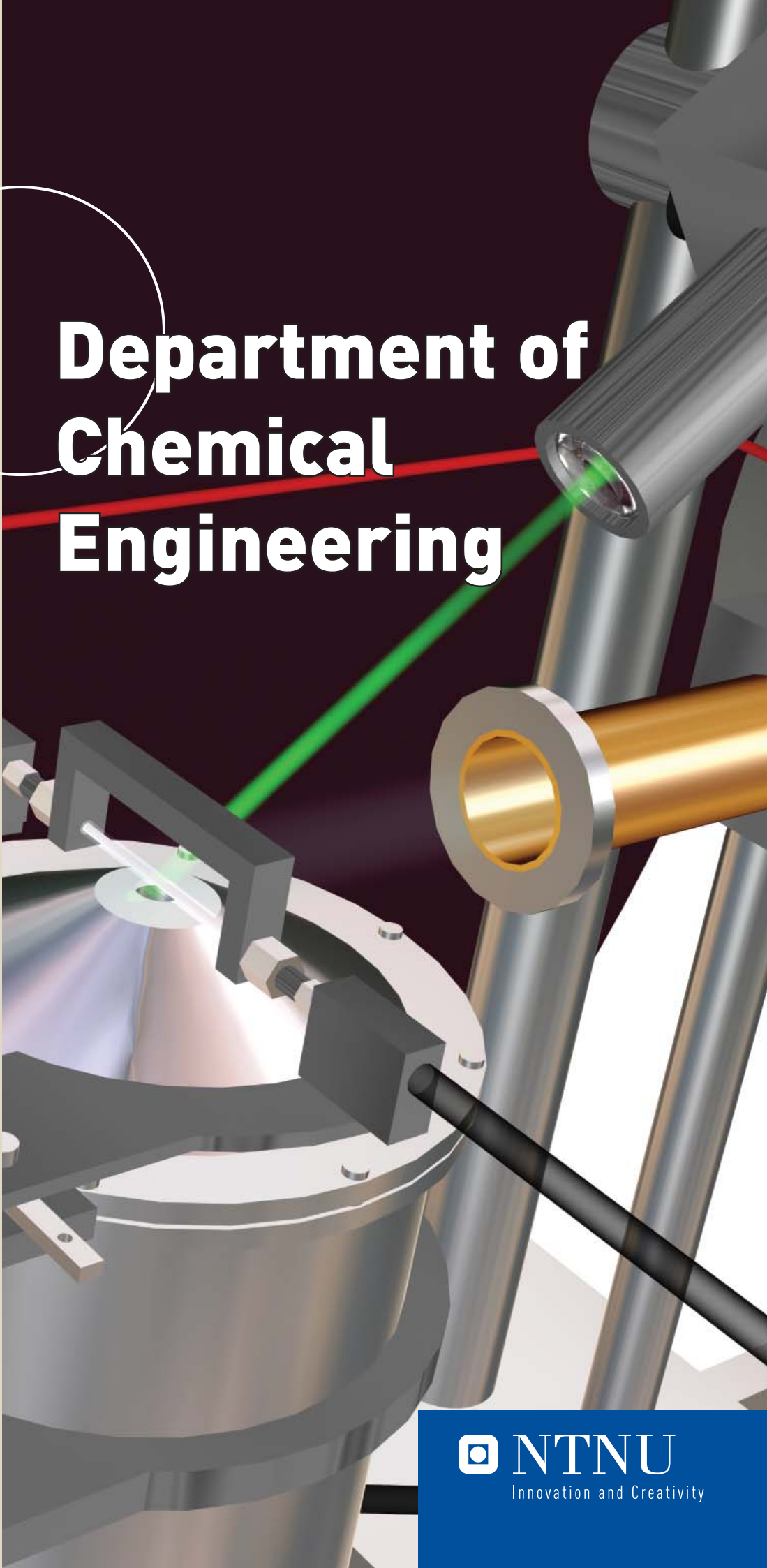
Department of Chemical Engineering

Annual Report 2008



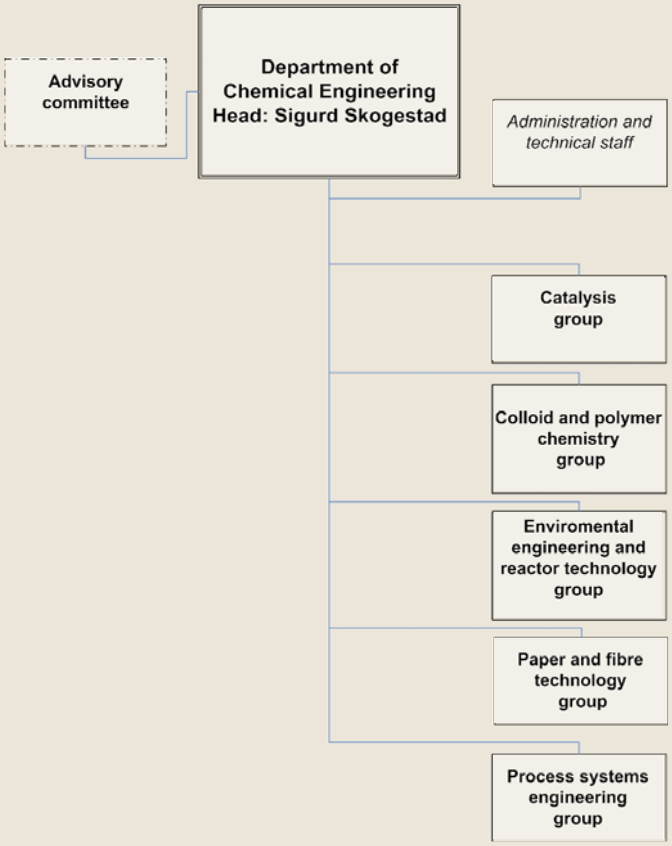
NTNU
Innovation and Creativity

DEPARTMENT OF CHEMICAL ENGINEERING, NTNU

Sem Sælands vei 4, 7491 Trondheim, Norway

Phone: +47 73594030
Fax: +47 73594080
E-mail: postmottak@chemeng.ntnu.no

Head of Department:
Professor Sigurd Skogestad
Deputy Head of Department:
Professor Edd A. Blekkan



