notice that the citation indicators presented here hardly reflect the citation rate of the more recent publications. The method adopted here is commonly applied in similar bibliometric performance analyses (see for example Moed & Velde, 1993; van Raan, 1996).

The problem of crediting citation counts to multi-authored publications is identical to the one arising in respect to publication counts. In this study the research groups and departments have received full credit of the citations – even when for example only one of several authors represents the respective research groups or department. This is also the most common principle applied in international bibliometric analyses. There are however arguments for both methods. A researcher will for example consider a publication as "his/her own" even when it has many authors. In respect to measuring contribution, on the other hand,

(and not participation) it may be more reasonable to fractionalise the citations, particularly when dealing with publications with a very large number of authors.

As described above the average citation rate varies a lot between the different scientific disciplines. As a response, various reference standards and normalisation procedures have been developed. The most common is the average citation rates of the journal or field in which the particular papers have been published. An indicator based on the journal as a reference standard is the Relative citation index – journal (also called the Relative Citation Rate). Here the citation count of each paper is matched to the mean citation rate per publication of the particular journals (Schubert & Braun, 1986). This means that the journals are considered as the fundamental unit of assessment. If two papers published in the same journal receive a different number of citations, it is assumed that this reflects differences in their inherent impact (Schubert & Braun, 1993). Below the indicators are further described.

For the Relative citation index – journal we used the mean citation rate of the department's journal package, calculated as the average citation rate of the journals in which the group/department has published, taken into account both the type of paper and year of publication (using the citation window from year of publication through 2007). For example, for a review article published in a particular journal in 2005 we identified the average citation rates (2005–2007) to all the review articles published by this journal in 2005. ISI refers to this average as the Expected Citation Rate (XCR), and is included as bibliometric reference value for all publications indexed in NCR. For each department we then calculated the mean citation rate of its journal package, with the weights being determined by the number of papers published in each journal/year. The indicator was then calculated as the ratio between the average citation rate of the department's articles and the average citation rate of its journal package. For example, an index value of 110 would mean that the department's articles are cited 10 % more frequently than "expected" for articles published in the particular journal package.

A similar method of calculation was adopted for the Relative citation index – field (also termed the Relative Subfield Citedness (cf. Vinkler, 1986, 1997). Here, as a reference value we used the mean citation rate of the subfields in which the department has published. This reference value was calculated using the bibliometric data from the NSI-database. Using this database it is possible to construct a rather fine-tuned set of subfield citation indicators. The departments are usually active in more than one subfield (i.e. the journals they publish in are assigned to different subfields). For each department we therefore calculated weighted averages with the weights being determined by the total number of papers published in each subfield/year. In ISI's classification system some journals are assigned to more than one subfield. In order to handle this problem we used the average citation rates of the respective subfields as basis for the calculations for the multiple assigned journals. The indicator was then calculated as the ratio between the average citation rate of the department's articles and the average subfield citation rate. In this way, the indicator shows whether the department's articles are cited below or above the world average of the subfield(s) in which the department is active.

The following example can illustrate the principle for calculating relative citation indexes: A scientist has published a regular journal article in *Acta Chrystallographica E* in 2004. This article has been cited 3 times. The articles published in *Acta Chrystallographica E* were in contrast cited 1.74 times on average this year. The Relative citation index – journal is: (3/1.74)*100 = 172. The world-average citation rate for the subfield which this journal is assigned to is 3.7 for articles published this year. In other words, the article obtains a lower score compared to the field average. The Relative citation index – field is: (3/3.7)*100 = 81. The example is base on a single publication. The principle is, however, identical when considering several publications. In these cases, the sum of the received citations is divided by the sum of the "expected" number of citations.

It is important to notice the differences between the field and journal adjusted relative citation index. A department may have a publication profile where the majority of the articles are published in journals being poorly cited within their fields (i.e. have low impact factors). This implies that the department obtains a much higher score on the journal adjusted index than the field adjusted index. The most adequate measure of the research performance is often considered to be the indicator in which citedness is compared to field average. This citation index is sometimes considered as a bibliometric "crown indicator" (van Raan, 2000). In the interpretation of the results this indicator should accordingly be given the most weight.

The following guide can be used when interpreting the *Relative citation index – field*:

<u>Citation index: > 150:</u> Very high citation level

<u>Citation index: 120-150:</u> High citation level, significant above the world average.

<u>Citation index: 80-120:</u> Average citation level. On a level with the international average of the field (= 100).

<u>Citation index: 50-80:</u> Low citation level**.**

<u>Citation index: < 50:</u> Very low citation level.

It should be emphasised once more that the indicators cannot replace an assessment carried out by peers. In the cases where a research group or department is poorly cited, one has to consider the possibility that in this case the citation indicators do not give a representative picture of the research performance (for example due to limited coverage of the publication literature). Moreover, the unit may have good and weak years. Citations have highest validity in respect to high index values. But similar precautions should be taken also here. For example, in some cases one highly cited researcher or one highly cited publication may strongly improve the citation record of a group or even a department.

2.2.3 Journal profiles

We also calculated the journal profile of the departments. As basis for one of the analyses we used the so called "impact factor" of the journals. The journal impact factor is probably the most widely used and well-known bibliometric product. It was originally introduced by Eugene Garfield as a measure of the frequency with which the average article in a journal has been cited. In turn, the impact factor is often considered as an indicator of the significance and prestige of a journal. In the standard product the impact factor is calculated as the mean number of citations in a given year, to journal items published during the preceding two years. This time period used as basis for the calculation of impact factor is however often considered to be too short. In this analysis we have therefore instead used a three-year period.

3 Norwegian chemistry in international comparison

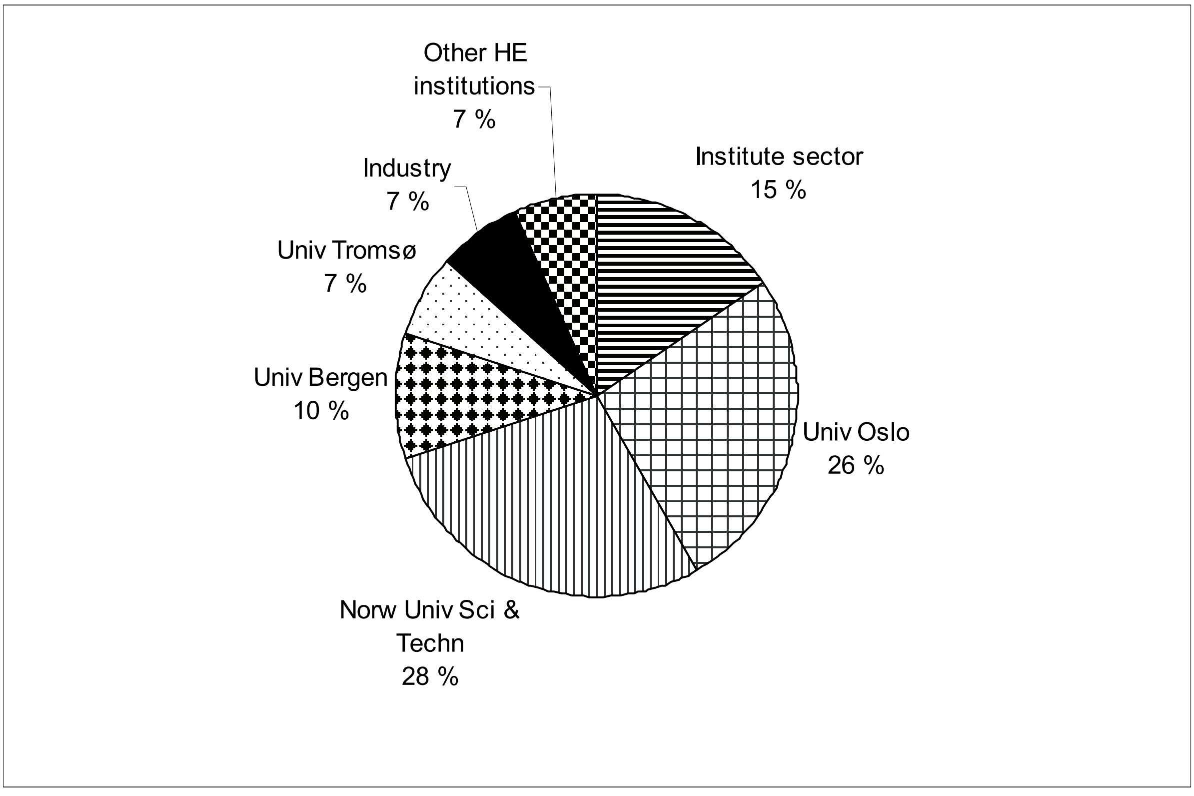
This chapter presents various bibliometric indicators on the performance of Norwegian chemistry research. The analysis is mainly based on the database National Science Indicators (cf. Method section), where Chemistry is a separate field category and where there also are categories for particular subfields within Chemistry.

3.1 Scientific publishing

In 2007 Norwegian scientists published 516 articles in journals classified within the field Chemistry. This is almost identical to the numbers for the two previous years 2006 and 2005 (509 and 537, respectively).

The universities account for the large majority of the scientific journal publishing within Chemistry. This can be seen from Figure 3.1, where the article production during the period 2005-07 has been distributed according to institutions/sectors. The basis for this analysis is the information available in the address field of the articles.

Figure 3.1 The Norwegian profile of scientific publishing in Chemistry. Proportion* of the article production 2005-2007 by institutions/sectors.



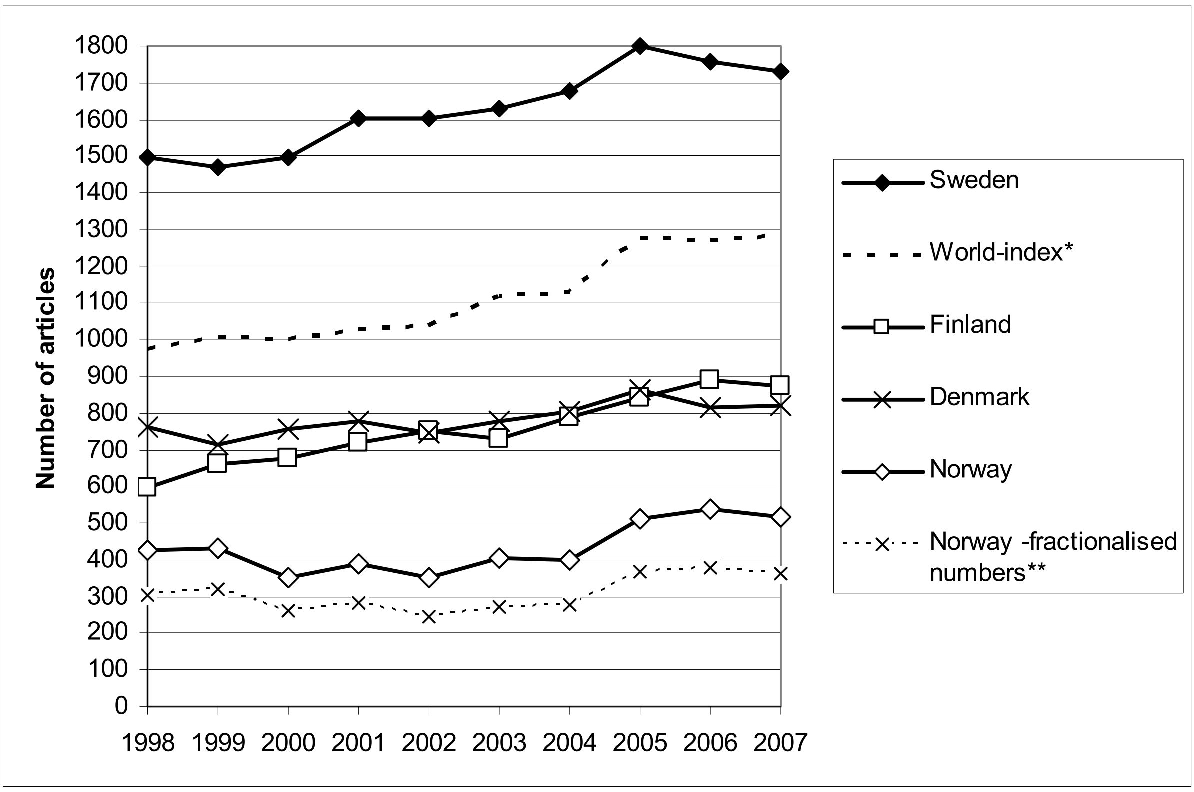
*) In the calculations each article has been fractionalised according to relative contributions (number of addresses).

The Norwegian University of Science and Technology is the largest contributor (28 %) followed by the University of Oslo (26 %). The Institute sector (private and public research institutes) accounts for 15 % of the production. It should be noted, however, that the incidence of journal publishing in this sector is generally lower than for the universities due to the particular research profile of these units (e.g. contract research published as reports). The industry accounts for 7 % of the Norwegian scientific journal production in Chemistry. In a similar way, only a very limited part of the research carried out by the industry is generally published. This is due to the commercial interests related to the research results which mean that the results cannot be published/made public.

In figure 3.2 we have shown the development in the annual production of articles in Chemistry for Norway and three other Nordic countries for the period 1998-2007. While more than 500 articles were published annually by Norwegian researchers in the years 2005-2007, the production fluctuated between 350 and 400 in the period 2000-2004. Thus, in terms of productivity there is a notable positive trend the recent years. However, part of this increase is probably due to increased database coverage. This can be seen from the reference line “world index”, which is the world production of articles in Chemistry divided by 100. (The world production in Chemistry increased by 13 % from 2004 to 2005, the Norwegian production by 27 %.). In this figure we can also observe a marked decrease in the Norwegian production from 1998/1999 to 2000. This is probably due to the fact that the journal *Acta Chemica Scandinavica,* which published a significant number of Norwegian articles, ceased to exist as an independent journal in January 2000.[7]

[7] The journal was merged with the Royal Society of Chemistry’s inorganic and organic journals. Although the Norwegian contributions in these journals increased subsequently, the increase was not strong enough to compensate for the loss of *Acta Chemica Scandinavica*.

Figure 3.2 Scientific publishing in Chemistry 1998-2007 in four Nordic countries.



*) The "world index" is a reference line, calculated as the world production of articles in Chemistry divided by 100.

**) For Norway we have also shown the publication counts using a fractionalised calculation method. Here, each article is fractionalised according to the number of author addresses.

As described in Chapter 2 many publications are multi-authored, and are the results of collaborative efforts involving researchers from more than one country. In the figure we have used the "whole" counting method, i.e. a country is credited an article of it has at least one author address from the respective country. For Norway we have also shown the publication counts using a fractionalised calculation method. Here, the credit is divided equally between all the addresses. For example, if an article has five addresses and two of them represent Norwegian institutions, Norway is credited 2/5 article (0.4). As expected, the line representing fractionalised article counts follows the trends of whole-count line, albeit at a lower level.

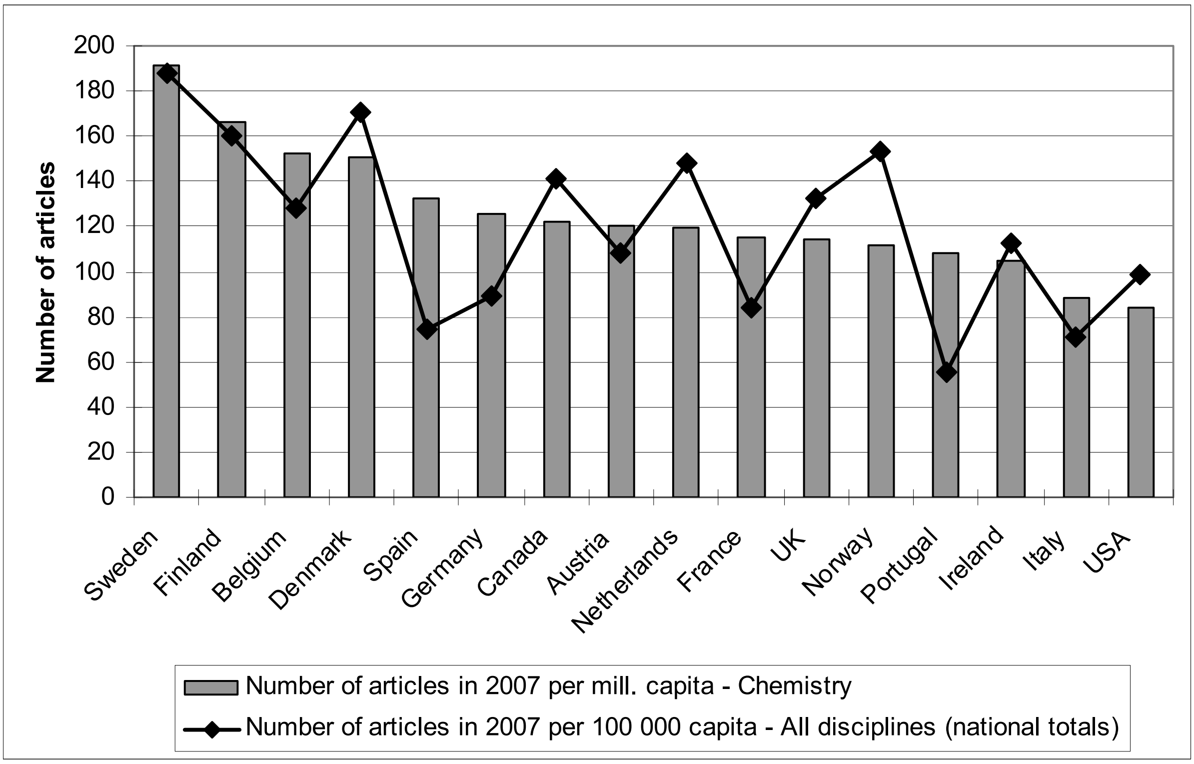
Among the four Nordic countries shown in the figure, Norway is the smallest contributor. Sweden is by far the largest nation in terms of publication output while Denmark and Finland make almost equal contributions. In 2007 the two latter countries produced 818 and 871 articles, respectively. Over the entire 10-year period Finland has the largest increase in the scientific production in Chemistry, 46 %, and Denmark the lowest, 8 %. The increase for Norway is 22 % (19 % using fractionalised publication counts).

In 2007 Chemistry accounted for 7.3 % of the Norwegian scientific and scholarly journal publishing (ISI-indexed). This proportion has been fairly constant over the ten year period. In other words, Chemistry has maintained its relative position among the disciplines in Norway.

In a global context Norway is a very small country science-wise. In Chemistry, the Norwegian publication output represented 0.33 % of the world production of scientific publications (measured as the sum of all countries' publication output). This proportion has also been fairly stable during the ten-year period with small annual variations. In comparison Norway has an overall publication share of 0.58 (national total, all fields). This means that Norway contributes much less to the global scientific output in Chemistry than it does in other fields. In order to reach the national average the number of articles in Chemistry would have to be increased by 75 %.

There are no international data available that makes it possible to compare the output in terms of publications to the input in terms of number of researchers. Instead, the publication output is usually compared with the size of the population of the different countries – although differences in population do not necessarily reflect differences in research efforts. Measured as number of articles per million capita, Norwegian scientists published 112 articles in Chemistry in 2007. In Figure 3.3 we have shown the corresponding publication output for a selection of other countries (grey bars). Here Sweden has the highest relative number of articles followed by Finland with publication counts of 191 and 166, respectively. However, Switzerland has an even higher number, 284 (not shown in the figure for visibility reasons). Norway ranks as number 12 among the 16 nations shown in this figure. In other words, Norway has a relative publication output in Chemistry which is among the lowest found in these Western countries.