Department advisory committee
External members:
Chair, Research Director Ole Wærnes, SINTEF
Professor Jon Kleppe, Petroleum Engineering

Internal members:
Professor Heinz Preisig
Professor Hallvard Svendsen
Associate Professor Hilde J. Venvik
Senior Engineer Berit Borthen
PhD-Candidate Ellen Marie Flaten
Student Stine T. Roset
Student Rebecca Williams

Staff
Academic staff, see the individual research groups:

Technical and administrative staff:
Head of Administration Tom Helmersen

Administrative staff:
Senior Executive Officer Torgrim Mathisen
Executive Officer Lisbeth B. Roel
Executive Officer Tove Barø
Executive Officer Gerd Sandvik

Technical staff:
Senior Engineer Berit Borthen
Engineer Harry Brun
Engineer Arne Fossum
Engineer Odd Ivar Hovin
Principal Engineer Signe Håkonsen
Principal Engineer Iva Králová
Principal Engineer Caterina Lesaint
Principal Engineer Andrea A. Mingot
Principal Engineer Jan Morten Roel
Principal Engineer Cecilie M. Selsbak
Engineer Frode Sundseth
Senior Engineer Bodhild Øvrevoll
Senior Engineer Asbjørn Øye

COVER PAGE (Illustration by Alexey Voronov and Vladislav Kalitka)
In situ microreactor for combined X-ray diffraction, X-ray absorption spectroscopy and Raman spectroscopy: The reactor is used at the European Synchrotron Radiation Facility to study the Fischer-Tropsch synthesis catalyst at realistic working conditions.

DEPARTMENT OF CHEMICAL ENGINEERING, NTNU

CONTENTS

Printed April 2009
Prepared and edited by Lisbeth Blekkan Roel, Tom Helmersen, Sigurd Skogestad

CHAPTER 1: INTRODUCTION

Introduction to Annual Report 2008

By Sigurd Skogestad (Head of Department)

This report aims at summing up the activity in 2008 as well as providing more general information about the department. We hope that you find it useful!

In 2008 a shift occurred towards a more international department. First, we admitted our first 9 students in the *international master program* in chemical engineering. All teaching in the 4th ond 5th year is now offered in English and the international master students follow the same courses as the ordinary Norwegian students in their two years of study.

Second, our PhD population is changing from largely Norwegian towards being truly international. The 38 new PhD students in 2008 (a record by a large margin!) are from the following 15 countries:

Norway	6
India	6
Iran	4
China	3
Czech Republic	3
Pakistan	3
Russia	3
Greece	2
Romania	2
Albania	1
Argentina	1
Bangla Desh	1
Netherlands	1
Slovenia	1
Tanzania	1

In 2008, the research output, as expressed by the number of graduated PhD candidates and publications, was good, although not quite as high as in the record breaking year 2007. The number of credited publications in international journals was 84 (2008), whereas it in the five previous years was 46 (2003), 48 (2004), 76 (2005), 74 (2006) and 108 (2007).

Furthermore, 13 PhD candidates graduated in 2008, which is about the same as previous years. Since the avarage time to complete a PhD is about 4-5 years (including leaves of absense), we can infer from the Table on the next page that the PhD production is likely to to drop slighly the new two years, but will then increase sharply because of the record number of 38 new PhD students in 2009, of which many are funded by the new GASSMAKS program of the Norwegian Research Council (NFR).

A problem for the Department over the last 7 years or so has been the low number of students in the *Chemical Engineeringy and Biotechnology* program. Partly in response to this situation, we have started a 2-year International Master program in Chemical Engineering. We presently have 9 students and are expecting to expand to 15-20 new students each year.

In terms of plans and faculty recruitment, we have followed quite closely the Departments strategic plan from 2003. In January 2008, Nadav ("Nadi") Skjøndal-Bar started as Associate Professor (*Førsteamanuensis*) in the field of systems biology. This is cooperation with similar activities in the Departments of Biotechnology and Biology. The Department has now completed a major replacement of its academic staff with 15 (of 19) new fulltime faculty members being hired since 1997.

The Department is located in Chemistry buildings K4 and K5, experimentall halls C and D (which could be considered building K6) and in the PFI-building across the street. Our chemistry buildings date back to 1957/58 (K5/Exp. Halls) and 1965 (K4). Due to inadequate ventilation in K4, some of the labs in the basement and ground floor have not been in use since the paper group moved out in 1998, and the two upper floors have been largely empty since the electro-chemistrry group moved out in late 2005. A complete renovation of K4 will take place in 2009, and is expected to be finished early 2010. The paper machine in the basement, which was officially opened by King Olav in 1967, will be removed to make place for new labs for the expanding CO2-removal activity. The funding for the renovation comes from the Government Financial Crisis Package (120 mill. NOK) and from the university (25 mill. NOK). This funding will also be used to start renovating the experimental halls, but a complete renovation will require additional money.

In 2008 the Department was evaluated by the Research Coincil as part of an evaluation of all Chemistry Research in Norway. The evaulation was very postive for the Department, and the committee writes: "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."

FACTS ABOUT THE DEPARTMENT OF CHEMICAL ENGINEERING

The Department of Chemical Engineering is located at the Gløshaugen campus of the Norwegian University of Science and Technology (NTNU) in Trondheim. NTNU is the only university in Norway that awards engineering degrees in all areas.

The Department offers a 5 year program leading to the degree of *sivilingeniør* (M.Sc.) in chemical engineering. Most of the students start at NTNU in their first year, but about 10 to 20% enter in the fourth year based on a 3-year engineering Bachelor degree. On top of this we offer a 3 year doctoral program leading to a Ph.D. degree in chemical engineering. In addition, we offer a 2 year International Master Program in Chemical Engineering.

The Department can trace its roots back to 1910 when the Norwegian Institute of Technology (NTH) started up in Trondheim with engineering chemistry as one of the seven majors. After the Second World War, three applied Departments were formed, namely pulp and paper chemistry (*treforedlingskjem*i, 1946), chemical engineering (*kjemiteknikk*, 1949) and industrial chemistry (*industriell kjemi,* 1950). These merged in 1999 to the present Department of chemical engineering (*kjemisk prosessteknologi*).

The objectives of the Department are:

1. *Education.* Offer a Master Degree in Chemical Engineering which is internationally recognized and makes the candidates attractive on the labour marked.
2. *Research*. Research shall be on an international level, and in some areas internationally leading.
3. The Department shall be attractive in order to recruit the best candidates, including academic faculty, PhD students and undergraduate students. The social environment shall be very good so that everyone feels welcome.

The permanent staff in 2008 included

- 17 technical/administrative
- 19 academic, incl.12 Professors and 7 Associate Professors (*Førsteamanuensis*)

The non-permanent staff in 2008 included

- 4 technical
- 5 Adjunct Professors (*Professor II*) (20% *position)*
- 98 PhD students
- 28 Post.docs and researchers

The Department also houses 8 Professor emeritus and 4 visitors, in addition to a large SINTEF group.

Student production

Year	MSc	PhD
1994	60	11
1995	79	2
1996	57	5
1997	67	9
1998	46	13
1999	81	8
2000	69	10
2001	18(*)	11
2002	75	12
2003	44	7
2004	30	10
2005	25	13
2006	19	15
2007	31	15
2008	31	13

(*) Transition from 4.5 to 5 year program.

MSc students 2008/09

5th year	33
4th year	39 (incl. 9 International Master)
3rd year	26

New PhD students (exchange students not included)

2003	20
2004	10
2005	9
2006	18
2007	15
2008	38

New Post.docs/Scientists

2006	10
2007	25
2008	28

CHAPTER 2: RESEARCH

CATALYSIS GROUP

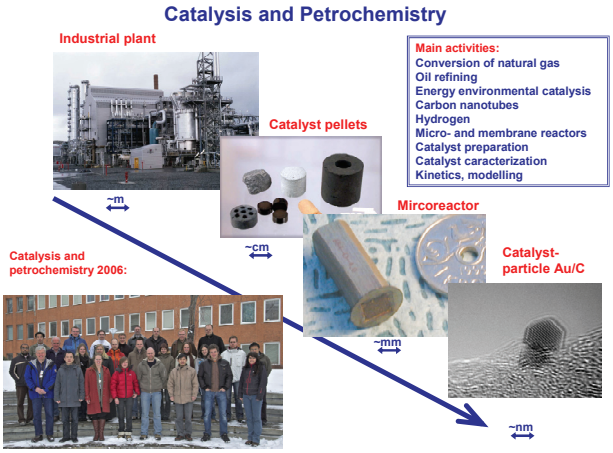
Academic staff
Professor Anders Holmen
Professor Edd A. Blekkan
Professor De Chen
Professor Magnus Rønning
Associate professor Hilde J. Venvik
Adjunct professor Kjell Moljord
Adjunct professor Erling Rytter

Post docs
Anna Maria Lind (until 31.08.08)
Espen Standal Wangen (from 05.05.08)
Estelle Vanhaecke (from 18.02.08)
Hongmin Wang (from 27.02.08)
Santhosh Kumar Matam (until 04.06.08)
Tiejun Zhao

PhD candidates
Alexej Voronov (from 30.04.08)
Anh Hoang Dam
Astrid Lervik Mejdell
Bjørn Christian Enger (until 31.10.08)
Eleni Patanou (from 03.03.08)
Fan Huang (from 31.01.08)
Fatemeh Hayer
Hamidreza Bakhtiary
Hassan Jamil Dar (from 01.08.08)
Hilde Meland (until 30.05.08)
Ilya Gorelkin (from 28.07.08)
Ingvild Tronstad (from 01.10.08)
Jia Yang (from 01.08.08)
Juan Maria Schena (until 29.02.08)
Li He
Miroslav Surma (from 12.08.08)
Navaneethan Mutuswamy (from 15.05.08)
Nikolaos Tsakoumis (from 03.03.08)
Nina Hammer (until 15.11.08)
Oana Mihai (from 02.05.08)
Paul Radstake (14.08.08)
Saima Sultana Kazi
Sara Boullosa Eiras
Šárka Zárubová (from 25.08.08)
Shreyas Pandurang Rane (from 02.01.08)
Silje Fosse Håkonsen (until 15.06.08)
Tayyaba Noor (from 01.04.08)
Xuyen Kim Phan