Figure 3.3 Scientific publishing per capita in 2007 in selected countries,* Chemistry and all disciplines.



*) Switzerland has a publication output in Chemistry of 284 per mill capita but been omitted from the figure of visibility reasons.

In Figure 3.3 we have also shown the production (per 100,000 capita) for all disciplines (national totals) (black line). This can be used to assess whether Chemistry has a higher or lower relative position in the science system of the countries than the average. For example, for Norway Chemistry clearly ranks far below the national average, while the opposite is the case for the Spain.

In order to provide further insight into the profile of Norwegian chemistry we have analysed the distribution of the articles at subfield levels. This is based on the classification system of Thomson Scientific where the journals have been assigned to different categories according to their content (journal-based research field delineation). There is a separate category for journals covering multidisciplinary (chemistry) topics.

Category descriptions

Analytical Chemistry: Covers resources on the techniques that yield any type of information about chemical systems. Topics include chromatography, thermal analysis, chemometrics, separation techniques, pyrolysis, and electroanalytical and radioanalytical chemistry. Some spectroscopy resources may be included in this category when focusing on analytical techniques and applications in chemistry.

Applied Chemistry: Covers resources that report on the application of basic chemical sciences to other sciences, engineering, and industry. Topics include chemical engineering (catalysis, fuel processing, microencapsulation, and functional polymers); food science and technology (cereals, hydrocolloids, and food additives); medicinal chemistry (pharmacology); dyes and pigments; coatings technology; and cosmetics.

Chemical Engineering: Covers resources that discuss the chemical conversion of raw materials into a variety of products. This category includes resources that deal with the design and operation of efficient and cost-effective plants and equipment for the production of the various end products.

Crystallography: Covers resources that report on the study of the formation, structure, and properties of crystals. This category also includes resources on X-ray crystallography, the study of the internal structure of crystals through the use of X-ray diffraction.

Electrochemistry: Covers resources that deal with the chemical changes produced by electricity and the generation of electricity by chemical reactions. Applications include dry cells, lead plate, storage batteries, electroplating, electrodeposition (electrolysis), purification of copper, production of aluminum, fuel cells, and corrosion of metals.

Inorganic & Nuclear Chemistry: Includes resources on both inorganic and nuclear chemistry. Chemistry, Inorganic covers resources that are concerned with non-carbon elements and the preparation, properties, and reactions of their compounds. It also includes resources on the study of certain simple carbon compounds, including the oxides, carbon disulfide, the halides, hydrogen cyanide, and salts, such as the cyanides, cyanates, carbonates, and hydrogencarbonates. Resources on coordination chemistry and organo-metallic compounds (those containing a carbon-metal bond) are also covered in this category. Chemistry, Nuclear includes resources on the study of the atomic nucleus, including fission and fusion reactions and their products. This category also covers radiochemistry resources focusing on such topics as the preparation of radioactive compounds, the separation of isotopes by chemical reactions, the use of radioactive labels in studies of mechanisms, and experiments on the chemical reactions and compounds of transuranic elements.

Medicinal Chemistry: Includes resources emphasizing the isolation and study of substances with therapeutic potential. Topics of interest are quantitative structure-function relationships, structural characterization and organic syntheses of naturally occurring compounds, and chemical and analytical techniques used in rational drug design.

Multidisciplinary (Chemistry): Includes resources having a general or interdisciplinary approach to the chemical sciences. Special topic chemistry resources that have relevance to many areas of chemistry are also included in this category. Resources having a primary focus on analytical, inorganic and nuclear, organic, physical, or polymer chemistry are placed in their own categories.

Organic Chemistry: Includes resources that focus on synthetic and natural organic compounds their synthesis, structure, properties, and reactivity. Research on hydrocarbons, a major area of organic chemistry, is included in this category.

Physical Chemistry: Includes resources on photochemistry, solid state chemistry, kinetics, catalysis, quantum chemistry, surface chemistry, electrochemistry, chemical thermodynamics, thermophysics, colloids, fullerenes, and zeolites.

Physics, Atomic, Molecular & Chemical: Includes resources concerned with the physics of atoms and molecules. Topics covered in this category include the structure of atoms and molecules, atomic and molecular interactions with radiation, magnetic resonances and relaxation, Mossbauer effect, and atomic and molecular collision processes and interactions.

Polymer Science: Includes all resources dealing with the study, production, and technology of natural or synthetic polymers. Resources on polymeric materials are also covered in this category.

Spectroscopy: Covers resources concerned with the production, measurement, and interpretation of electromagnetic spectra arising from either emission or absorption of radiant energy by various sources. This category includes resources that report on any of several techniques for analyzing the spectra of beams of particles or for determining mass spectra.

Source: Thomson Reuters

Figure 3.4 Scientific publishing in Chemistry fields, Norway, total number of articles for the period 1998-2007.

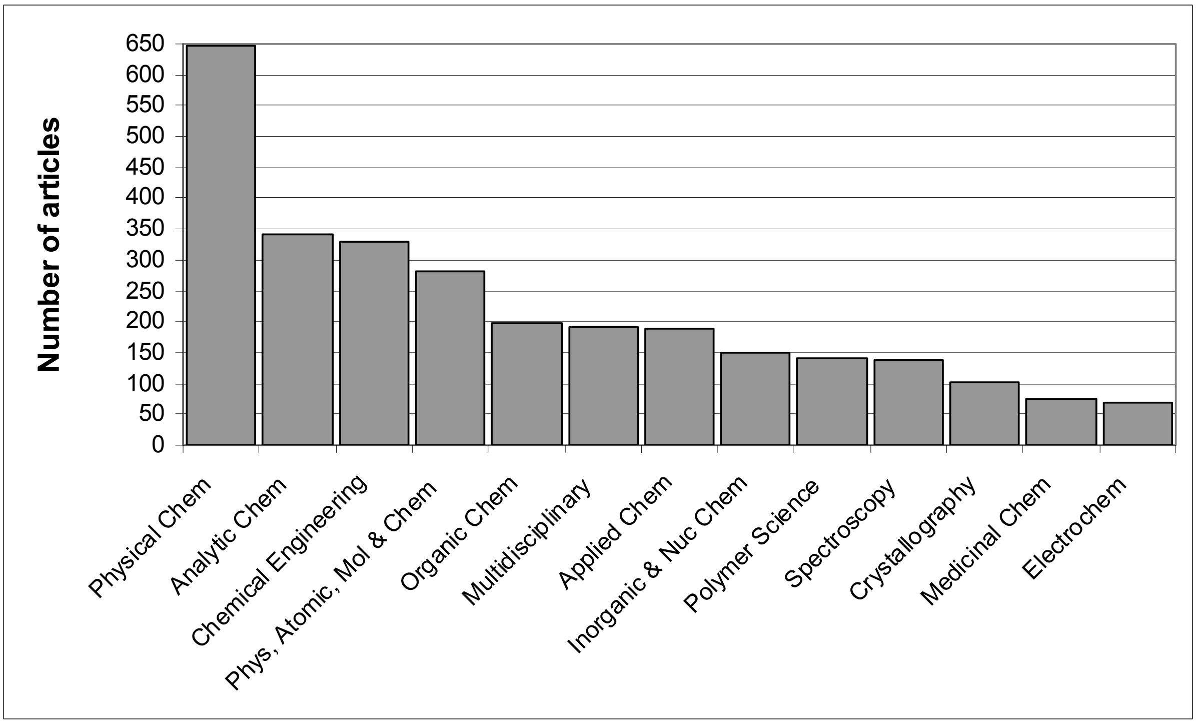
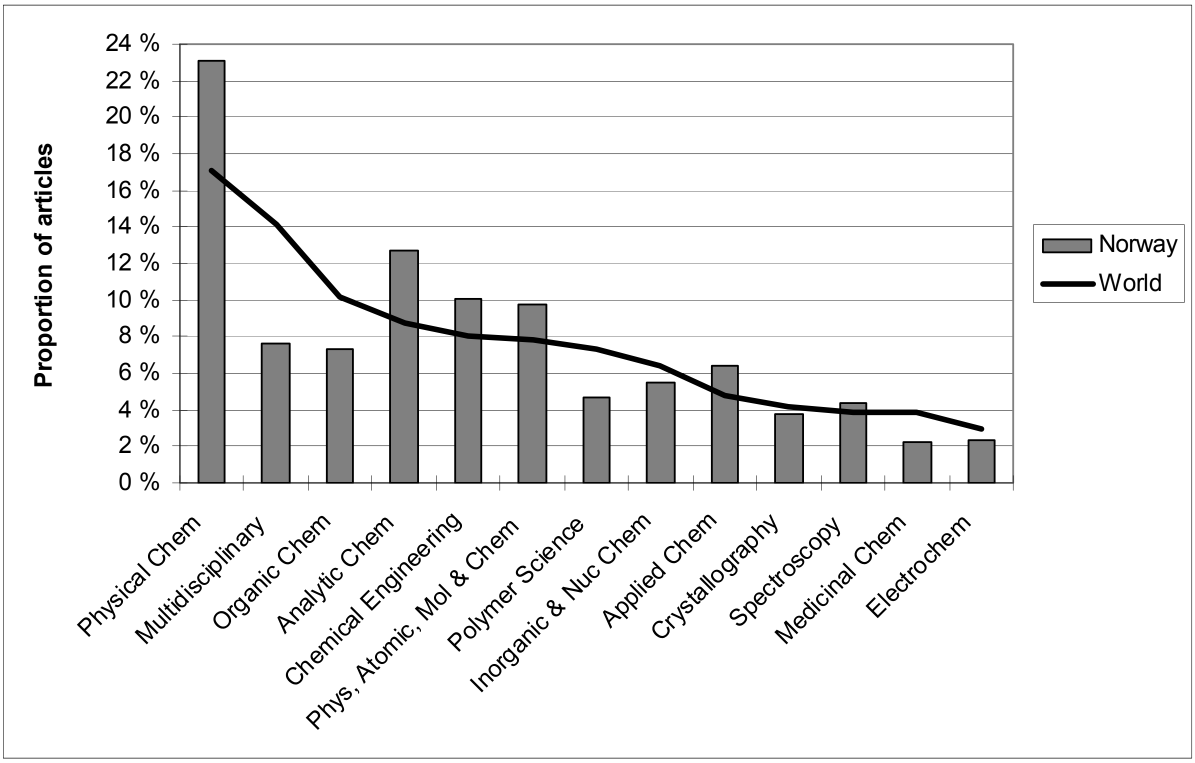


Figure 3.4 shows the distribution of articles for the 10-year period 1998-2007. Physical chemistry is by far the largest category, and 650 articles have been published within this subfield by Norwegian researchers during the period, which is 23 % of the overall publication output in Chemistry. Then follow Analytical chemistry and Chemical engineering with 340 and 330 articles, respectively.

The particular distribution of articles by subfields can be considered as the specialisation profile of Norwegian Chemistry. In order to further assess its characteristics, we have compared the Norwegian profile with the global average distribution of articles. The results are shown in Figure 3.5. As can be seen, Norway has a much higher proportion of articles in Physical chemistry than the world average (respectively 23 and 17 %). Also for Analytical chemistry the Norwegian proportion (13 %) is significantly higher than the world average (9 %). On the other hand, Norway has lower proportions in Organic chemistry and Polymer science than the world average (7 vs. 10 % and 5 vs. 7 %). It should be noted however, that the world average should not be considered as a normative reference standard. For a country, particularly a small one like Norway, there may be strong reasons for specialising in some fields and not in others. Thus, the analysis is primarily interesting for providing insight into the particular characteristics of Norwegian chemistry.

Figure 3.5 Relative distributions of articles on Chemistry subfields, Norway and the world average, based on publication counts for the period 1998-2007.



The Norwegian contributions in the field Chemistry during the ten-year period 1998-2007 were distributed on more than 360 different journals. Table 3.1 gives the annual publication counts for the most frequent journals. On the top of the list we find the *Journal of Chemical Physics* with 157 entries, followed by *Journal of Physical Chemistry A* (115) and *Journal of Molecular Structure* (112). The table shows how the Norwegian contribution in the various journals has developed during the time period. From the list of journals one also gets an impression of the overall research profile of Norwegian chemistry research.

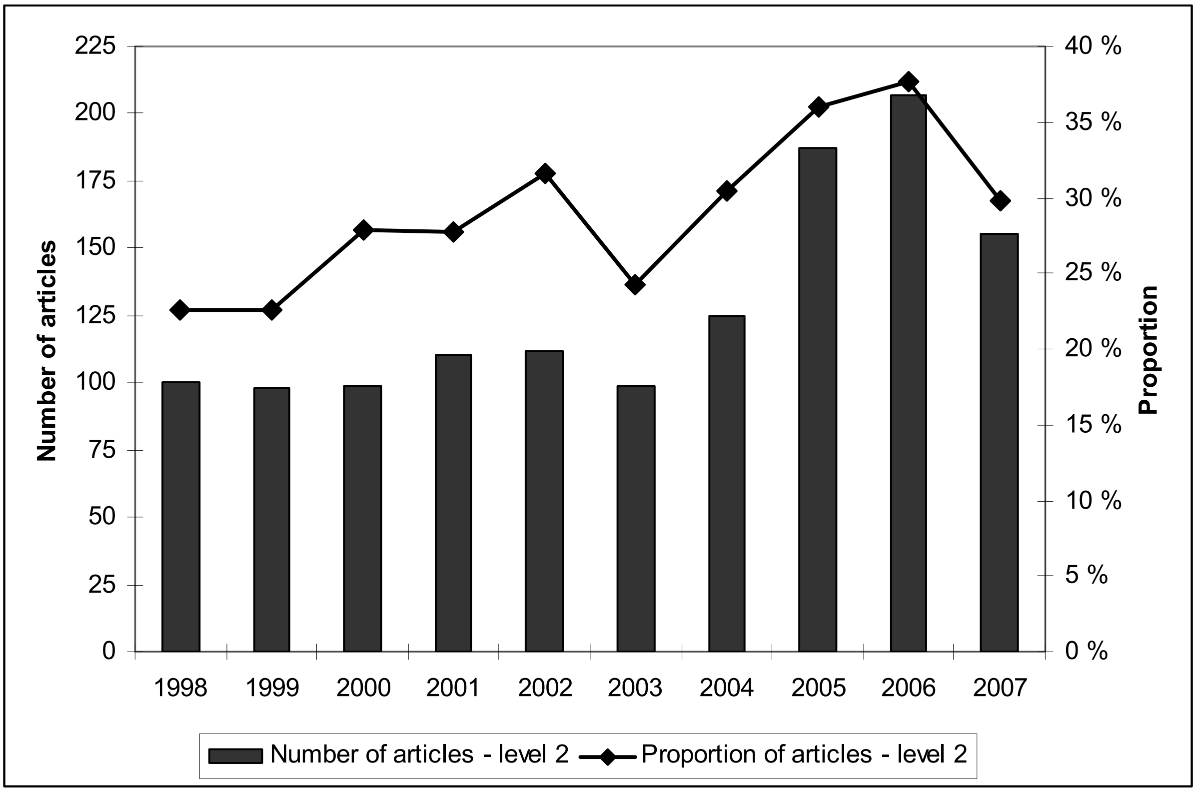
Table 3.1 The most frequently used Chemistry journals for the period 1998-2007, number of articles Norway

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
JOURNAL OF CHEMICAL PHYSICS	18	15	12	11	10	21	22	16	17	15	157
JOURNAL OF PHYSICAL CHEMISTRY A	5	10	11	6	13	8	8	18	20	16	115
JOURNAL OF MOLECULAR STRUCTURE	21	27	8	23	8	5	8	4	3	5	112
JOURNAL OF CHROMATOGRAPHY A	8	7	10	8	9	9	9	9	18	8	95
JOURNAL OF ENVIRONMENTAL MONITORING		14	6	6	6	12	10	10	7	10	81
JOURNAL OF PHYSICAL CHEMISTRY B	4	7	3	5	3	9	9	15	13	13	81
ACTA CHEMICA SCANDINAVICA	44	35	1								80
JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	2	5	3	5	5	2	7	16	19	14	78
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-	3	5	6	4	9	9	7	13	12	9	77
ACTA CRYSTALLOGRAPHICA SECTION E-				11	9	14	10	15	8	9	76
INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH		5	2	6	4	11	7	8	9	14	66
PHYSICAL CHEMISTRY CHEMICAL PHYSICS		4	9	7	9	6	8	6	9	8	66
CHEMOMETRICS AND INTELLIGENT LABORATORY SYSTEMS	10	11	8	8		5	5	4	2	11	64
JOURNAL OF DISPERSION SCIENCE AND TECHNOLOGY	5	8	4	1	1	5	3	14	15	7	63
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	4	4	7	10	9	2	5	7	9	4	61
CHEMICAL PHYSICS LETTERS	13	6	2	3	3	6	7	3	7	4	54
CHEMICAL ENGINEERING SCIENCE	1	6	1	8	1	4	1	14	10	7	53
BIOMACROMOLECULES				3	3	8	7	7	9	11	48
JOURNAL OF SOLID STATE CHEMISTRY	10	6	3	2	5	6	5	2	3	6	48
JOURNAL OF CHEMOMETRICS	2	2	5	3	6	2	6	6	5	10	47
COLLOIDS AND SURFACES A-PHYSICOCHEMICAL AND ENGINEERING ASPECTS	6	6	3	6	2	5	2	3	8	4	45
JOURNAL OF COLLOID AND INTERFACE SCIENCE	5	7	6	7	4	1		4	4	2	40
ACTA CRYSTALLOGRAPHICA SECTION C-CRYSTAL STRUCTURE COMMUNICATIONS	2	5	6	6	5	2	5	2	2	4	39
APPLIED CATALYSIS A-GENERAL	4	3	2	3	3	1	5	9	6	3	39
JOURNAL OF THE ELECTROCHEMICAL SOCIETY	5	5	2	2	6	3	3	2	7	3	38
CATALYSIS TODAY	4		3	4	1	1		19	3	2	37
JOURNAL OF SEPARATION SCIENCE				5	6	4	2	10	3	7	37
TETRAHEDRON LETTERS	8		4	5	3	3	3	3	3	5	37
SURFACE SCIENCE	6	7	3	5	4		1	3	3	4	36
TRANSPORT IN POROUS MEDIA	3	2	2	3	9	2	2	3	3	7	36
JOURNAL OF CATALYSIS	3		4		6	5	6	7	1	3	35
CARBOHYDRATE POLYMERS	6	4	1	5	2	4	3	4	3	2	34
INORGANIC CHEMISTRY	5	3		1	2	4	2	4	8	5	34
ELECTROCHIMICA ACTA	3		1	6	3	1	3	3	9	1	30
JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY	2	2	4	2	6	2	8	2	1	1	30
ANALYTICA CHIMICA ACTA	1	3	2	2	3	4	2	2	7	3	29
CARBOHYDRATE RESEARCH	2	1	2	5	1	3	3	6	4	2	29
COMPUTERS & CHEMICAL ENGINEERING	3	2	2	6	1	1	6	5	1	2	29
JOURNAL OF POWER SOURCES		3	3	1	1	3	3	2	10	2	28
MACROMOLECULES	8	3	5	2		2	1	4	2	1	28
LANGMUIR	3	1	1	3	3	1	3	5	4	3	27
ORGANOMETALLICS	4	2	2	2	1		2	2	7	5	27
OTHER JOURNALS	191	195	192	180	165	208	191	218	243	264	2047
TOTAL	424	431	351	391	350	404	400	509	537	516	4313

Norway has recently implemented a bibliometric model for performance based budgeting of research institutions. The funding of the higher education institutions is now partially based on the measurement of their scientific and scholarly publishing (see Sivertsen, 2006). In this system journals are divided into two levels. The highest level (level 2) is giving extra weight and includes only the leading and most selective international journals (accounts for about 20 % of the world's publications), see Appendix for an overview. The national councils in each discipline participate annually in determining and revising the highest level under the guidance of the Norwegian Association of Higher Education Institutions.

In our analysis we identified the journal production at this highest level of journals. Figure 3.6 shows the results of this analysis. As can be seen, both the number and proportion of articles in these journals have increased markedly during the time period. In 2006 38 % of the international journal production appeared in leading journals, although this proportion decreased to 30 % in 2007. It can be concluded that the ambitions when selecting journals for publication has increased. Moreover, in order to appear in these journals it can reasonably be assumed that the quality of the research is generally very good. Thus, the analysis suggests that the ambitions and quality has increased in recent years.

Figure 3.6 Number and proportion of articles in leading Chemistry journals – "level 2"*, Norway 1998-2007.



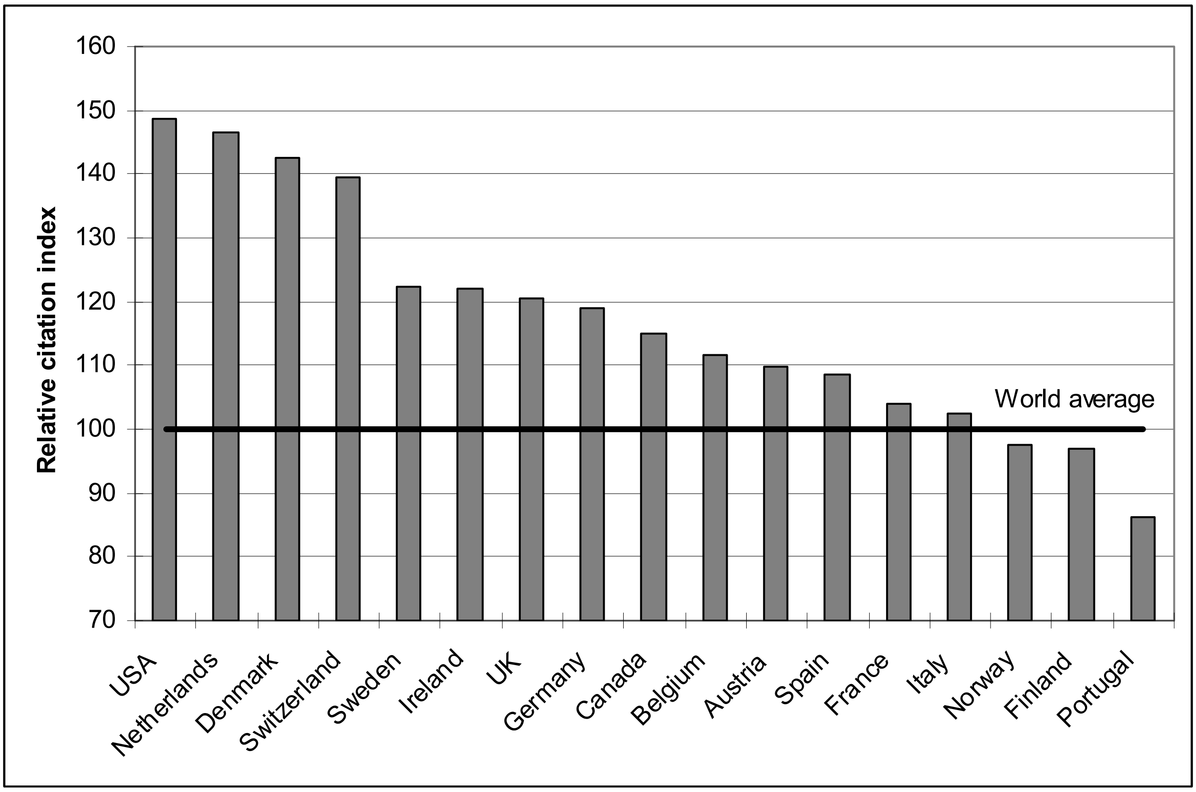
*) Cf. the guidance of the Norwegian Association of Higher Education Institutions.

3.2 Citation indicators

As described in Chapter 2, the extent to which the articles have been referred to or cited in the subsequent scientific literature is often used as an indicator of scientific impact and international visibility. In absolute numbers the countries with the largest number of articles also receive the highest numbers of citations. It is however common to use a size-independent measure to assess whether a country's articles have been highly or poorly cited. One such indicator is the relative citation index showing whether a country's scientific publications have been cited above or below the world average (=100).

Figure 3.7 shows the relative citation index in Chemistry for a selection of countries, based on the citations to the publications from the four year period 2003-2006. The publications from the USA, the Netherlands, Denmark and Switzerland are all very highly cited, approximately 40 and 50 % above world average. Norway ranks as number 15 among the 17 countries shown in this figure with a citation index of 98. In other words, the performance of Norwegian Chemistry in terms of citations is rather poor compared to these countries. Although the Norwegian citation index is still only slightly below world average, this average does not represent a very ambitious reference standard as it includes publications from countries with less developed science systems. The Norwegian index in Chemistry is also significantly lower than the Norwegian total (all disciplines) for this period which is above 120.

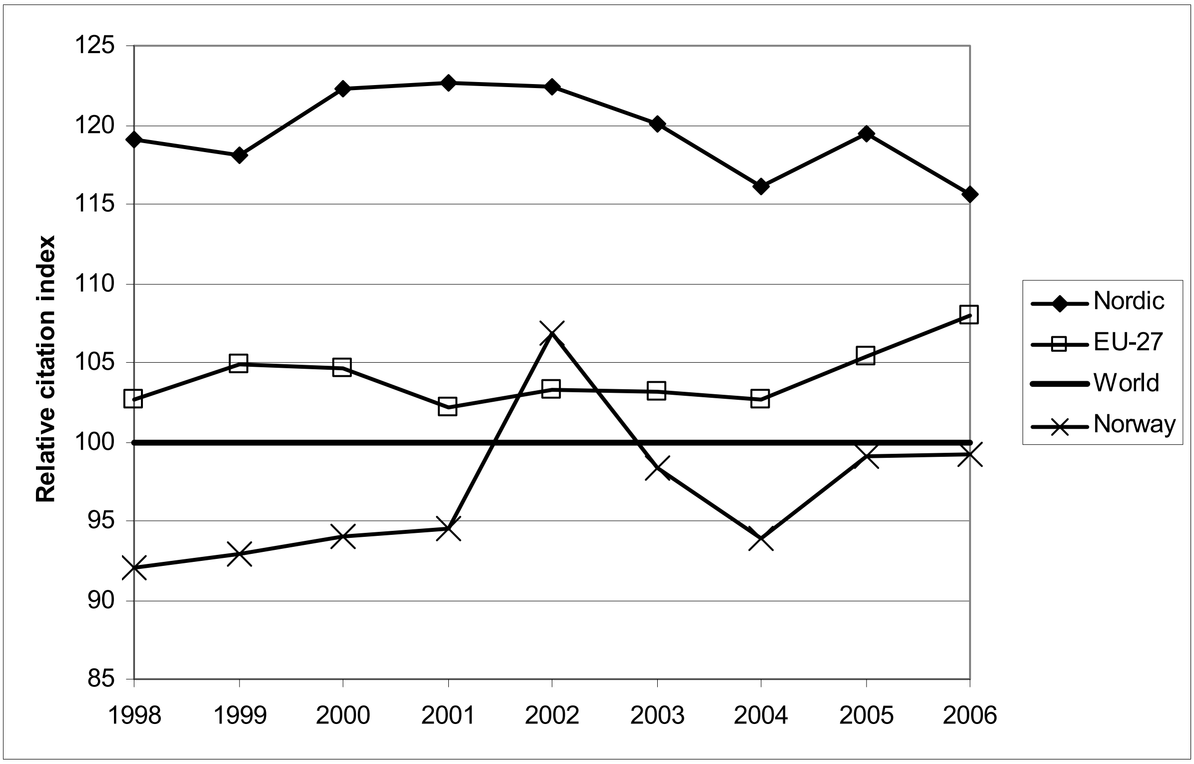
Figure 3.7 Relative citation index in Chemistry for selected countries (2003-2006).*



*) Based on the publications from the period 2003-2006 and accumulated citations to these publications through 2007. The category Chemistry does not include the subfield Chemical engineering. In this subfield Norway has a citation index of 143.

We have also analysed how the citation rate of the Norwegian Chemistry publications has developed over the period 1998-2006. The results are shown in Figure 3.8. Also the respective averages for the Nordic countries, the EU-27 and the world (=100) have been included in this figure. With the exception of an outlier year (2002)[8] the Norwegian publications have been cited below the world average and far below the Nordic average during the entire period. However, there is a positive trend and the index has improved from 92 in 1998 to 99 in 2006.

Figure 3.8 Relative citation index in Chemistry for Norway compared with the average for the Nordic countries, the EU-27 and the world for the period 1998-2006.

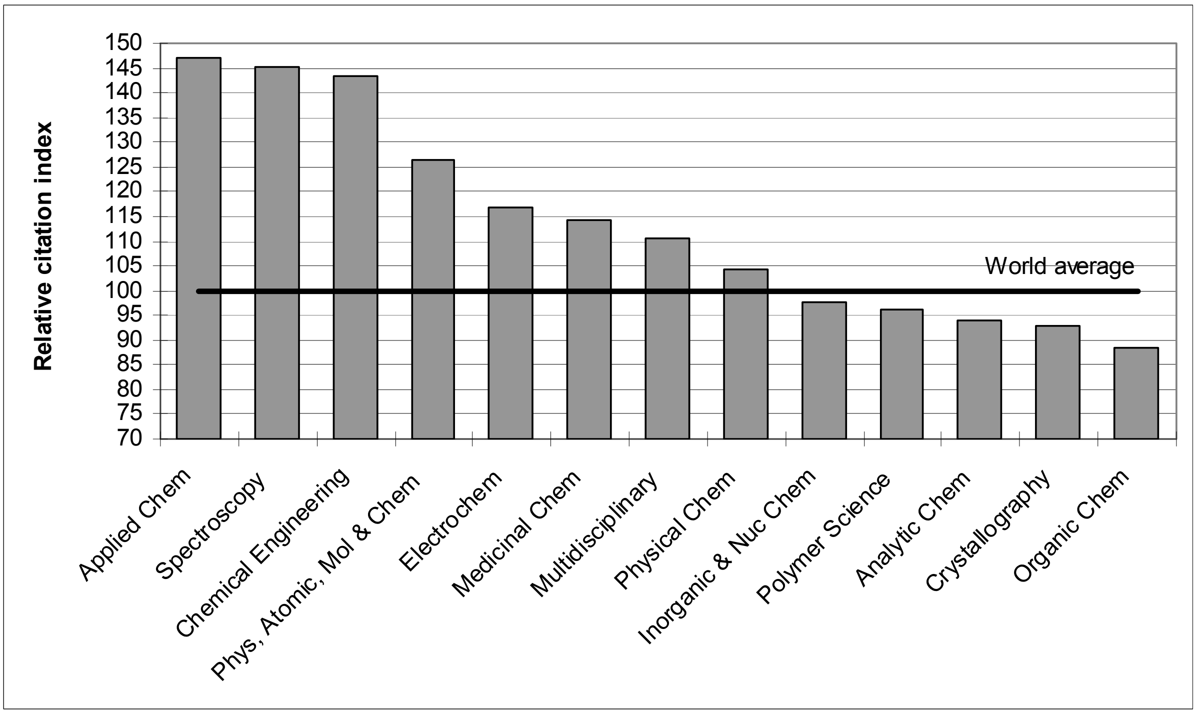


*) Based on annual publication windows and accumulated citations to these publications. The category Chemistry does not include the subfield Chemical engineering. In this subfield Norway has an average citation index of 143 in the period 2003-06.

The overall citation index for Chemistry does however disguise important differences at subfield levels. This can be seen in figure 3.9 where a citation index has been calculated for each of the Chemistry subfields for the 2003-2006 publications. In fact, Norway performs very well in several of the subfield, notably Applied chemistry, Spectroscopy, and Chemical Engineering with index values of above 140. Lowest citation rate is found for Organic chemistry (88).

[8] It is a general phenomenon that annual citation indicators, particularly at subfield levels, may show large annual fluctuations. In particular, this may be due to variations in the importance of highly cited papers.

Figure 3.9 Relative citation index in Chemistry subfield (2003-2006)*



*) Based on the publications from the period 2003-2006 and accumulated citations to these publications through 2007.

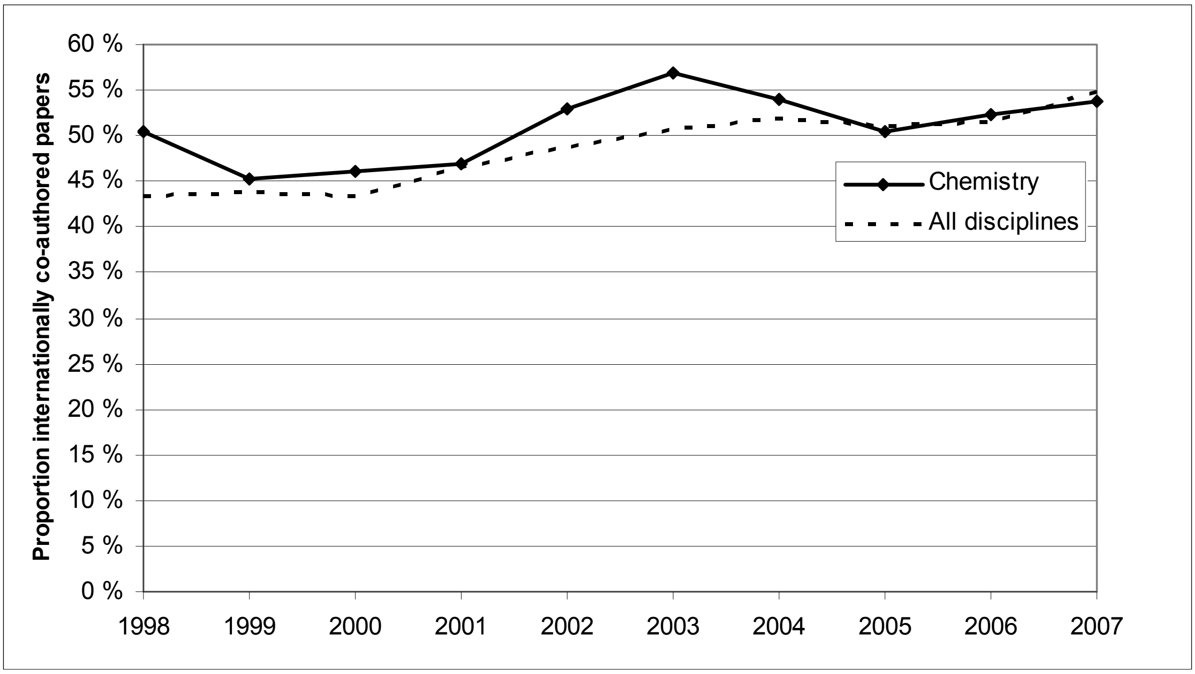
3.3 Collaboration indicators

This chapter explores the Norwegian publications involving international collaboration (publications having both Norwegian and foreign author addresses). As described in Chapter 1, increasing collaboration in publications is an international phenomenon and is one of the most important changes in publication behaviour among scientists during the last two decades.

In Figure 3.10 we have shown the development in the extent of international co-authorship for Norway in Chemistry and for all disciplines (national total). In Chemistry 54 % of the articles had co-authors from other countries in 2007. This is on par with the national average (55 %). Thus, more than every second paper published by Norwegian researchers in 2007 has foreign co-authors.

The proportion in Chemistry has varied between 45 and 57 % in the 10 year period. The national total has increased steadily during the period from 43 % in 1998 to 55 % in 2007.

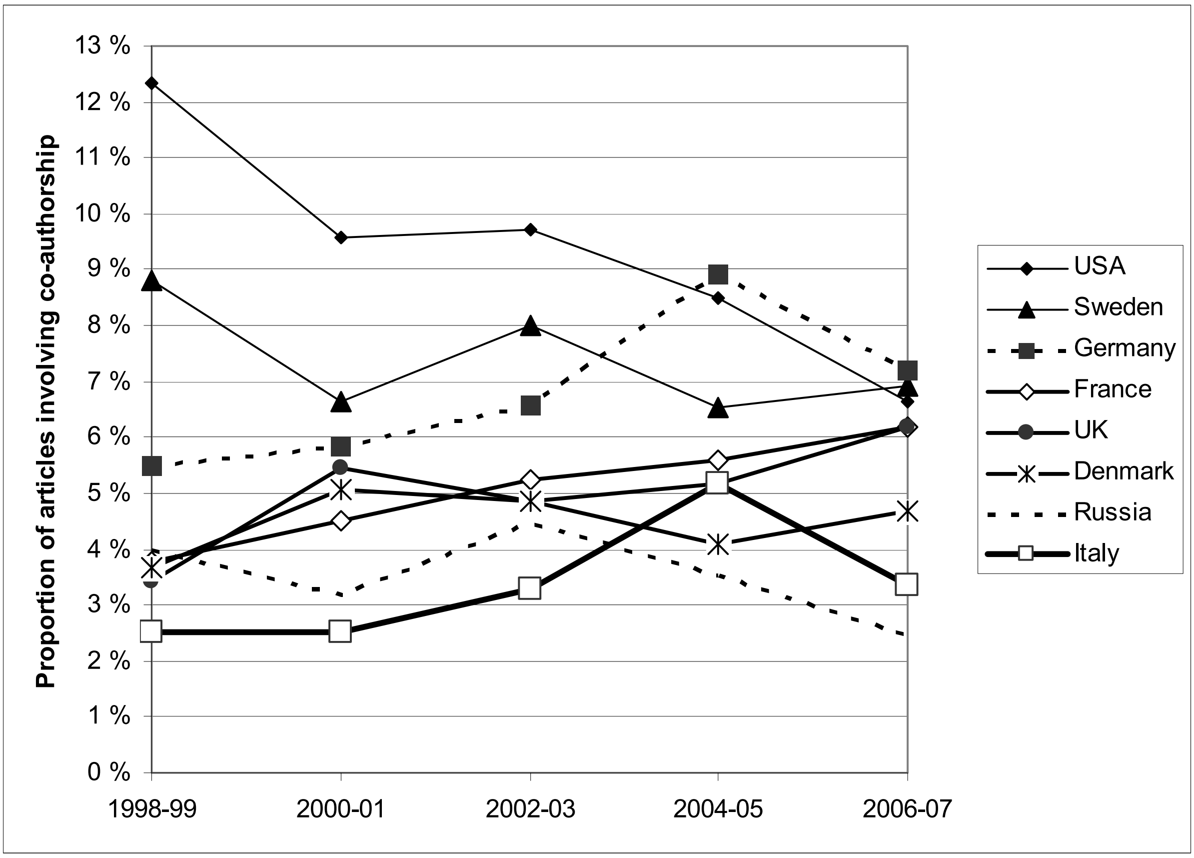
Figure 3.10 The proportion of international co-authorship, 1998-2007, Norway.