Guests
Fernando Bimbela (PhD student from Zaragoza, Spain)
Matteo Lualdi (PhD student from KTH, Sweden)
Sara Lögdberg (PhD student from KTH, Sweden)
Yian Zhu (Guest rechearcher from East China Univ. of Science, China)
Johan den Breien (PhD student from Utrecht Univesity, The Netherlands)
Romas Skudas (PhD student from Johannes Gutenberg University, Mainz, Germany

The Organization
The research and teaching in catalysis, petrochemistry and related subjects (including surface science, adsorption and physical studies of porous materials, reaction kinetics and process engineering) is organised in the Catalysis Group, a joint effort where NTNU, and the research company SINTEF share laboratories and equipment.



Personnel from the two organisations work together and participate in teaching and research. About 10-15 students graduate each year (M.Sc.). The group participates extensively in international networks, research programs etc., and cooperates closely with a number of universities and research groups inside and outside the EU.

The group and the laboratories
At present the group comprises about 50 people: 5 Professors, 2 Adjunct professors, about 10 fulltime research scientists holding Ph.D's, 4 Post.doc's and about 25 Ph.D students. The laboratories and equipment include a large number of microreactors for catalyst studies, several small pilot plants, all the necessary equipment for catalyst and material characterization (chemisorption, physical adsorption, Temperature Programmed techniques (TPR, TPD, thermal analysis), XPS, Auger spectroscopy, STM, FTIR and others). Recently, *in situ* IR/Raman and the TEOM-technique (Tapered Element Oscillating Microbalance) have been introduced in the laboratory, and we were the first group in Europe to utilize the TEOM technique in catalyst studies. Cooperation with the Departments of Physics (TEM and surface science), and Materials Science and Engineering, the other groups at the department of Chemical Engineering (all aspects of chemical and process engineering, particularly reactor engineering and colloid and polymer chemistry) and other departments ensures a wide scope and a high quality of the work. The research is funded by the Norwegian Research Council and by industry and spans from fundamental studies of

ideal surfaces to studies of real catalysts to process development work in small pilot plans.

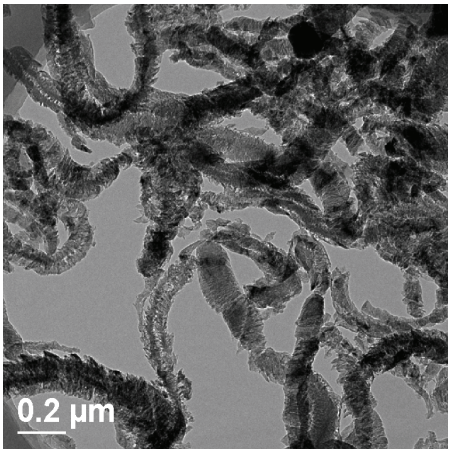
The projects
A description of the Group as well as further details of all the projects, are given in our Annual Report.

Natural Gas Conversion
Natural gas is an abundant hydrocarbon fuel and chemical feedstock, and utilizing this resource with minimum environmental impact is a major challenge to catalysis. It is the main goal of the present programme to study catalytic processes for conversion of natural gas to chemicals and fuels including hydrogen. The programme includes production of synthesis gas, Fischer-Tropsch synthesis, and dehydrogenation of C_2-C_4 alkanes. The work is carried out in close collaboration with Norwegian industry and SINTEF. The group also participates in a Centre for Research Innovation (SFI-inGAP) focusing on the use of natural gas.

Hydrogen Technology
Particular attention is directed towards hydrogen technology: Catalysis is important in the production of hydrogen from hydrocarbons. Natural gas in an important source of hydrogen, and research is thus linked to syngas issues. In addition, the conversion of "transportable" hydrogen carriers such as propane, methanol and (bio) ethanol is studied. Of particular relevance is the integration of CO_2 separation technologies in hydrogen production processes, and this is targeted through sorption enhanced reactions and membrane reactors (see below). The group is also involved in development of improved fuel cell catalysts based on carbon nanofibers (also below). Collaborations include SINTEF as well as Norwegian industry. Hydrogen technology is also part of the MIT-NTNU cooperation.

Design and Preparation of New Catalysts and Supports
The catalytically active material is the key to any catalytic process, and the preparation of these, highly specalized functional materials is an important industry. Understanding the preparation methods, and developing new techniques is therefore a central research area.This programme deals with new methods to prepare supports and catalysts such as flame spray pyrolysis and spray drying, as well as the preparation and use of structured, mesoporous supports. This work is done in collaboration with the Ugelstad laboratory and SINTEF.

Carbon Nanofibres
Carbon nanofibres (CNF) have several interesting properties such as high resistance to strong acids and bases, high electric conductivity (similar to graphite), relatively high surface area and high mechanical strength. These unique properties lead to a large number of applications, such as catalyst supports, selective sorption agents, energy storage, composite materials, nano-electric and nano-mechanical devices, as well as field emission devices. The programme includes synthesis of carbon nanofibres and nanotubes of different morphology and the use of CNF/CNT in applications such as heterogeneous catalysis, fuel cells and conversion and storage of energy. This is done in collaboration with other groups at NTNU, SINTEF and Norwegian Industry



Carbon Nanofibres (TEM image)

Novel reactor concepts and structured supports
Emerging reactor technologies such as microstructured reactors and (catalytic) membrane reactors are being developed and tested. The use of structured supports such as monoliths and foams is being studied, particularly for short contact time reaction systems such as partial oxidation and oxidative dehydrogenation. The work on microstructured reactors, where channels micrometer dimensions (1-1000µm) and up-scaling by parallelization is applied to enable new properties/possibilities, is performed in collaboration with Forschungzentrum Karlsruhe in Germany. Membrane reaction concepts based on novel Pd thin film technology are being developed together with SINTEF, and a partnership with MIT, and StatoilHydro is directed towards the use of high-temperature proton-conducting membranes in hydrogen production with CO_2 capture.