Which countries are the most important collaborative partners for Norway in Chemistry, and has this profile changed during the recent decade? In order to answer this question we analysed the distribution of co-authorship. Figure 3.11 shows the distribution of co-authorship in the countries that comprise Norway's main collaborative partners from 1998 to 2007.

The USA, Sweden, Germany, France, UK, Denmark, Italy and Russia are the most important countries in terms of collaboration with Norway in Chemistry. A main finding is that collaboration with US scientists has decreased during the period. In 1997/98 12 % of the Norwegian Chemistry articles had co-authors from USA, this proportion was only 7 % in the most recent period (2006-07). For the other countries, there is a mixed picture: Some have had an increase (UK, France, Germany) while other a decrease (Sweden, Russia). Thus, the importance of collaboration with USA has decreased, while the relative importance of collaboration with the some of the EU-countries, excluding the Nordic countries, has increased. This change is probably related to Norwegian participation in the EU Framework Programmes. In addition the collaboration profile of Norway has broadened in the recent decade and now includes co-authorship with scientists in most countries that are active in research. The category for other countries (i.e. countries not shown in the figure) increased from 26 % in 1998/99 to 31 % in 2006/07.

Figure 3.11 Collaboration by country 1998-2007, proportion of the Norwegian article production in Chemistry involving international co-authorship.



4 University of Oslo

Department of Chemistry at the University of Oslo is the largest chemistry department in Norway, both in terms of staff and number of publications. Below we present an analysis of this department, based on the publications during the period 2003 to 2007.[9]

4.1 Productivity indicators

The analysis shows that the tenured staff at the Department of Chemistry published 744 publications in the period 2003-2007. This includes for the large part articles in international journals, but also some scientific publications in the category of books and book chapters.

Table 4.1 Number of publications 2003-2007, Department of Chemistry, UiO.

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	36	744	239.1	6.6
Analysis and environment		5	84	27.2	5.4
Catalysis		4	64	19.2	4.8
Functional inorganic materials		6	197	60.7	10.1
Nuclear chemistry		3	41	6.6	2.2
Polymers – organic materials		5	63	19.3	3.9
Quantum mechanics, structure and dynamics		6	197	62.9	10.5
Synthesis and molecular structure		7	107	43.3	6.2
Post docs/researchers		32	372	116.5	–

Table 4.1 shows various publication indicators for the department and its research groups. When fractionalised for co-authorship contributions, the 744 publications corresponded to 239.1 publications. This represents 6.6 publications (fractional counts) per staff member. This is significantly above the national average for the population of staff included in this

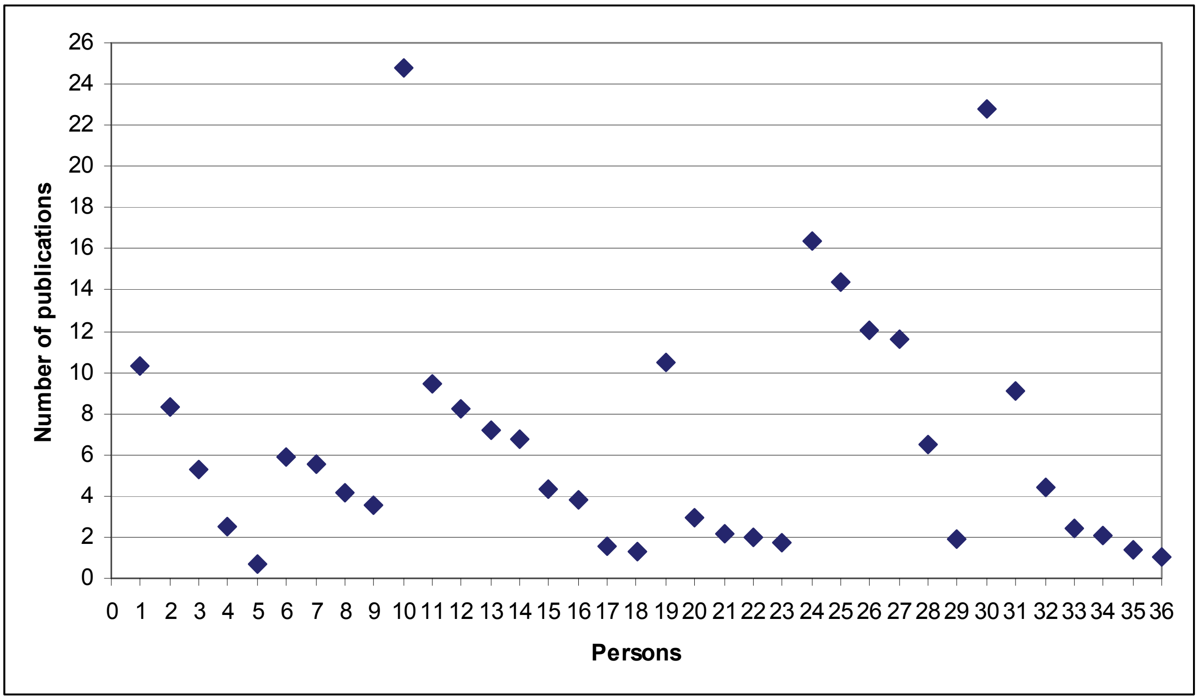
[9] Notes on the persons included:
Tenured staff: One person who recently has left the department is not included in this analysis. The School laboratory at the Department of Chemistry is not included.
Post docs/researchers: This category also includes post docs/researchers affiliated with Centre for Materials Science and Nanotechnology (SMN). Two persons who recently have left the department are not included in this analysis.

evaluation (4.6). Compared to the other departments it is the second highest average. In other words, the productivity at the department is very good.

There are, however, large differences among the various research groups/subdivisions. The two research groups, Functional inorganic materials and Quantum mechanics, structure and dynamics, have the highest levels, 10.1 and 10.5 respectively. For the first group this is particularly due to one person with an exceptionally high productivity, while for the latter groups there are several persons with very high levels. This is evident from Figure 4.1 which shows the number of publications per person. The Nuclear chemistry group, on the other hand, has the lowest productivity level, 2.2 publications per person.

There is a significant number of post docs and other researchers affiliated with the department. As can be seen from Table 4.1, there are 32 persons within this category. They contributed to 337 publications (116.5 publications when fractionalised for co-authorship).

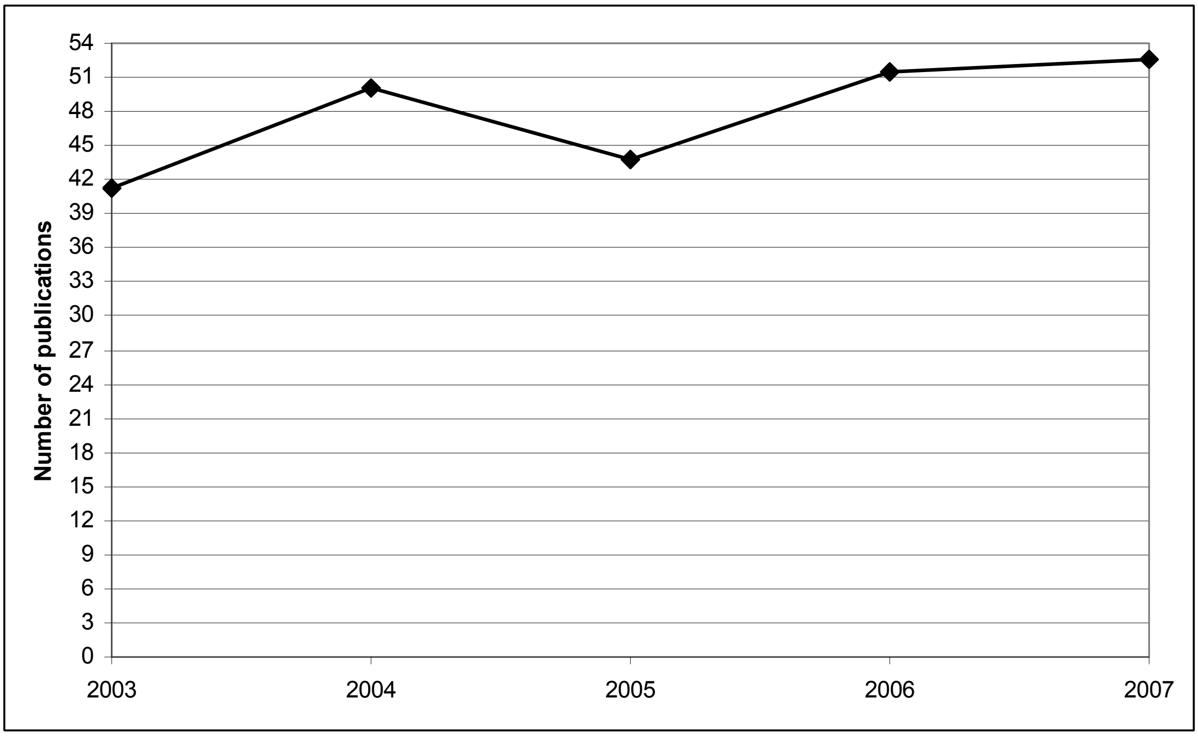
Figure 4.1 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Department of Chemistry, UiO.



Legends: 1-5 Analysis and environment. 6-9: Catalysis.10-15: Functional inorganic materials.16-18: Nuclear chemistry.19-23: Polymers - organic materials. 24-29: Quantum mechanics, structure and dynamics. 30-36: Synthesis and molecular structure

In the period 2003-2007 the annual number of publications has been fairly stable, but with a positive trend, cf. Figure 4.2.

Figure 4.2 Number of publications per year, 2003-2007, fractionalised counts. Department of Chemistry, UiO.



4.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 4.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

The tenured personnel at the department have published 38 % of their journal articles in level 2 journals, which is close to the national average for the population of persons encompassed by this evaluation (39 %). The proportions at group levels vary from 28 % (Synthesis and molecular structure) to 62 % (Catalysis). Since the productivity differs among the various groups, one gets a complementary picture by looking at the average number of level 2 articles per person. Then we find that the groups Functional inorganic materials, Quantum mechanics, structure and dynamics and Catalysis have the highest levels, 12.7, 10.3 and 9.3 articles per person respectively. There are not large differences in the average impact factors among the groups, with the exception of Catalysis (8.2). Based on these figures one can conclude that Catalysis has a very strong journal record, and Synthesis and molecular structure the weakest.

Table 4.2 Journal profile, 2003-2007 publications (whole counts). Department of Chemistry UiO.

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	36	445	270	38 %	7.5	5.3
Analysis and environment		5	50	34	40 %	6.8	4.7
Catalysis		4	23	37	62 %	9.3	8.2
Functional inorganic materials		6	111	76	41 %	12.7	4.9
Nuclear chemistry		3	25	16	39 %	5.3	5.5
Polymers – organic materials		5	42	21	33 %	4.2	5.5
Quantum mechanics, structure and dynamics		6	122	62	34 %	10.3	5.3
Synthesis and molecular structure		7	76	29	28 %	4.1	4.9
Post docs/researchers		32	204	148	42 %	–	5.6

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the “standard” journal impact factor is calculated in a different way).

Table 4.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 4.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Department of Chemistry, UiO (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Analysis and environment	JOURNAL OF SEPARATION SCIENCE	13	5.1	2
	JOURNAL OF CHROMATOGRAPHY A	10	7.0	2
	ANALYTICAL AND BIOANALYTICAL CHEMISTRY	6	4.7	1
Catalysis	JOURNAL OF PHYSICAL CHEMISTRY B	10	8.1	2
	JOURNAL OF CATALYSIS	8	8.6	2
	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	6	16.0	2
Functional inorganic materials	PHYSICAL REVIEW B	26	6.0	2
	JOURNAL OF SOLID STATE CHEMISTRY	21	4.5	1
	JOURNAL OF ALLOYS AND COMPOUNDS	14	2.8	1
Nuclear chemistry	PHYSICAL REVIEW C	8	6.2	2
	RADIOCHIMICA ACTA	4	2.4	1
Polymers - organic materials	EUROPEAN POLYMER JOURNAL	9	4.5	1
	JOURNAL OF PHYSICAL CHEMISTRY B	9	8.1	2
	BIOMACROMOLECULES	8	8.2	1
Quantum mechanics structure and dynamics	JOURNAL OF PHYSICAL CHEMISTRY A	39	6.0	2
	JOURNAL OF CHEMICAL PHYSICS	29	5.9	1
	JOURNAL OF MOLECULAR STRUCTURE	14	2.8	1
Synthesis and molecular structure	ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	15	1.3	1
	ACTA CRYSTALLOGRAPHICA SECTION C-CRYSTAL STRUCTURE COMMUNIC.	11	2.1	1
	TETRAHEDRON LETTERS	6	5.0	1

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the “standard” journal impact factor is calculated in a different way).

4.3 Citation indicators

Finally, we have analysed the citation rate of the journal publications. The results are given in Table 4.4. Altogether the articles published by the tenured personnel in the period 2003-2007 have received more than 4000 citations. This corresponds to a field citation index of 131. In other words, the articles have been cited 31 % more than the corresponding field average. Compared to the citation average for the journals where the articles have been published the index value is 116. Thus, in terms of citation rates the department performs well. There are, nevertheless, large differences among the various units. The Polymer – organic materials group has a rather poor citation record and their publications are cited significantly below average. The Catalysis group, on the other hand, has obtained very high citation rates, with a citation index – field of 207.

Table 4.4 Citation indicators, 2003-2007 publications (whole counts). Department of Chemistry, UiO.

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	716	4060	116	131
Analysis and environment		84	409	117	123
Catalysis		60	534	121	207
Functional inorganic materials		188	834	106	120
Nuclear chemistry		41	275	105	130
Polymers – organic materials		63	216	73	82
Quantum mechanics, structure and dynamics		184	1306	138	143
Synthesis and molecular structure		105	509	120	114
Post docs/researchers		359	2131	101	120

*) Only articles in ISI-indexed journals are included

5 Norwegian University of Science and Technology (NTNU)

Three departments from the Norwegian University of Science and Technology (NTNU) are included in the evaluation, Department of Material Science and Engineering, Department of Chemistry and Department of Chemical Engineering. In this chapter we present the analysis for the departments.

Department of Material Science and Engineering

From department of Material Science and Engineering only two sections are included in the evaluation, Electrochemistry and Inorganic chemistry (there are two additional sections which are not included, Physical Metallurgy and Process Metallurgy).

5.1 Productivity indicators

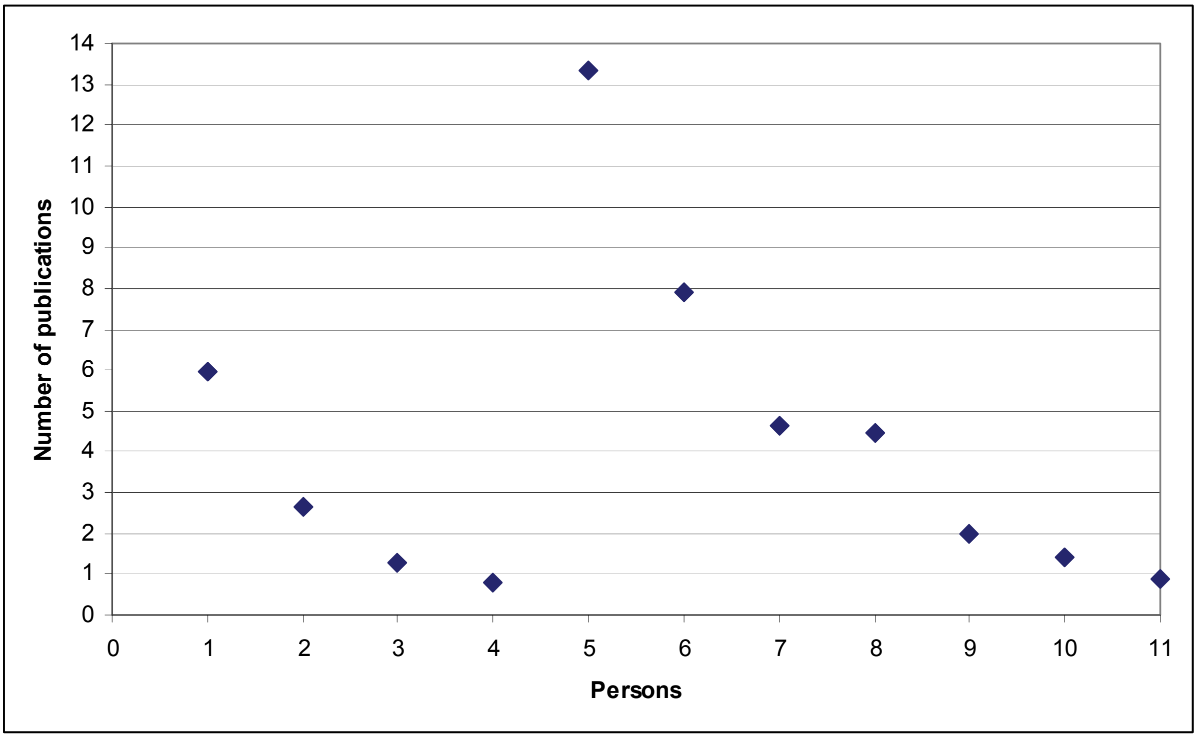
There are 11 persons (tenured personnel, professor IIs excluded) in the two sections encompassed by the evolution, 7 in the Inorganic chemistry group and 4 in the Electrochemistry group. In total these persons published 131 publications during the period 2003-2007, or 45.4 publications fractionalised for co-authorship, cf. Table 5.1. This is 4.1 fractionalised publications per person, slightly below the national average for the population of staff included in this evaluation (4.6). The average productivity is however higher for the Inorganic chemistry croup than for the Electrochemistry group, 4.9 and 2.7 publications per person, respectively.

Table 5.1 Number of publications 2003-2007. Department of Material Science and Engineering, NTNU.

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	11	131	45.4	4.1
Electrochemistry		4	39	10.7	2.7
Inorganic Chemistry		7	92	34.6	4.9
Post docs/researchers		5	31	8.9	–

Figure 5.1 shows the productivity of the individual persons included in the evaluation.

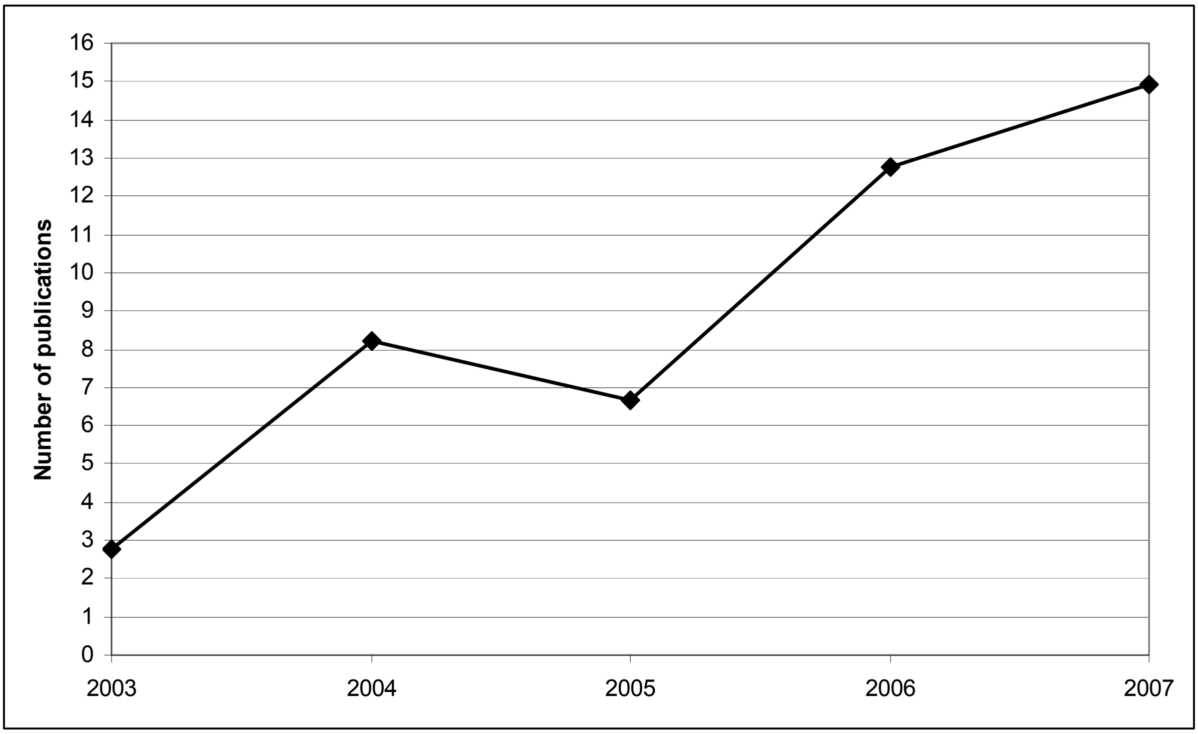
Figure 5.1 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Department of Material Science and Engineering, NTNU.



Legends: 1-4: Electrochemistry. 5-11: Inorganic chemistry

Although the productivity for the entire period 2003-2007 is below the national average, there is a marked increase in the annual numbers of publications during the time period. This is evident from figure 5.2. Particularly the Inorganic chemistry group has contributed to this increase.

Figure 5.2 Number of publications per year, 2003-2007, fractionalised counts. Department of Material Science and Engineering, NTNU.



5.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 5.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

The tenured personnel at the department published 47 % of their journal articles in level 2 journals, which a high proportion. However, we find large differences in this proportion among the two groups, 68 % for Electrochemistry and 39 % for Inorganic chemistry. In comparison the national average is 39 % (average for the set of persons included in this evaluation). However, measured as number of level 2 journal articles per person, there are not significant differences among the two groups. Moreover, the average journal citation rate is higher for the Inorganic chemistry group than for the Electrochemistry group (4.6 and 3.6, respectively). Thus, the picture of the journal profile of the groups is somewhat mixed.

Table 5.2 Journal profile, 2003-2007 publications (whole counts). Department of Material Science and Engineering, NTNU.

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	11	63	55	47 %	5.0	4.3
Electrochemistry		4	10	21	68 %	5.3	3.6
Inorganic Chemistry		7	53	34	39 %	4.9	4.6
Post docs/researchers		5	23	7	23 %	–	4.6

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 5.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 5.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Department of Material Science and Engineering, NTNU (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Electrochemistry	CORROSION SCIENCE	7	3.6	2
	JOURNAL OF THE ELECTROCHEMICAL SOCIETY	7	4.6	2
	JOURNAL OF APPLIED ELECTROCHEMISTRY	3	2.6	1
Inorganic Chemistry	JOURNAL OF THE AMERICAN CERAMIC SOCIETY	13	2.8	2
	JOURNAL OF LIGHT METALS	13	–	1
	SOLID STATE IONICS	9	4.5	1

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

5.3 Citation indicators

We have also analysed the citation rates of the journal articles, the results are given in Table 5.4. The analysis shows that the articles (105 ISI-indexed publications) published by the tenured personnel have received approximately 250 citations. This corresponds to a field citation index of 96, which is the lowest index value of all the departments included in the evaluation. In terms of citation rates, there are not large differences among the two units.

Table 5.4 Citation indicators, 2003-2007 publications (whole counts). Department of Material Science and Engineering, NTNU.

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	105	253	88	96
Electrochemistry		31	78	101	99
Inorganic Chemistry		74	175	83	94
Post docs/researchers		30	274	218	207

*) Only articles in ISI-indexed journals are included

Department of Chemistry

The Department of Chemistry at the NTNU is the third largest department in terms of number of tenured personnel included in the evaluation (24). There are three sections: Organic chemistry, Physical Chemistry and Environmental and Analytical Chemistry (including Chemistry Dissemination).

5.4 Productivity indicators

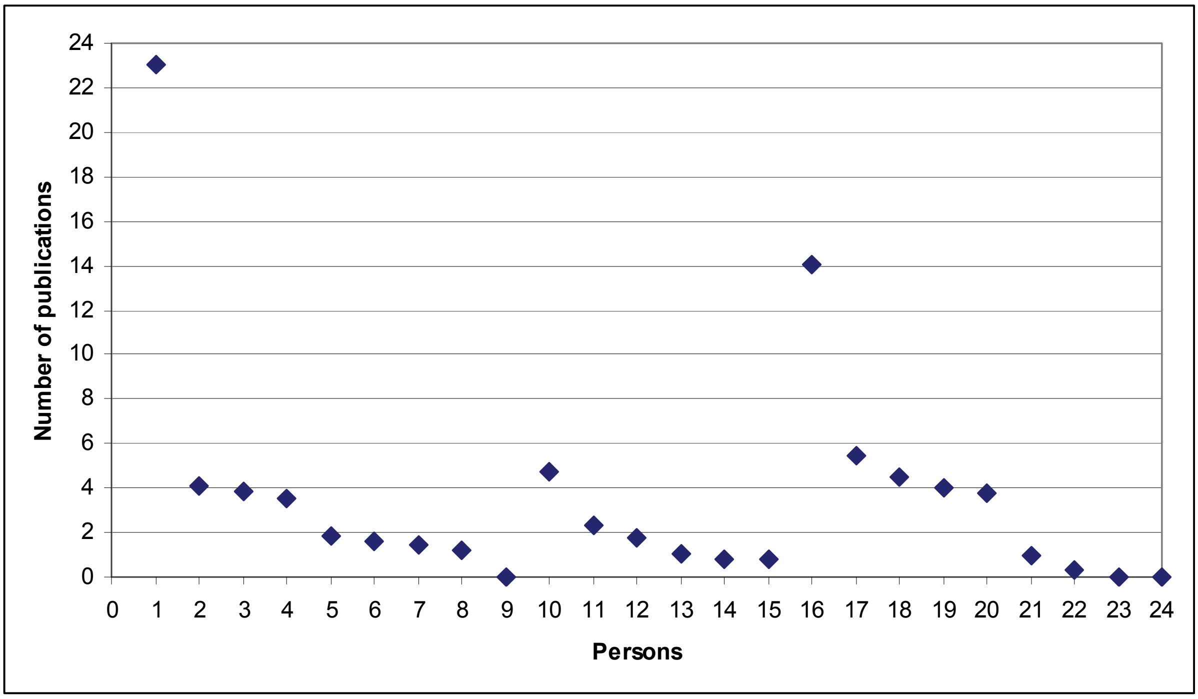
In total the 24 staff members published 276 publications during the period 2003-2007, or 85.3 publications fractionalised for co-authorship, cf. Table 5.5. The productivity per person is 3.6 publications for the five-year period (fractionalised counts), which is below the national average for the population of staff included in this evaluation (4.6). As can be seen from Table 5.5 the number of publications per person is particularly low at the Organic chemistry section (1.9).

Table 5.5 Number of publications 2003-2007, Department of Chemistry, NTNU.

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	24	276	85.3	3.6
Environment		9	127	40.6	4.5
Organic Chemistry		6	43	11.5	1.9
Physical Chemistry		9	112	33.2	3.7
Post docs/researchers		2	4	0.9	–

At the individual levels we find two persons with exceptionally to very high productivity of publications, while a large number of the staff is not very active in terms of publishing activity. This is evident from Figure 5.3.

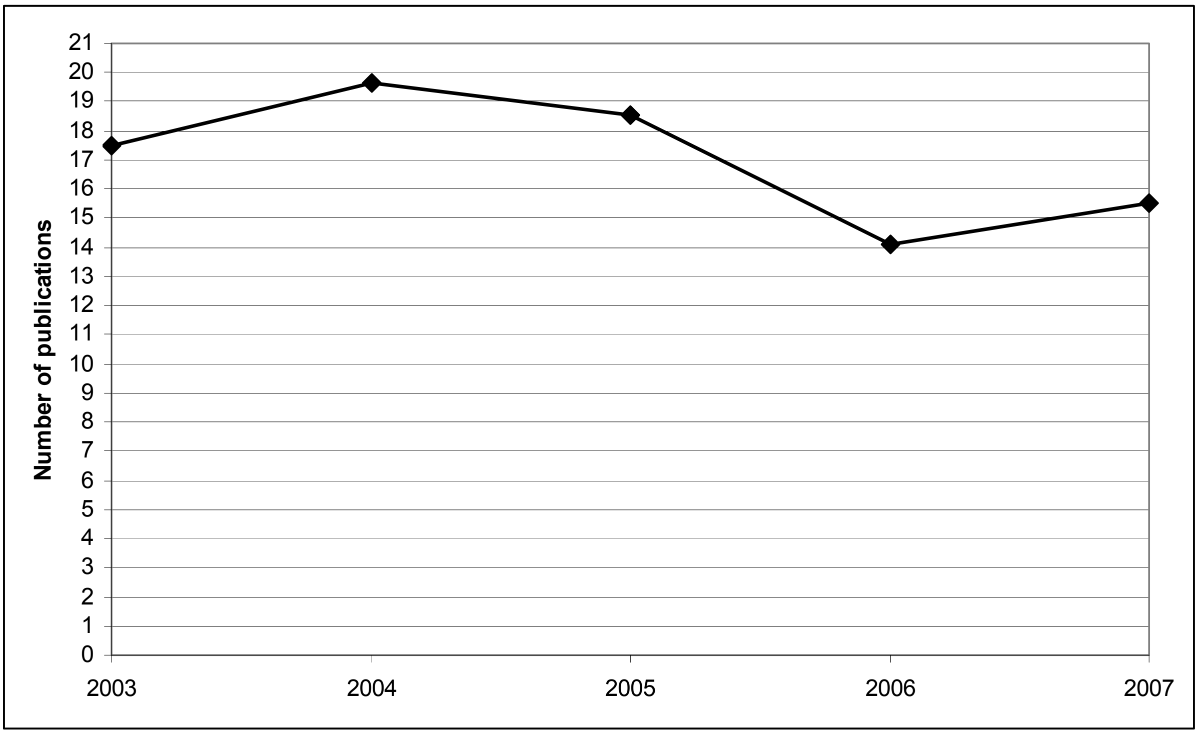
Figure 5.3 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Department of Chemistry, NTNU.



Legends:1-9: Environment. 10-15: Organic chemistry. 16-24: Physical chemistry

We also find that the annual publication counts have been decreasing during the period 2003-2007, cf. Figure 5.4.

Figure 5.4 Number of publications per year, 2003-2007, fractionalised counts. Department of Chemistry, NTNU.



5.5 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 5.6. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

The department has a lower proportion of articles in level 2 journals (30 %) than the national average for the population of persons included in the evaluation (39 %). But there are large differences among the units. The lowest proportion is found for Environment (17 %) and the highest for Physical chemistry (45 %). The latter group also has the highest number of articles in level 2 journals per person (5.4). This is identical to the corresponding national average of 5.4. The average journal citation rates show a similar picture. Based on the figures, one can conclude that Environment and Organic chemistry have a weak journal record, while Physical chemistry has a good.

Table 5.6 Journal profile, 2003-2007 publications (whole counts). Department of Chemistry, NTNU.

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	24	181	79	30 %	3.3	4.6
Environment		9	95	20	17 %	2.2	3.6
Organic Chemistry		6	32	10	24 %	1.7	4.1
Physical Chemistry		9	60	49	45 %	5.4	5.9
Post docs/researchers		2	1	2	67 %	–	6.2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 5.7 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 5.7 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Department of Chemistry, NTNU (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Environment	JOURNAL DE PHYSIQUE IV	9	0.4	1
	JOURNAL OF RADIOANALYTICAL AND NUCLEAR CHEMISTRY	8	1.1	1
	ELECTROANALYSIS	8	5.7	1
Organic Chemistry	JOURNAL OF HETEROCYCLIC CHEMISTRY	5	1.4	1
	MOLECULES	4	2.1	1
Physical Chemistry	JOURNAL OF CHEMICAL PHYSICS	15	5.9	1
	JOURNAL OF PHYSICAL CHEMISTRY B	13	8.1	2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

5.6 Citation indicators

The analysis of the citation frequencies shows that the 260 articles published by the tenured personnel (ISI-indexed) have received almost 1300 citations cf. Table 5.8. This corresponds to a field citation index of 109. In other words, the articles have been cited 9 % more than the world average in the fields where the department is active. This is an intermediate position among the departments included in the evaluation. At group levels, the Physical chemistry unit has a good citation record, while the Organic chemistry unit has a weak.

Table 5.8 Citation indicators, 2003-2007 publications (whole counts). Department of Chemistry, NTNU.

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	260	1282	109	109
Environment		115	563	123	98
Organic Chemistry		42	139	105	72
Physical Chemistry		109	597	98	132
Post docs/researchers		4	6	48	64

*) Only articles in ISI-indexed journals are included

Department of Chemical Engineering

The Department of Chemical Engineering at NTNU has 19 persons included in the evaluation (tenured personnel, professor IIs excluded). The department is organised in six research groups: Catalysis, Colloid and polymer chemistry, Paper and fibre technology, Process systems engineering, Reactor technology, Separation and environmental technology.

5.7 Productivity indicators

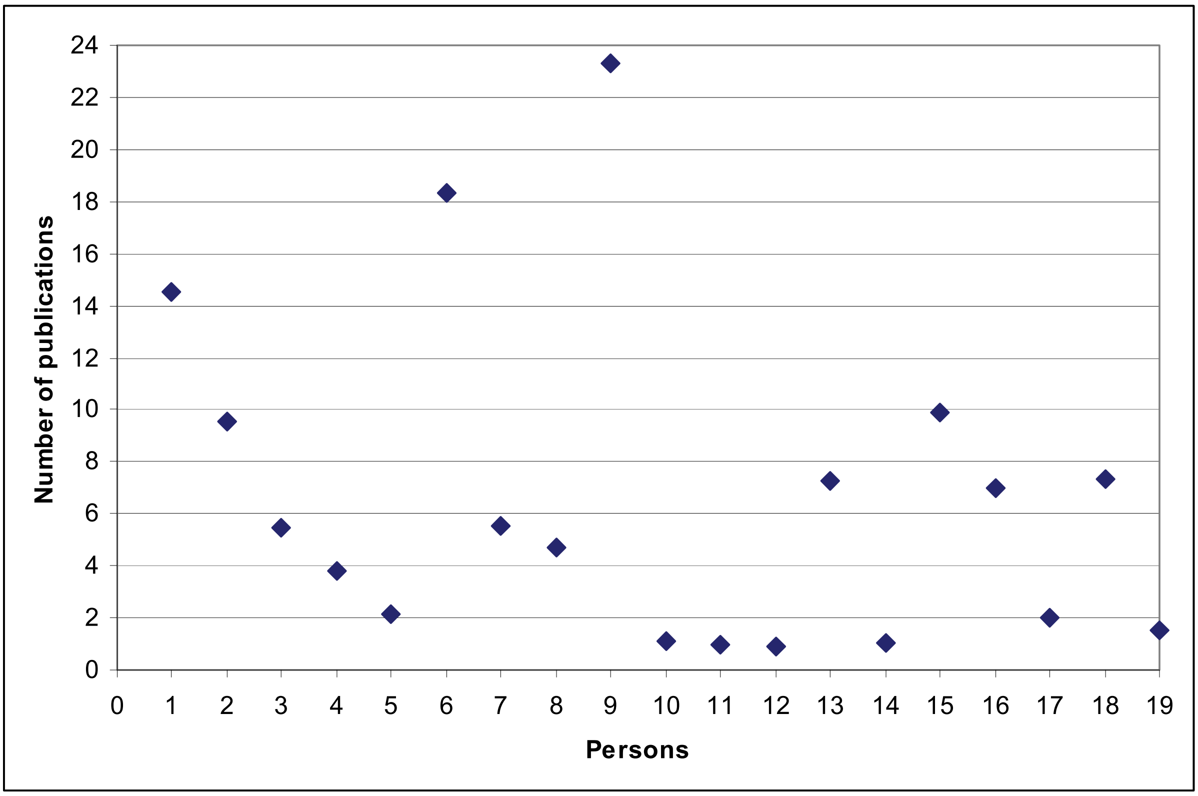
During the period 2003 to 2007 the tenured personnel published 319 publications, or 126.4 items when fractionalising for co-authorship. This is 6.7 fractionalised publications per person and the highest average among the departments included in the evaluation. Particularly the group for Colloid and polymer chemistry has a high average number of publications per person (9.5).

Table 5.9 Number of publications 2003-2007, Department of Chemical Engineering, NTNU.

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	19	319	126.4	6.7
Catalysis		5	105	35.4	7.1
Colloid		3	79	28.5	9.5
Process		4	53	26.3	6.6
Pulp/Paper		2	24	8.3	4.2
Reactor		3	46	18.9	6.3
Separation		2	19	8.8	4.4
Post docs/researchers		20	92	26.9	–

However, at individual levels we find large differences in the number of publications. This is evident from Figure 5.5. There are three persons with exceptionally to very high number of publications and a few persons with low publication levels.