Oil Refining
Upgrading of crude oil and oil fractions is an important subject of research, especially due to new environmental legislation demanding more efficient processes. The programme includes catalytic reforming, isomerization, hydrotreating/ hydrocracking and heavy oil upgrading. The work is carried out in close cooperation with SINTEF and the industry.

Biofuels
The research is focused on catalytic aspects of thermochemical conversion, such as syngas adjustment, residual hydrocarbon reforming and Fischer-Tropsch synthesis.

In the EU project "GreenSyngas" the Catalysis group works on reducing the methane and tar contents in the syngas from the gasifier in Güssing (Austria) where woodchips is the raw material.

Fundamental Studies in Heterogeneous Catalysis
Several experimental techniques are used to study the details of solid catalysts. We are working together with Department of Physics on the use of Transmission Electron Microscopy and Scanning Tunneling Microscopy. We focus on characterisation of catalysts at working conditions and for this purpose we are using the European Synchrotron Radiation Facility in Grenoble and together with the Ugelstad Laboratory we have recently purchased new facilities for IR and Raman spectroscopy. The TEOM (Tapered Element Oscillating Microbalance) is also a powerful technique for studying important phenomena like catalyst deactivation, diffusion in porous materials and adsorption, absorption and desorption. Photocatalysis is also introduced as an important topic in the group.

COLLOID- AND POLYMER CHEMISTRY GROUP (UGELSTAD LABORATORY)

Academic staff
Professor Johan Sjöblom
Associate professor Wilhelm R. Glomm
Associate professor Gisle Øye
Adjunct professor Egil Gulbrandsen (until 30.09.08)
Adjunct professor Per Stenius (until 14.09.08)
Professor emeritus Arvid Berge
Professor eneritus Preben C. Mørk

Scientists
Sebastien Simon
Brian Grimes
Cédric M. Lesaint
Kristofer Paso

Post docs
Yanru Fan
Sondre Volden

PhD candidates
Asal Amiri
Umer Farooq
Serkan Keleşoğlu
Erland Nordgård
Jamil Ahmad (from 15.05.08)
Ann-Mari Dahl Hanneseth (until 31.07.08)
Simone Less (until 31.07.08)
Agnethe Knudsen (from 15.08.08)
Nild van der Tuuk Opedal (from 15.08.08)
Anne Silset (until 19.09.08)
Dorota Dudásová (until 30.09.08)
Martin Smestad Foss
Klodian Xhanari (from 15.01.08)

Technical staff
Signe Håkonsen
Caterina Lesaint
Iva Králová (from 15.08.08)
Cecilie M. Selsbak (until 20.08.08)
Bodhild Øvrevoll (until 31.07.08)

Overview:
The Ugelstad Laboratory was founded in honour of Professor John Ugelstad at the Norwegian University of Science and Technology in January 2002 (Department of Chemical Engineering). The laboratory specializes in surfactant chemistry and its technical applications, emulsions and emulsion technology, preparation of polymers and polymer particles and their technical applications, plasma chemical modification of surfaces and silica-based chemistry.
Applications include crude oil production and processing, pulp and paper, biomedicine, catalysis and materials science.
The main purpose is to raise the national level of colloidal science by establishing a modern educational, research and development laboratory within the field of colloid, polymer and surface chemistry.

Diploma and Ph.D. studies are offered within these topics, often in close collaboration with industrial companies. The aim is to educate highly qualified candidates for industrial positions. In order to attract the best and most motivated students and researchers, the laboratory has invested in new and modern instrumentation. The laboratory also participates in international exchange programmes, and hosts internationally renowned guest researchers and lecturers.

The Ugelstad Laboratory is sponsored by industrial companies, the Research Council of Norway (NFR), research institutes and NTNU. All the members are annually invited to a presentation of the recent research activities at the laboratory. This is combined with the Ugelstad Lecture, where invited scientists lecture within the field of colloid, polymer and surface chemistry.

Research Activities:
In the following paragraphs, selected ongoing research programs for 2008 are briefly described. For a complete description of the research activities at the Ugelstad Laboratory, please visit our web page: http://www.chemeng.ntnu.no/research/polymer/ugelstadlab/

Improved Oil recovery by Low Salinity Waterflooding: Surface Chemistry and SCAL Studies (VISTA 2007 – 2010)
The project focuses on how the surface chemistry of reservoir surfaces can contribute to improved oil recovery by low salinity waterflooding. An important goal is to understand the interaction mechanisms between the solid surfaces and surface active components in crude oils as the extension of the electrical double layer varies.

Multiphase Flow Assurance Innovation Centre (FACE) – Centre for Research-Based Innovation (SFI) 2006-2014
An increasing fraction of hydrocarbon reserves are difficult or impossible to produce and process today mainly due to the complexity of the fluids. Production of these reserves will require new and innovative technologies. FACE will develop the knowledge base for the new predictive tools that will be essential in order to develop the new, innovative production solutions. It is expected that new SMB's will be generated based on knowledge and technology from the centre as well as development of new or improved products in existing companies.

The research is focused on transport and separation aspects of three thematic topics, i.e. heavy crude oils, dispersed systems (emulsions), and solid particulate suspensions (hydrates, wax, sand and fines). Fluid characterization is a central tool to describe complex fluids within the three thematic topics and a necessary input to hydrodynamic modeling.

We will use existing laboratories to perform both small-scale and high-pressure, large-scale flow experiments in pipes and separators. These experiments will be accompanied by multidimensional model development and their verification.

Collaborative effort between NTNU, SINTEF, IFE and UiO.

An Integrated Approach to Interfacial/Surface Processes in Crude Oil Systems (NFR PETROMAKS)
In crude oil production and processing heterogeneous systems play an important role in the whole value chain, starting from oil recovery from the reservoir and ending with crude oil refining in the refineries. A rational definition of heterogeneous systems is systems with either interfaces or surfaces or both. A brief survey of such systems and processes reveal wettability of the mineral surfaces in the reservoir as extremely important in the recovery of oil, chemical composition of the interface between water and oil as important for the separation process (and droplet-droplet coalescence) with consequences for both oil and waste water quality, corrosion inhibition of steel surfaces to prevent corrosion to deteriorate pipelines and the contamination of solid surfaces to poison catalysts. A general problem including most of the sub-processes in the exploitation of crude oil is a proper lack of instrumentation and competence to undertake a proper characterization of surface structures and concentrations in order to improve the understanding of oil recovery and especially enhanced oil recovery, separation technology and maintenance of pipeline integrity and transport.

Treatment of Produced Water: Characterization and New Treatment Strategies.
Petromaks program (NFR).
The research tasks in this program will contribute to the development of new and improved technology for a more efficient and cost effective treatment of produced water from offshore installations. A fundamental necessity of developing and designing any treatment scheme is the knowledge and understanding of the fluid to be treated. The work on treatment strategies will focus on two areas: treatment of suspended constituents and of dissolved/soluble constituents. A major factor in achieving a zero harmful discharge to sea is the removal of suspended solids and dispersed oil from produced water. Particle separation is a fundamental process in any treatment process for the production of high quality effluent from an aqueous stream. The removal of dissolved constituents in produced water is necessary within the zero harmful discharge network. One of the research tasks in this proposal is to investigate the applicability of biological degradation of specific target compounds.

This programme ended in 2008 with the dissertation of 2 PhD students. The main outcome of the research tasks were identification of variables contributing to the stabilisation of solid suspensions and o/w emulsions. The fundamental understanding of the stabilisation mechanisms is valuable for ensuring reliability and optimisation of existing produced water treatment processes, as well as in developing existing and new treatment technologies.

Development of nanostructured microreactor-based reaction technologies for continuous in situ production of food and drug intermediates from renewable resources. Case studies of synthesis of gluconic acid and enantiopure components of natural flavors (Polish-Norwegian Research Fund) 2008-2010
The project aims at developing novel family of high performance technologies for the in situ production of valuable chemicals – natural intermediates for food and pharmaceuticals synthesized from renewable resources, e.g. cellulose materials. The development of effective, high throughput technologies for in situ (local) production of valuable chemical intermediates from renewable resources is one of the top priorities of EU for sustainable development.

Thermoresponsive Polymer Brushes on Nanoparticles and Surfaces (NFR FRINAT 2007-2010)
An interesting category of amphiphilic polymer systems are those who undergo phase transitions in response to environmental stimuli such as temperature and pH. These have been widely investigated for drug delivery, separations and diagnostics applications. The aim of this project is to develop an understanding - both mechanistic and applied - of different thermo-responsive polymers adsorbed to planar surfaces and particle substrates. Changes in structural and dynamic properties of the systems under various conditions will be examined.

This project is a collaborative effort between the Ugelstad laboratory and Dept. of Chemistry, UiO, with several international partners.

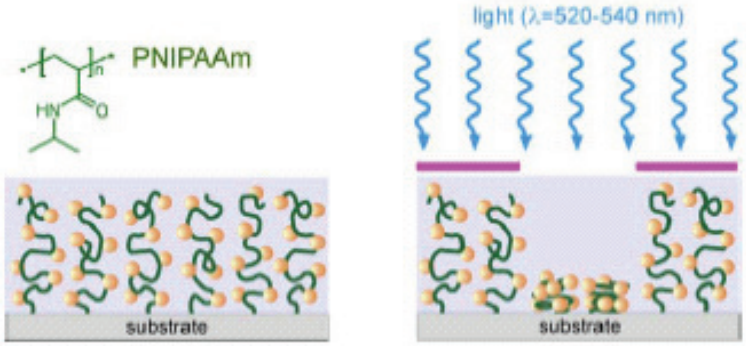


Figure 1: Schematic illustration of the "T-jump" modulated conformational transitions in surface-anchored PNIPAAm brushes. Gold nanoparticles will be loaded inside the brush and will attach to the NIPAAm monomers via H-bonds. Light having a wavelength close to the plasmon band of Au will be used to locally heat the particles, which in turn will cause collapse of the PNIPAAm chains. Through employment of a mask placed between the light course and the polymer, the PNIPAm collapse can be spatially modulated.