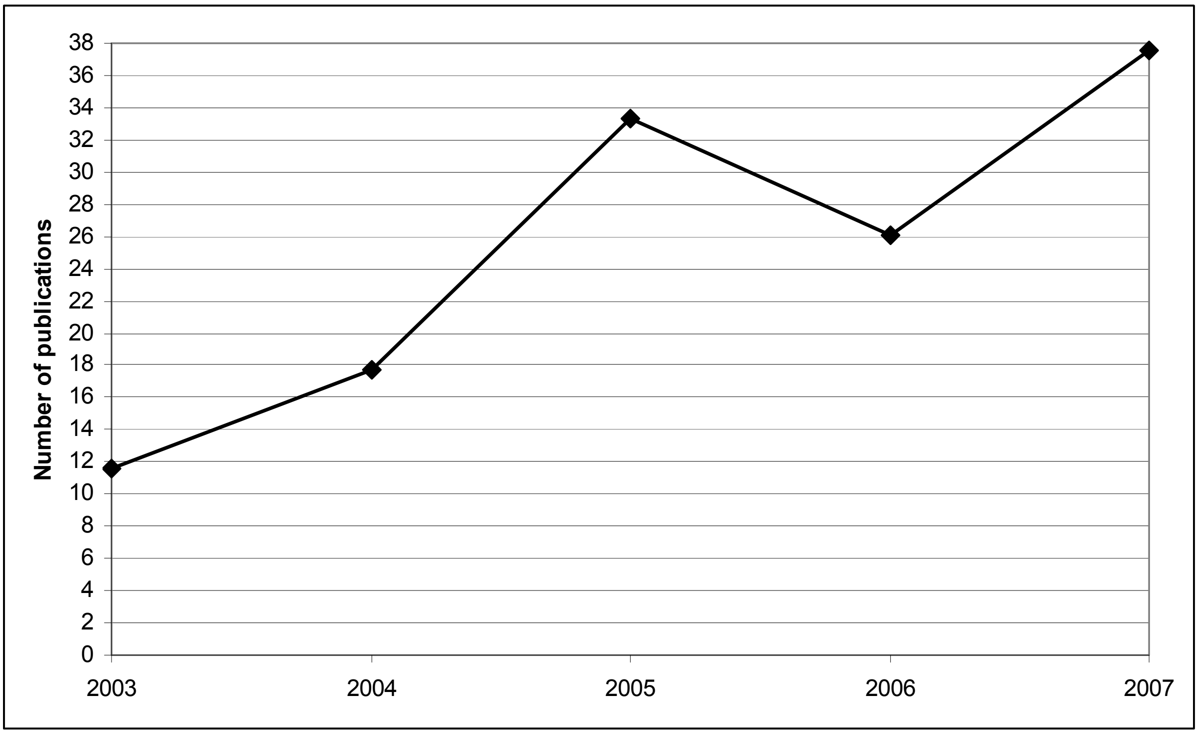
Figure 5.5 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Department of Chemical Engineering, NTNU.



Legends:1-5 Catalysis. 6-8: Colloid. 9-12: Process. 13-14: Pulp/paper. 15-17: Reactor. 18-19: Separation

The annual number of publications has been increasing remarkably during the period, cf. Figure 5.6. Particularly the research groups Catalysis, Colloid and polymer chemistry and Reactor technology have contributed to this positive trend.

Figure 5.6 Number of publications per year, 2003-2007, fractionalised counts. Department of Chemical Engineering, NTNU.



5.8 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 5.10. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

The tenured personnel at the department have published 32 % of their journal articles in level 2 journals, which is lower than the national average for the population of persons encompassed by this evaluation (39 %). The proportions at group levels vary from 0 % (Pulp/paper) to 46 % (Process). Since the productivity differ among the various groups, one gets a complementary picture by looking at the average number of level 2 articles per person. Then we find that groups Colloid, Process, and Catalysis have the highest levels, 6.7, 5.8 and 5.4 articles per person respectively. The average impact factors (journal citation rates) for all the groups are lower than the corresponding national average (5.4). Based on these figures one can conclude that the journal record of the department is not particularly strong.

Table 5.10 Journal profile, 2003-2007 publications (whole counts). Department of Chemical Engineering, NTNU.

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	19	191	88	32 %	4.6	3.6
Catalysis		5	57	27	32 %	5.4	5.0
Colloid		3	51	20	28 %	6.7	3.6
Process		4	27	23	46 %	5.8	2.7
Pulp/Paper		2	23	0	0 %	0.0	1.3
Reactor		3	27	15	36 %	5.0	2.9
Separation		2	10	6	38 %	3.0	4.4
Post docs/researchers		20	40	38	49 %	–	5.1

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 5.11 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 5.11 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Department of Chemical Engineering, NTNU (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Catalysis	CATALYSIS TODAY	18	4.6	1
	TOPICS IN CATALYSIS	12	4.4	1
	STUD SURF SCI CATAL	12	0.7	1
Colloid	JOURNAL OF DISPERSION SCIENCE AND TECHNOLOGY	38	1.8	1
	MICROPOROUS AND MESOPOROUS MATERIALS	5	5.2	2
Process	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	15	3.3	1
	COMPUTERS & CHEMICAL ENGINEERING	9	2.4	2
	JOURNAL OF PROCESS CONTROL	5	2.7	2
Pulp/Paper	NORDIC PULP & PAPER RESEARCH JOURNAL	13	1.3	1
	JOURNAL OF PULP AND PAPER SCIENCE	6	1.3	1
Reactor	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	16	3.3	1
	CHEMICAL ENGINEERING SCIENCE	6	3.7	2
	COMPUTERS & CHEMICAL ENGINEERING	4	2.4	2
Separation	JOURNAL OF MEMBRANE SCIENCE	4	5.7	2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

5.9 Citation indicators

In terms of citation rates, the department performs very well. The 279 articles (ISI-indexed) published by the tenured personnel in the period 2003-2007 have received more than 1100 citation. This corresponds to a field citation index of 147. In other words, the articles have received almost 50 % more citations than the average articles in the fields where the department is active. This is the third highest index value among the departments included in the evaluation. At group level, the Pulp/paper unit has the highest index value, although the number of citations is very low (due to poor citation rates in the field). The groups, Colloid, Reactor and Catalysis have also very high index values, while Separation does not perform well in terms of citation rates.

Table 5.12 Citation indicators, 2003-2007 publications (whole counts). Department of Chemical Engineering, NTNU.

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	279	1129	138	147
Catalysis		84	322	124	146
Colloid		71	471	172	162
Process		50	181	121	130
Pulp/Paper		23	38	154	180
Reactor		42	112	148	156
Separation		16	37	68	84
Post docs/researchers		82	501	117	161

*) Only articles in ISI-indexed journals are included

6 University of Bergen (UiB)

The Department of Chemistry at the University of Bergen is the second largest department in terms of number of tenured personnel included in the evaluation (26, professor IIs excluded).[10] The department is organised in three sections: Inorganic chemistry, nanostructures and modelling (ICNM), Physical-, petroleum- and process chemistry (PPPC), and Organic, biophysical and medicinal chemistry (OBMC). The latter section also includes associate members from Centre of Pharmacy at the University of Bergen.

6.1 Productivity indicators

In total the 26 staff members published 244 publications during the period 2003-2007, or 92.8 publications fractionalised for co-authorship, cf. Table 6.1. The productivity per person is 3.6 publications for the five-year period (fractionalised counts), which is below the national average for the population of staff included in this evaluation (4.6). As can be seen from Table 6.1 the number of publications per person is particularly low at the PPPC section (2.1).

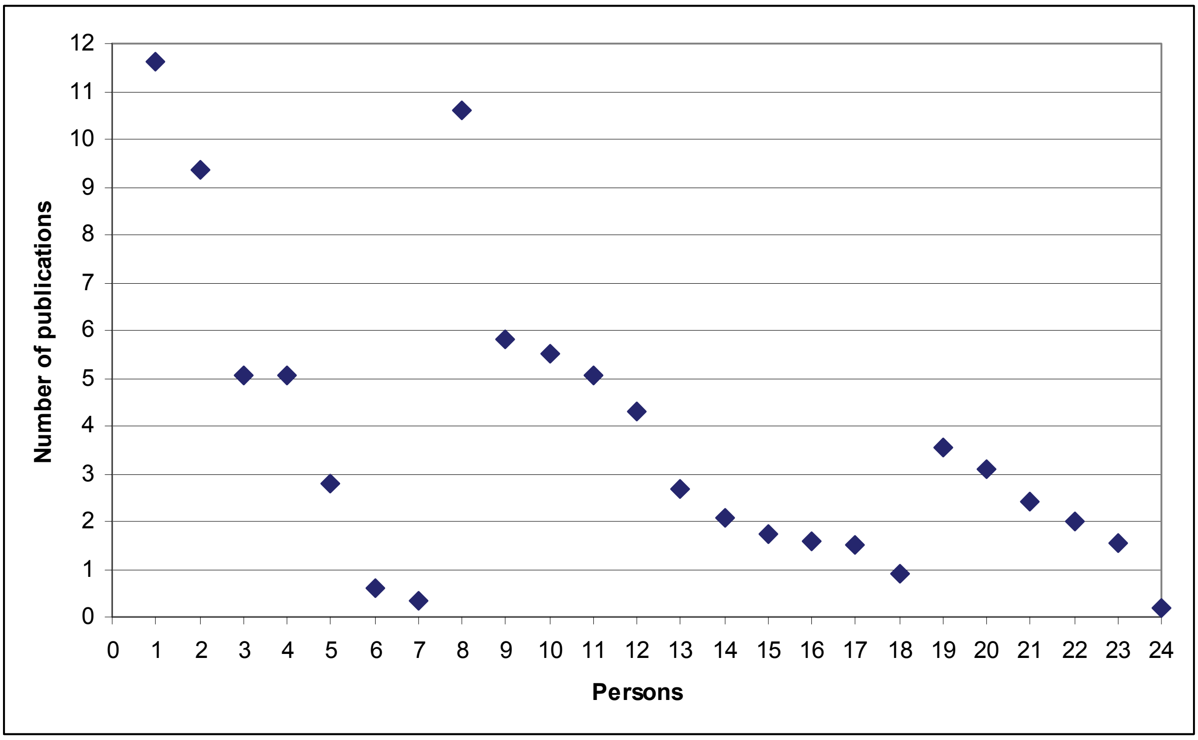
Table 6.1 Number of publications 2003-2007, Department of Chemistry, UiB.

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	26	244	92.8	3.6
ICNM		7	97	34.9	5.0
OBMC		11	106	41.8	3.8
PPPC		6	38	12.8	2.1
Post docs/researchers		10	62	17.6	–

Figure 6.1 provides background data by showing the number of publications per person. At the department there are three persons with very high productivity levels (two in the ICNM group and one in the OBMC group).

[10] Notes on the persons included:
Tenured staff: Two persons employed at Centre for Pharmacy but closely associated to Dep. of Chemistry are included in the analysis (in the OBMC group). One person employed at Centre for Integrated Petroleum Research (CIPR) at the University of Bergen is also included in the analysis. One person is not assigned a group in the factual report (is included in the total).

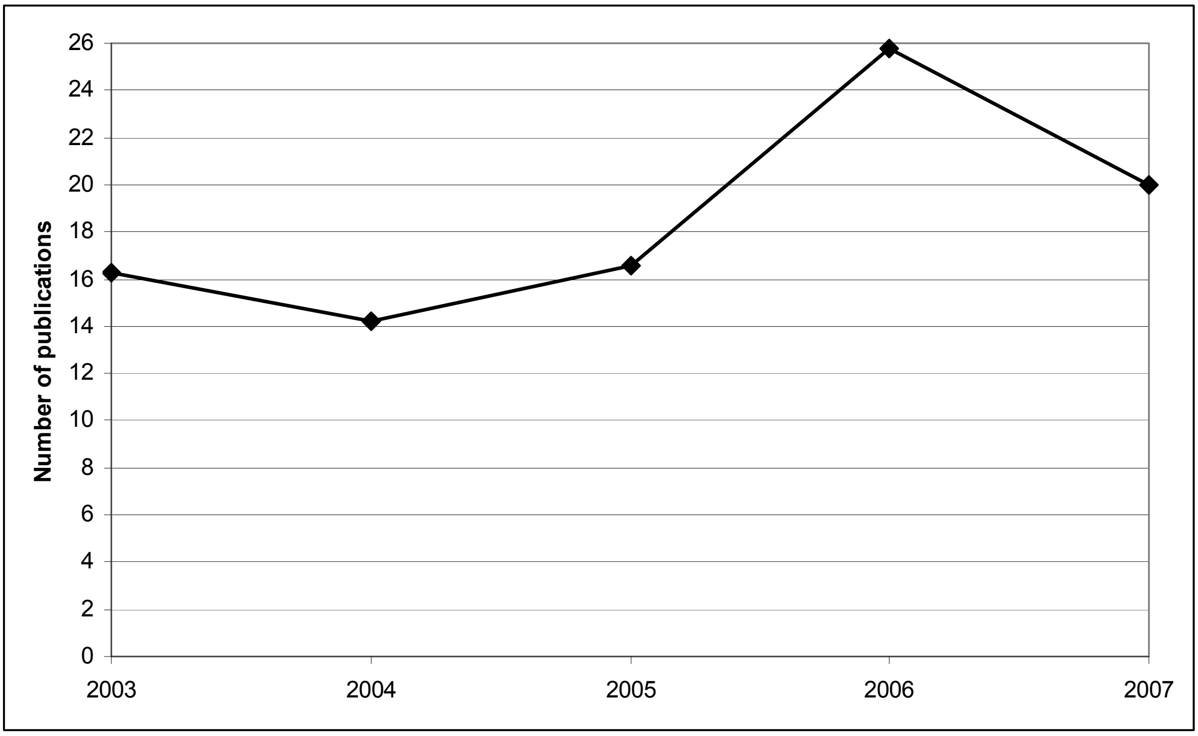
Figure 6.1 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Department of Chemistry, UiB.



Legends: 1-7: ICNM. 8-18: OBMC. 19-24: PPPC

In the period 2003-2007 the annual numbers of publications have varied between 14 and 26 (fractionalised counts), but with a positive trend, cf. Figure 6.2.

Figure 6.2 Number of publications per year, 2003-2007, fractionalised counts. Department of Chemistry, UiB.



6.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 6.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

For the Department of Chemistry at the University of Bergen we find that 53 % of the journal articles are published in level 2 journals. This is the second highest average among the departments included in the evaluation. Also the average impact factor (journal citation rate) of the journals (6.7) is significantly above the national average for the units encompassed by the evaluation (5.4). There are, however, large differences among the three sections. The ICNM group has an extraordinary strong journal record, with 68 % of the articles in level 2 journals and an average of 9.3 such papers per person. Also the journal profile of the OBMC group is very good, with a proportion of level 2 articles of 56 %. The PPPC group, on the other hand, does not perform well on these measures, with a proportion of level 2 journal articles of 29 %, and only 1.7 such papers per person.

Table 6.2 Journal profile, 2003-2007 publications (whole counts). Department of Chemistry, UiB.

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	26	102	117	53 %	4.5	6.7
ICNM		7	31	65	68 %	9.3	7.8
OBMC		11	38	48	56 %	4.4	6.8
PPPC		6	25	10	29 %	1.7	4.6
Post docs/researchers		10	12	45	79 %	–	8.3

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 6.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 6.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Department of Chemistry, UiB (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
ICNM	ORGANOMETALLICS	9	7.7	2
	ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	9	17.3	2
	JOURNAL OF ORGANIC CHEMISTRY	8	7.8	2
OBMC	PHYTOCHEMISTRY	9	4.5	2
	CHEMISTRY-A EUROPEAN JOURNAL	7	10.8	2
	JOURNAL OF AGRICULTURAL & FOOD CHEMISTRY	6	4.9	2
	JOURNAL OF ORGANIC CHEMISTRY	6	7.8	2
PPPC	JOURNAL OF COLLOID AND INTERFACE SCIENCE	4	4.3	1
	PHYSICAL CHEMISTRY CHEMICAL PHYSICS	3	6.3	2
	ANALYTICAL CHEMISTRY	3	10.5	2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

6.3 Citation indicators

Finally, we have analysed the citation frequencies of the publications. The results are given in Table 6.4. The analysis shows that the 219 articles published by the tenured personnel (ISI-indexed) have received more than 1100 citations. This corresponds to a field citation index of 108. In other words, the articles have been cited 8 % more than the world average in the fields where the department is active. This is an intermediate position among the departments included in the evaluation. At group levels, the ICNM unit has a strong citation record, while the OBMC unit has a weak. Because the staff at the department tend to publish in high impact journals, the journal based citation index is significantly lower than the field based citation index.

Table 6.4 Citation indicators, 2003-2007 publications (whole counts). Department of Chemistry, UiB.

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	219	1162	90	108
ICNM		96	592	105	153
OBMC		86	353	66	72
PPPC		35	156	105	104
Post docs/researchers		57	326	99	148

*) Only articles in ISI-indexed journals are included

7 University of Tromsø (UiT)

The Department of Chemistry at the University of Tromsø has 12 persons included in the evaluation (excluding professor IIs). The department has four research groups: Organic chemistry, Inorganic and materials chemistry, Structural chemistry and Theoretical chemistry.[11]

7.1 Productivity indicators

In total the tenured staff encompassed by the evaluation published 212 publications during the period 2003-2007, or 73.4 publications fractionalised for co-authorship, cf. Table 7.1. This is 6.1 fractionalised publications per person, significantly above the national average for the population of staff included in this evaluation (4.6). The average productivity is however much higher for the Theoretical chemistry group (10.2) than for the two other sections (4.6 and 3.8).

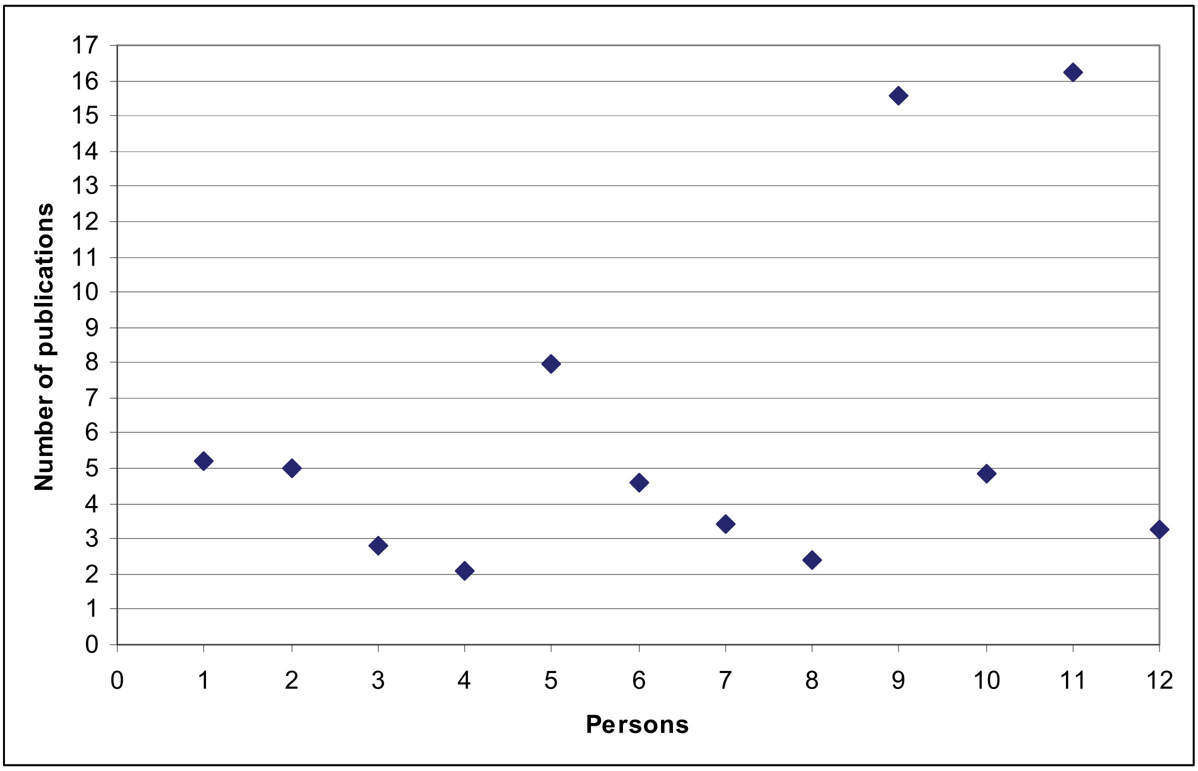
Table 7.1 Number of publications 2003-2007, Department of Chemistry, UiT.