Structure, behaviour and reactivity of tetrameric naphthenic acids (ARN) in bulk and at w/o interfaces 2005-2008

The naphthenate R&D group at Statoil has done very systematic work during the past years to identify the structure of the naphthenic acid being the most active in forming metalnaphthenate deposits, which is a severe obstacle in processing of acid crudes. The results from the Statoil research in this field are pioneering, and have lead to the discovery of the so-called ARN naphthenic acid, which represents an acid family of C80 tetramers. The results from the Statoil discovery have recently been published, and one can foresee a heavy international scientific follow-up in this area in the years to come.

The objective of this programme is to focus on combining the efforts of the Statoil Naphthenate R&D Group and from our recently completed VISTA project. In the new VISTA programme, we are going to undertake a fundamental study of the ARN family of naphthenic acids with regard to clarify the structure(s), the physico-chemical properties, the interfacial activity and reactivity, selectivity in reaction patterns with multivalent cations, filmforming properties, etc.

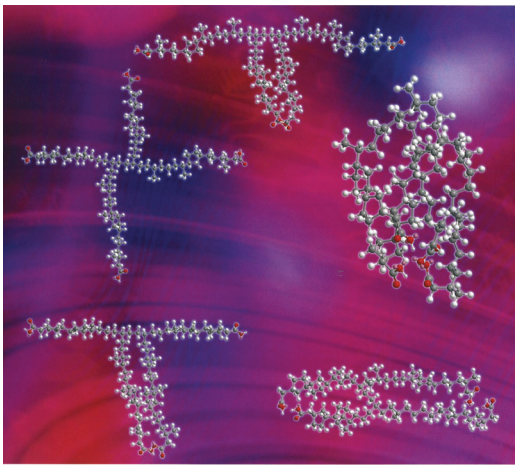


Figure 2: Archeal C_{80} isoprenoid tetraacids responsible for naphthenate deposition in crude oil processing.

Official opening of the new laboratory in 3rd floor, Chemistry building 5 (K5) by Head of Department Sigurd Skogestad and Professor Johan Sjøblom.

PROCESS SYSTEMS ENGINEERING GROUP

Academic staff
Professor Sigurd Skogestad
Professor Terje Hertzberg
Professor Heinz A. Preisig
Associate professor Tore Haug-Warberg
Associate professor Nadi S. Bar
Professor emeritus Terje Hertzberg

Post docs
Sridharakumar Narasimhan (until 26.06.08)
Mohammad Samsuzzoha (from 29.09.08)

PhD candidates
Andreas Linhart
Bjørn Tore Løvfall (until 31.07.08)
Elvira Marie B. Aske
Heidi Sivertsen (until 19.12.08)
Henrik Manum
Håkon Dahl-Olsen
Ivan Dones
Jens Petter Strandberg
Johannes Jäschke
Jørgen Bauck Jensen (until 16.05.08)
Jørgen Skancke (from 01.09.08)
Magnus Glosli Jacobsen
Maryam Ghadrdan (from 16.07.08)
Mehdi Panahi (from 07.01.08)
Olaf Trygve Berglihn
Ramprasad Yelchuru (from 16.01.08)

Guests
Jakub Osusky (PhD student from Slovak University of Technology, Bratislava, 17.04.08-17.05.08.)

Profile:
Process systems engineering deals with the overall system behaviour, and how the individual units should be combined to achieve optimal overall performance. Important topics are multi-scale process modelling, operation and control, design and synthesis, and simulation, statistics and optimization. The group closely cooperates with other systems-oriented departments at the university, including Engineering Cybernetics, Energy and Process Engineering, and Industrial Ecology, and also with SINTEF. The process systems engineering activity at NTNU (PROST) holds high international standards and was already in 1994 recognized as a strong-point centre, both by NTNU and SINTEF.
At present, the main activities in the group are within process control and process modelling including efficient thermodynamic calculations. A new interdisciplinary branch focusing on systems biology is currently being initiated enriching the NTNU biology effort with a systems component.

Control Activities:
Industrial use of advanced process control increases rapidly, and candidates who combine process knowledge and control expertise are in high demand in industry. Control is an enabling technology, thus basic for any industry-based society. The use of advanced control is transforming industries previously regarded as "low-tech" into "high-tech". In process control (Sigurd Skogestad and Heinz Preisig), the objective of the research is to develop simple yet rigorous tools to solve problems significant to industrial applications.

From left: Laszlo, Magnus, Mehdi, Deeptanshu, Ramprasad, Shams, Maryam, Heinz, Sigurd, Johannes, Tore, Jørgen, Ivan, Håkon, Nadi

Up to now, the design of the overall "plant-wide" control structure has been based on engineering experience and intuition, whilst the aim has been to develop rigorous techniques. The concept of "self-optimizing control" provides a basis for linking economic optimization and control (Sigurd Skogestad). For example, for a marathon runner, the heart rate may be a good "self-optimizing" variable that may be kept constant in spite of uncertainty. Control is done in a hierarchical construct. At the bottom of the hierarchy, the main issue is to "stabilize" the operation and follow the setpoints provided by the layer above. Further up in the hierarchy one finds optimising control co-ordinating the control of units and plants. A special case is sequential control, which is used to implement recipes in batch operations but also is the basics of handling start-up and shut-down as well as all fault and emergency handling. Another important concept is controllability, which links control and design. Here the main focus is on applications, which currently include reactor and recycle processes, distillation columns, gas processing plants, cooling cycles including liquefied natural gas (LNG) plants, low-temperature polymer fuel cells and anti-slug control. Small-scale experimental rigs have been built to study anti-slug control and novel distillation arrangements. In most cases, control is an "add-on" to enable and improve

operation, but the anti-slug rig demonstrates how control in some cases can be used to operate the system in a completely different manner.