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	12	212	73.4	6.1
Organic chemistry		4	39	15.1	3.8
Structural Chemistry		4	73	18.4	4.6
Theoretical chemistry		2	62	20.4	10.2
Post docs/researchers		13	88	24.3	–

From Figure 7.1 we can see that there are two persons at the department with extraordinary high publication rates, and they contribute significantly to the high average for the department. Moreover, there are no members of the tenured personnel that are inactive in terms of publication activity.

[11] Notes on the persons included:
Tenured staff: The inorganic and materials chemistry group consists of only one tenured staff member. Separate figures are not shown for this person. One person is assigned two groups in the factual report, theoretical chemistry and structural chemistry. Both persons are only included in the total.

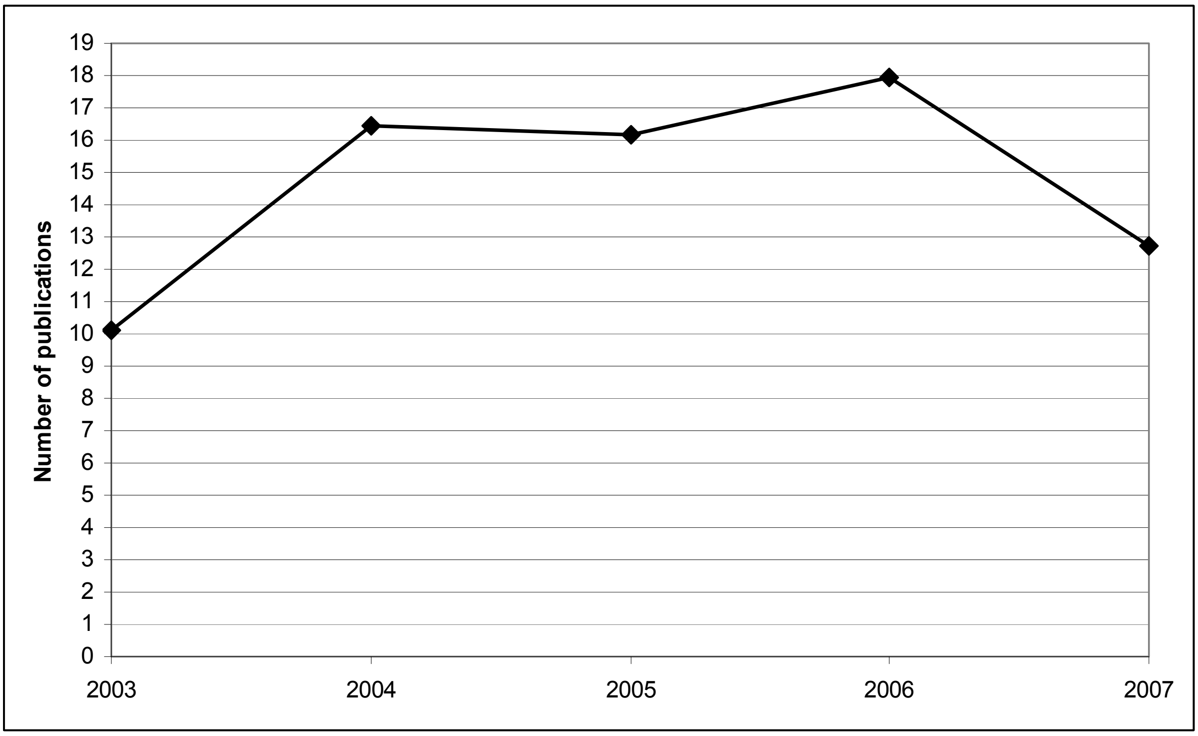
Figure 7.1 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Department of Chemistry, UiT.



Legends:1-4: Organic chemistry. 5-8: Structural chemistry. 9-10: Theoretical chemistry. 11-12: Other

We also find that the annual publication counts have varied during the period 2003-2007, cf. Figure 7.2.

Figure 7.2 Number of publications per year, 2003-2007, fractionalised counts. Department of Chemistry, UiT.



7.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 7.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

The tenured personnel at the department published 34 % of their journal articles in level 2 journals. There are some differences in this proportion among the three groups, 39 % for Structural chemistry, 31 % for Organic chemistry and 21 % for Theoretical chemistry. In comparison the national average is 39 % (average for the set of persons included in this evaluation). Also measured as number of level 2 journal articles per person, there are significant differences among the two groups, the lowest level is found for Organic chemistry (2.8 articles). The staff tend to publish in journals with above average impact factors. Overall, the Structural chemistry group at the department appears as the strongest in terms of journal record with good scores on all the different measures.

Table 7.2 Journal profile, 2003-2007 publications (whole counts). Department of Chemistry, UiT.

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	12	132	68	34 %	5.7	6.9
Organic chemistry		4	24	11	31 %	2.8	5.5
Structural Chemistry		4	43	27	39 %	6.8	6.7
Theoretical chemistry		2	46	12	21 %	6.0	5.6
Post docs/researchers		13	52	32	38 %	–	7.2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 7.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 7.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Department of Chemistry, UiT (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Organic chemistry	JOURNAL OF PEPTIDE SCIENCE	4	4.1	1
	JOURNAL OF MEDICINAL CHEMISTRY	4	10.5	2
	ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	4	1.3	1
Structural Chemistry	ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	16	1.3	1
	JOURNAL OF MOLECULAR BIOLOGY	9	10.0	2
	JOURNAL OF BIOLOGICAL CHEMISTRY	6	11.9	2
Theoretical chemistry	JOURNAL OF CHEMICAL PHYSICS	25	5.9	1
	JOURNAL OF PHYSICAL CHEMISTRY A	5	6.0	2
	CHEMICAL PHYSICS LETTERS	5	4.6	1

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

7.3 Citation indicators

In terms of citation rates, the department performs well. The 200 articles (ISI-indexed) published by the tenured personnel in the period 2003-2007 have received more than 1500 citations. This corresponds to a field citation index of 129. In other words, the articles have received almost 30 % more citations then the average articles in the fields where the department is active. This is the fourth highest index value among the departments included in the evaluation. Nevertheless, we find large differences at group levels. The Theoretical chemistry group has obtained exceptionally high citation rates, while the two other groups do not perform well on this indicator.

Table 7.4 Citation indicators, 2003-2007 publications (whole counts). Department of Chemistry, UiT.

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	200	1523	110	129
Organic chemistry		35	131	79	77
Structural Chemistry		70	368	82	80
Theoretical chemistry		58	593	174	184
Post docs/researchers		85	571	96	113

*) Only articles in ISI-indexed journals are included

8 University of Stavanger (UiS)

Two units from the Department of Mathematics and Natural Science at the University of Stavanger are included in the evaluation: Biological Chemistry and Chemistry and Environment. In total 11 persons (tenured personnel, professor IIs excluded) are encompassed by the analysis.

8.1 Productivity indicators

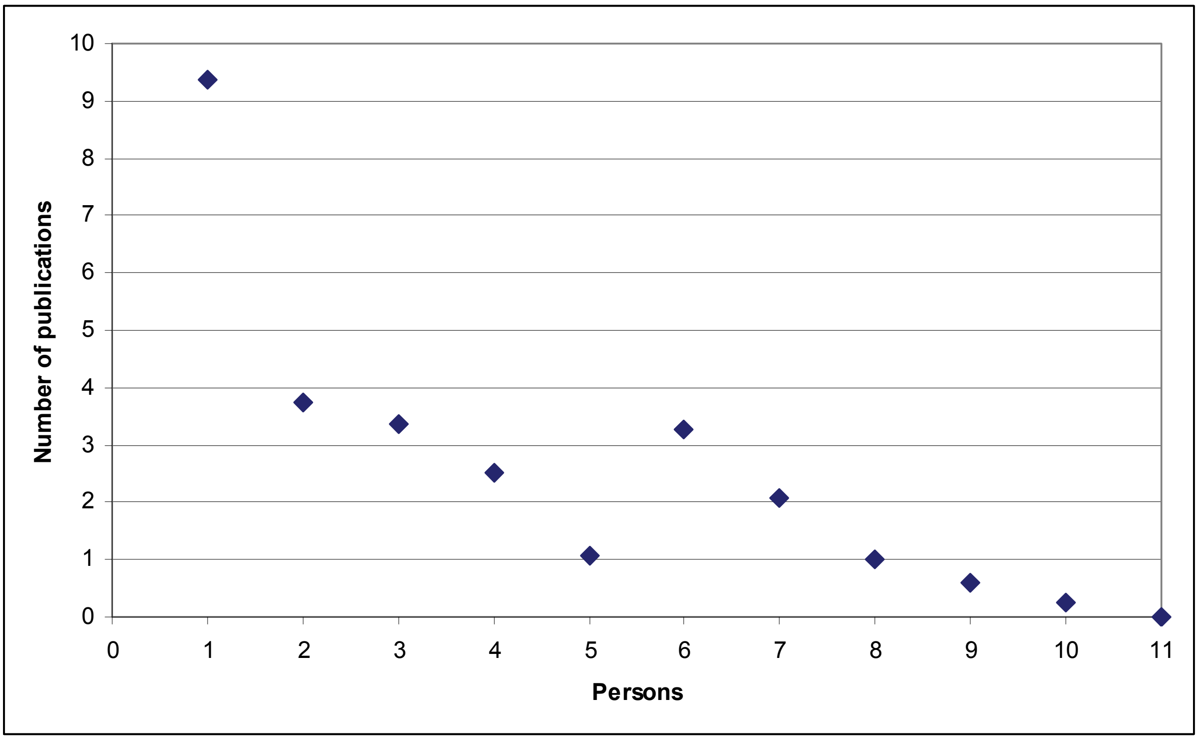
During the period 2003-2007 the staff members have published 72 publications, corresponding to 27.2 items when fractionalising for co-authorship. This amounts to 2.5 fractionalised publications per person. This is the lowest average productivity level of all the departments included in the evaluation. The number of publications per person is particularly low at the Chemistry and environment group (1.2). It should be noted, however, that the University of Stavanger has obtained its university status quite recently (in January 2005). Until then the school was a state university college with teaching as the main activity, and has gradually developed a research agenda to obtain university status.

Table 8.1 Number of publications 2003-2007, University of Stavanger (UiS).

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personell	11	72	27.2	2.5
Biological Chemistry		5	53	20.1	4.0
Chemistry and Environment		6	19	7.2	1.2
Post docs/researchers		8	36	11.2	–

Figure 8.1 provides background data by showing the number of publications per person. As can be seen, there is one person with a high publication rate, while the majority of the personnel have rather poor publication records.

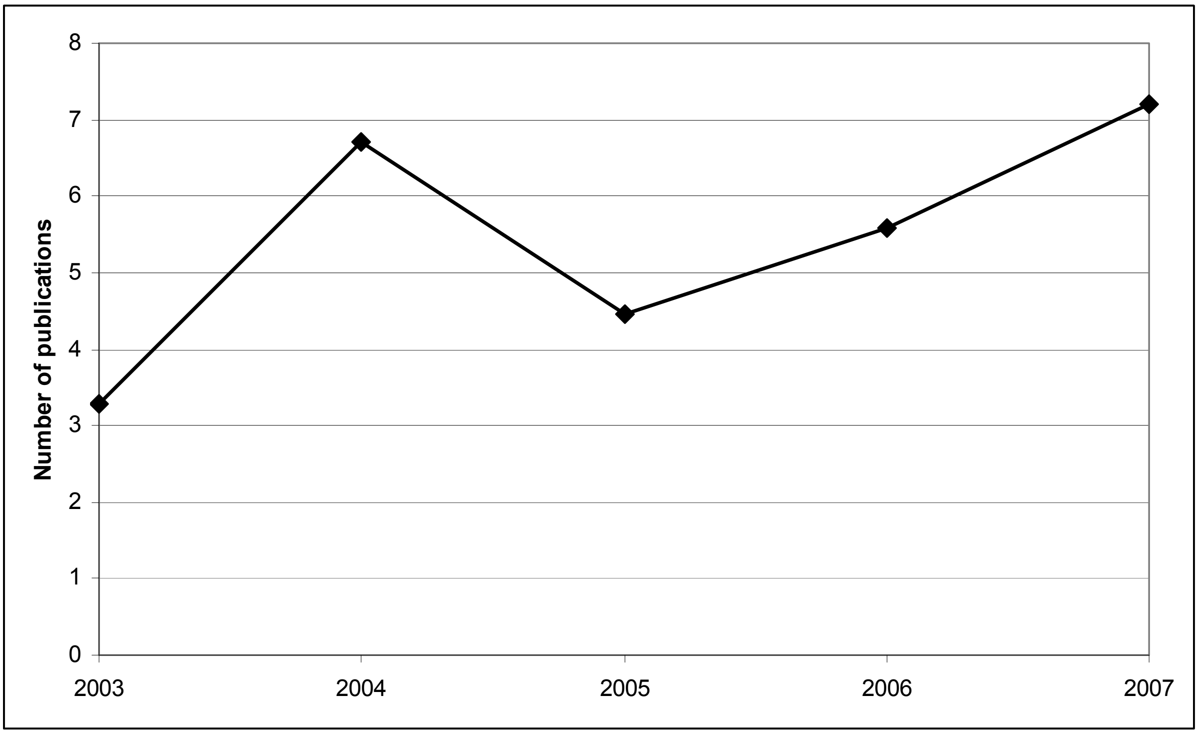
Figure 8.1 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. University of Stavanger (UiS).



Legends:1-5: Biological chemistry. 6-11: Chemistry and environment

There is, however, a positive development and the annual number of publications has been increasing during the period 2003-2007, cf. Figure 8.2

Figure 7.2 Number of publications per year, 2003-2007, fractionalised counts. University of Stavanger (UiS).



8.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 8.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

For the University of Stavanger we find that 63 % of the journal articles are published in level 2 journals. This is the highest average among the departments included in the evaluation. Also the average impact factor (journal citation rate) of the journals (9.9) is significantly above the national average for the units encompassed by the evaluation (5.4). The two chemistry groups at the University both have very high proportions of level 2 articles – the proportion for the Biological chemistry group is 67 % and for the Chemistry and environment group, 53 %. However, on the two other journal measures the latter group obtains significantly lower scores than the other group, and only 1.3 level 2 journal articles are published per person.

Table 8.2 Journal profile, 2003-2007 publications (whole counts). University of Stavanger (UiS).

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	11	22	38	63 %	3.5	9.9
Biological Chemistry		5	15	30	67 %	6.0	11.6
Chemistry and Environment		6	7	8	53 %	1.3	4.5
Post docs/researchers		8	14	19	56 %	–	11.3

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 8.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 8.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, University of Stavanger (UiS) (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Biological Chemistry	PLANT PHYSIOLOGY	5	12.3	2
	PLANT CELL	4	20.6	2
Chemistry and Environment	JOURNAL OF ORGANOMETALLIC CHEMISTRY	5	5.2	1

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

8.3 Citation indicators

In terms of citation rates, we find a polarised picture. The 45 articles (ISI-indexed) published by the tenured staff at the Biological chemistry group have received more than 600 citations, which corresponds to a field citation index of 200. The articles associated with the Chemistry and environment group, on the other hand, are hardly cited at all.

Table 8.4 Citation indicators, 2003-2007 publications (whole counts). University of Stavanger (UiS).

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personell	60	627	100	187
Biological Chemistry		45	619	105	200
Chemistry and Environment		15	8	21	31
Post docs/researchers		33	356	86	164

*) Only articles in ISI-indexed journals are included

9 Norwegian University of Life Sciences (UMB)

The Norwegian University of Life Sciences (UMB) has two research groups included in the evaluation: The environmental chemistry group at the Department of Plant and Environmental Sciences and The organic chemistry group at the Department of Chemistry, Biotechnology and Food.

9.1 Productivity indicators

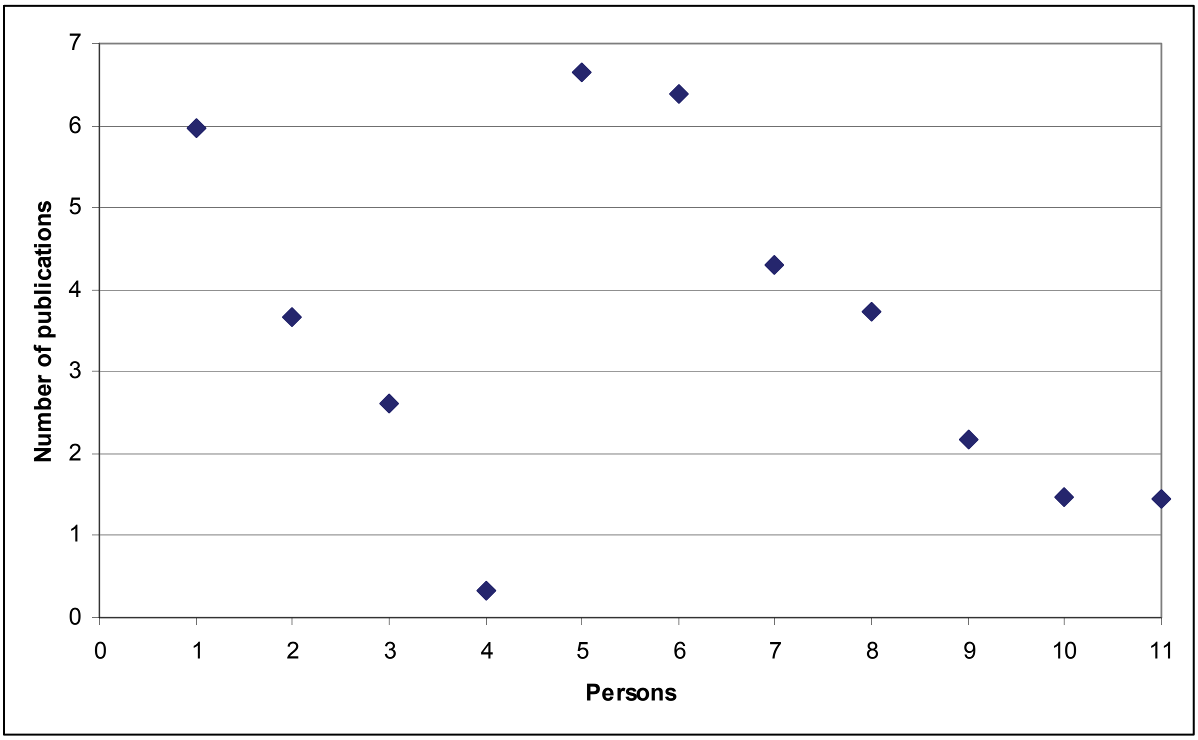
There are 11 persons (tenured personnel, professor IIs excluded) in the two sections encompassed by the evaluation, 7 in the Environmental chemistry group and 4 in the Organic chemistry group. In total these persons published 118 publications during the period 2003-2007, or 38.7 publications fractionalised for co-authorship, cf. Table 9.1. This is 3.5 fractionalised publications per person, below the national average for the population of staff included in this evaluation (4.6). The average productivity does not differ much between the two groups (3.7 and 3.5).

Table 9.1 Number of publications 2003-2007, Norwegian University of Life Sciences (UMB).

Unit		Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	Tenured personnel	11	118	38.7	3.5
Organic chemistry		4	50	12.6	3.1
Environmental chemistry		7	68	26.2	3.7
Post docs/researchers		2	19	5.0	–

At the individual levels, there are significant variations in the number of publications per person, cf. Figure 9.1, but both groups mainly consist of persons with low to moderate publication output.

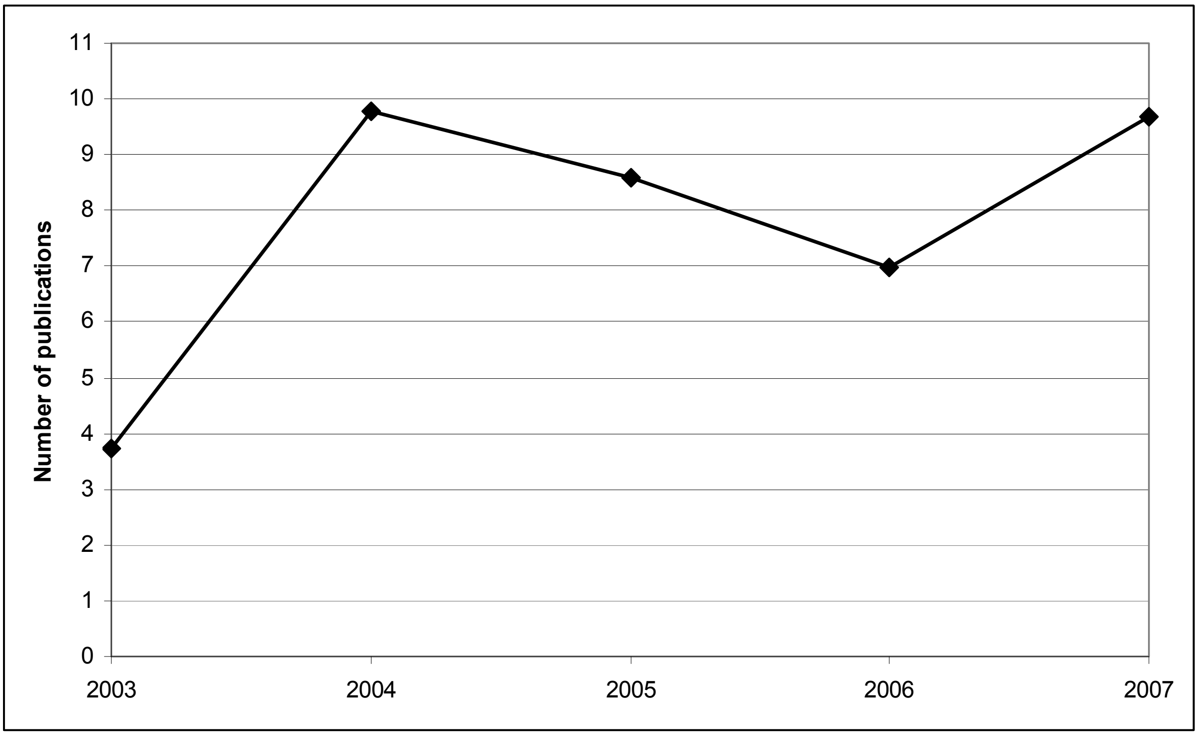
Figure 9.1 Productivity of the tenured personnel. Number of publications per person 2003-2007, fractionalised counts. Norwegian University of Life Sciences (UMB).



Legends: 1-4: Organic chemisty. 5-11: Environmental chemistry

We find that the annual publication counts have varied during the period 2003-2007, cf. Figure 9.2.

Figure 9.2 Number of publications per year, 2003-2007, fractionalised counts. Norwegian University of Life Sciences (UMB).



9.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 9.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

The department has a slightly lower proportion of articles in level 2 journals (34 %) than the national average for the population of persons included in the evaluation (39 %). On this parameter there are not large differences among the two chemistry groups at the University. However, the Organic chemistry group has a higher number of articles in level 2 journals per person (4.3) than the Environmental chemistry group (2.6). Moreover the average impact factor is significantly higher for the Organic chemistry group. Thus, this group has the strongest journal record of the two chemistry units at the University.

Table 9.2 Journal profile, 2003-2007 publications (whole counts). Norwegian University of Life Sciences (UMB).

Unit		Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	Tenured personnel	11	68	35	34%	3.2	4.9
Organic chemistry		4	30	17	36 %	4.3	6.3
Environmental chemistry		7	38	18	32 %	2.6	3.7
Post docs/researchers		2	11	4	27 %	–	3.2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 9.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 9.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Norwegian University of Life Sciences (UMB) (tenured personnel).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
Organic chemistry	JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY	5	4.9	2
	CARBOHYDRATE RESEARCH	3	3.4	1
	JOURNAL OF PHYSICAL CHEMISTRY A	3	6.0	2
Environmental chemistry	JOURNAL OF ENVIRONMENTAL RADIOACTIVITY	14	1.7	1
	SCIENCE OF THE TOTAL ENVIRONMENT	8	5.0	2
	ENVIRONMENTAL SCIENCE & TECHNOLOGY	4	8.2	2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

9.3 Citation indicators

Finally, we have analysed the citation rate of the journal publications. The results are given in Table 9.4. Altogether the articles (ISI-index) published by the tenured personnel in the period 2003-2007 have received more than 450 citations. This corresponds to a field citation index of 101. In other words, the articles have been cited equal to the corresponding field average. This is the second lowest level among the departments included in the evaluation. In terms of citation rates, the Environmental chemistry group performs slightly better than the Organic chemistry group.

Table 9.4 Citation indicators, 2003-2007 publications (whole counts). Norwegian University of Life Sciences (UMB).

Unit		Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	Tenured personnel	103	458	101	101
Organic chemistry		47	208	88	91
Environmental chemistry		56	250	116	111
Post docs/researchers		15	27	73	67

*) Only articles in ISI-indexed journals are included

10 Norwegian Institute for Air Research (NILU)

From Norwegian Institute for Air Research staff from two departments is included in the evaluation: Environmental Chemistry Department (MILK) (15 persons) and the Atmospheric and Climate Change Department (ATMOS) (1 person). [12]

10.1 Productivity indicators

The analysis shows that the staff included in the evaluation published 207 publications in the period 2003-2007.

Table 10.1 Number of publications 2003-2007, Norwegian Institute for Air research (NILU).

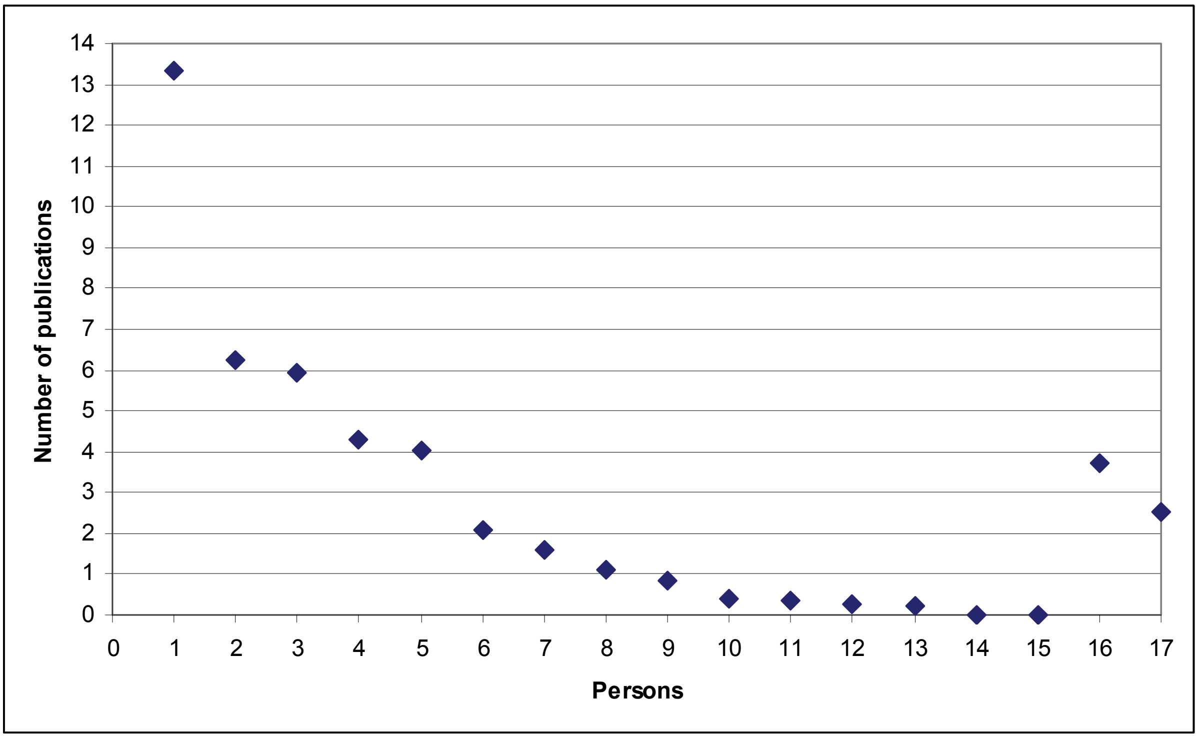
Unit	Number of persons incl.	Publications - whole counts	Publications - fractional counts	Number of publications - fractional counts per person
TOTAL	17	207	46.9	2.8
MILK	15	182	40.7	2.7

Table 10.1 shows various publication indicators for the institute and its research group MILK. When fractionalised for co-authorship contributions, the 207 publications corresponded to 46.9 publications. This represents 2.8 publications (fractional counts) per staff member. This is significantly below the national average for the population of staff included in this evaluation (4.6). It should be noted, however, that NILU represents a different kind of unit than the other departments encompassed by the evaluation. For institutes like NILU, which is part of the Norwegian institute sector, the mission and research profile differ from the Higher Education Institutions. As a consequence of an applied research profile (contract research) one typically finds a publication profile consisting of many reports (not included in this evaluation).

From Figure 10.1 which shows the number of publications per person we find: There is one person at the institute with a very high productivity of publications, a few persons with high to moderate levels, and a significant number of persons with few publications.

[12] Notes on the persons included:
One person is not assigned a group in the factual report. The ATMOS group consists of only one tenured staff member. Separate figures are not shown for this person. Both persons are only included in the total.

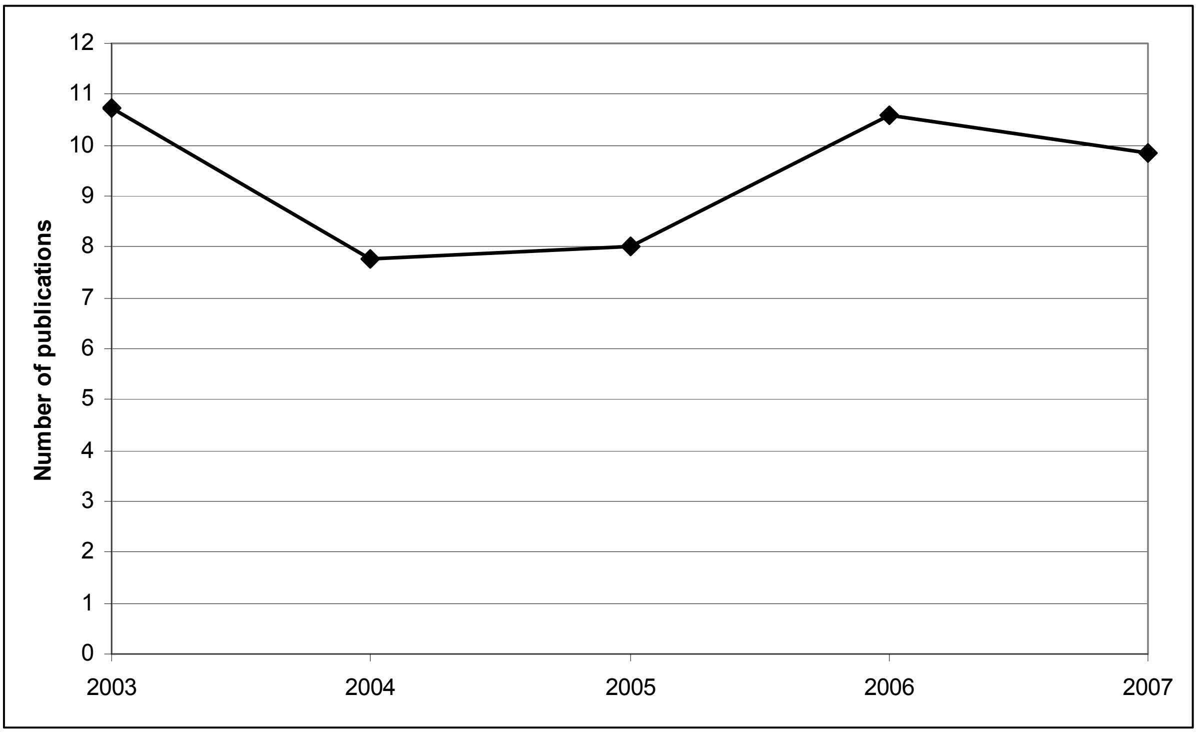
Figure 10.1 Productivity of the personnel. Number of publications per person 2003-2007, fractionalised counts.). Norwegian Institute for Air Research (NILU).



Legends: 1-15: MILK. 16-17: Other Units

Figure 10.2 shows that the annual publication numbers have varied from 8 to 11 (fractionalised items) during the period 2003-2007.

Figure 10.2 Number of publications per year, 2003-2007, fractionalised counts. Norwegian Institute for Air Research (NILU).



10.2 Journal profile

We have analysed the distribution of journal articles from the period 2003-2007. The results are given in Table 10.2. The table shows the number of articles (whole counts) for the department and groups in the two categories of journals applied in the UHR's bibliometric funding model for performance based budgeting of research institutions. The highest level (level 2) includes only the leading and most selective international journals. We have also calculated the proportion of level 2 articles and the average number of such articles per person. Moreover, we have calculated the average citation rate (impact factor) for the journals the staff have published their articles in (weighted average).

We find that 42 % of the journal articles have been published in level 2 journals, which is good, and slightly above the national average for the departments encompassed by the evaluation (39 %). The average impact factor (journal citation rate) is also above the corresponding national average (5.5).

Table 10.2 Journal profile, 2003-2007 publications (whole counts). Norwegian Institute for Air Research (NILU).

Unit	Numb. of persons incl.	Numb. of articles - level 1	Numb. of articles - level 2	Prop. of articles - level 2	Avg. numb. of articles - level 2 per person	Avg. journal citation rate (impact factor)*
TOTAL	17	112	82	42 %	4.8	6.1
MILK	15	100	71	42 %	4.7	6.2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

Table 10.3 shows which journals the staff most often published their articles in and the journal citation rates and levels of the respective journals.

Table 10.3 The most frequently used journals, number of publications (whole counts) 2003-2007 by groups/sections, Norwegian Institute for Air Research (NILU).

Group/section	Journal	Numb. of articles	Journal citation rate (impact factor)*	Level
MILK	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	37	6.2	2
	ATMOSPHERIC CHEMISTRY AND PHYSICS	26	9.8	1
	ATMOSPHERIC ENVIRONMENT	9	4.6	1
	CHEMOSPHERE	8	5.3	1
	ENVIRONMENTAL SCIENCE & TECHNOLOGY	8	8.2	2
	JOURNAL OF CHROMATOGRAPHY A	8	7.0	2

*) The average journal citation rate is here based on the 2005 articles published in the respective journals and their citation rates in the period 2005-2007 (the "standard" journal impact factor is calculated in a different way).

10.3 Citation indicators

The number of citations received during the period 2003-2007 is exceptionally high. The 194 articles (ISI-indexed) have received almost 2000 citations. This corresponds to a field citation index of 217. In other words, the articles have received 117 % more citations then the average articles in the fields the Institute is active. With this the Institute ranks far above the other departments included in the evaluation. The distribution is, however, very skewed and one person accounts for a significant number of these citations.

Table 10.4 Citation indicators, 2003-2007 publications (whole counts). Norwegian Institute for Air Research (NILU).

Unit	Number of articles*	Total number of citations	Citation index - journal	Citation index - field
TOTAL	194	1996	177	217
MILK	171	1739	179	214

*) Only articles in ISI-indexed journals are included.

Appendix – "Level 2" journals

List of "level 2" journals within chemistry and related fields (material science, nanotechnology, process technology, energy and environmental technology)*

Accounts of Chemical Research
Acta Crystallographica Section B: Structural Science
Acta Materialia
Advanced Materials
AIChE Journal
Analytical Chemistry
Angewandte Chemie International Edition
Annual Review of Materials Research
Applied Catalysis A : General
Applied Physics A: Materials Science & Processing
Biomaterials
Chemical Communications
Chemical Engineering Science
Chemical Reviews
Chemical Society Reviews
Chemistry - A European Journal
Chemistry of Materials
Combustion and Flame
Combustion Science and Technology
Composites Part B: Engineering
Composites Science And Technology
Coordination chemistry reviews
Corrosion
Corrosion Science
Electrochimica Acta
Energy & Fuels
Environmental Modelling & Software
Environmental Science and Technology
European Journal of Organic Chemistry
Experimental heat transfer
Fluid Phase Equilibria
Fuel
Heat and Mass Transfer
Heat Transfer Engineering
IEEE transactions on nanotechnology
Inorganic Chemistry
International Journal of Fatigue
International journal of plasticity
International Materials Reviews
Journal of Agricultural and Food Chemistry
Journal of Analytical Atomic Spectrometry
Journal of applied crystallography
Journal of Biomechanics
Journal of Biomedical Materials Research
Journal of Catalysis
Journal of Chromatography A
Journal of Hazardous Materials
Journal of Hydraulic Engineering
Journal of hydrologic engineering
Journal of magnetic resonance
Journal of Materials Chemistry
Journal of Membrane Science
Journal of Nanobiotechnology
Journal of Organic Chemistry
Journal of Physical Chemistry A
Journal of Physical Chemistry B
Journal of Separation Science
Journal of The American Ceramic Society
Journal of the Electrochemical Society
Journal of the European Ceramic Society
Langmuir
Macromolecules
Mass spectrometry reviews (Print)
Materials Science & Engineering: A
Materials Science and Technology
Materials transactions, JIM
Metallurgical and Materials Transactions. A
Metallurgical and materials transactions. B
Microporous and Mesoporous Materials
MRS bulletin
Nano letters (Print)
Nanostructured materials
Nanotechnology
Natural product reports (Print)
Nature
Nature Materials
Organic Letters
Organometallics
Physical Chemistry, Chemical Physics
Proceedings of the Combustion Institute
PNAS
Progress in Materials Science
Science
Scripta Materialia
Tetrahedron
Trends in Food Science & Technology

*) Journals accredited as level 2 journals by UHR's National Councils (ref. 1.1.2008). In the analysis also "level 2" journals in other subjects are included.

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The Research Council of Norway
P.O. Box 2700 St. Hanshaugen
NO-0131 Oslo
Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@forskningsradet.no
www.rcn.no/english

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