Modelling Behaviours:
The centre piece of process systems engineering is the model. Modelling is seen as a difficult and time consuming operation. The step-wise approach developed in this group has transformed the art of modelling into a nearly procedural operation, which has been captured in a program environment. The modelling operation is thereby lifted up from writing equations to choosing concepts and mechanisms. The equations are then generated and assembled automatically taking the applicable equations from a data base that has built applying mechanistic descriptions where ever applicable. Multi-scale modelling is supported by enabling order-of-magnitude assumptions, which automatically induce model reduction thereby eliminating structure-related mathematical problems. The overall objective in the group is to develop efficient object-oriented software tools that implement this method and assist in developing consistent and structurally solvable process models on different scales that match the particular application. The technology is physics-based with extensions to allow for grey-box modelling. It aims at replacing various graphical interfaces to simulators and generates code for the major chemical engineering simulators such as gProms, Matlab, Modelica etc. but will also be able to generate stand alone, application-tailored simulators.
The fourth generation of a high-level modelling tool is presently being developed (Heinz Preisig), which we aim to apply to large-scale plants, including the Mongstad refinery. It incorporates object-oriented tools for efficient thermodynamic modelling, which extend into the efficient computation of thermodynamic information. Rather than a traditional implementation of activity or fugacity coefficients, emphasis is put on the use of structured equation sets governed by thermodynamic consistency rules (Haug-Warberg).

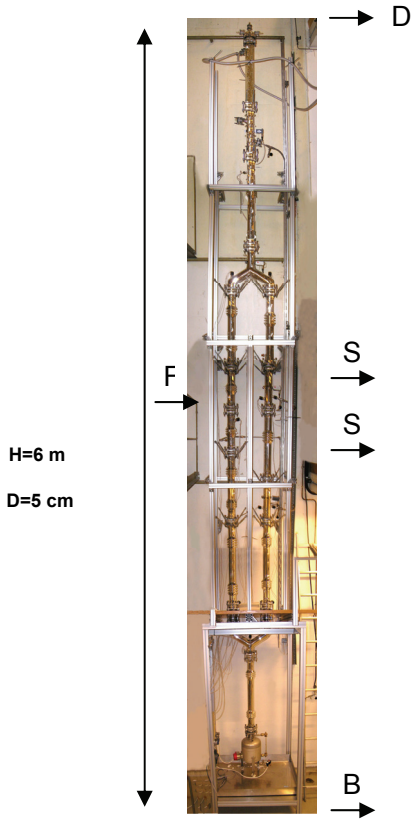
The thermodynamic models are implemented in symbolic form with automatic differentiation capabilities and serves as the basis of several industrial strength simulations (YASIM, CADAS) and energy accounting tools (HERE) in co-operation with StatoilHydro and Yara. A primary aspect of thermodynamic (and other physics) modelling is the required consistency of physical units. We have a procedure to obtain self-consistent models, including automatic generation of gradients. This technique has so far been tested up to sixth order gradients, which are needed for higher-order critical point calculations.

In cooperation with Yara AS, Tore Haug-Warberg implemented a thermodynamic stream calculator "Yasim". It has a gentle learning curve using the familiar Excel worksheet interface whilst using state-of-the-art thermodynamic methods. All model information including mass balances, energy balances, chemical and phase equilibrium relations are defined in symbolic form. Differentiations are done in symbolic form. These properties add unsurpassed flexibility to Yasim that is not found in any other software of its kind. The ease of use should make it ideally suited for training and use in an industrial environment.

Model-Process Interface:
The model generally needs to be fitted to experimental data, and the group has always has a strong focus on statistical methods and experimental design (Hertzberg). Although Terje retired as professor in 2007, he is still active in this area, and in particular, in teaching.

Equipment:
The Kaibel distillation column (see picture) is 6 meter high and 5 cm in diameter and can be used to study "thermally coupled" columns, including the three-product Petlyuk column and the four-product Kaibel column. Dr. Ivar Halvorsen from SINTEF and Sigurd Skogestad manage this integrated distillation project. The group also has an automatic drink mixer, which is used for demonstration purposes and to study sequence control based on automata theory (Heinz Preisig).

Funding Resources:
Funding comes from the Norwegian Research Council, the Gas Technology Centre at NTNU and SINTEF, from industry (StatoilHydro, Gassco) and from the EU (ProMatch program).



Kaibel Distillation column.

ENVIRONMENTAL ENGINEERING AND REACTOR TECHNOLOGY GROUP

Academic staff
Professor Hallvard Svendsen
Professor May-Britt Hägg
Professor Hugo A. Jakobsen
Professor Magne Hillestad
Associate professor Jens-Petter Andreassen
Adjunct professor Didrik Malthe-Sørenssen
Adjunct professor Jon Samseth
Professor emeritus Olav Erga
Professor emeritus Gunnar Thorsen
Professor emeritus Norvald Nesse (until 31.12.08)

Scientists
Taek-Joong Kim
Tom-Nils Nilsen

Post docs
Ameeya Kumar Nayak (from 25.08.08)
Arne Lindbråthen (until 30.06.08)
Arshad Hussain (from 01.04.08)
Edel M. Sheridan
Eirik Falck da Silva (until 31.03.2008)
Geir Watterud (IFE, Kjeller)
Jon Arvid Lie
Jorge Mario Marchetti (from 18.08.08)
Sholeh Ma'mun
Yuefa Wang (from 24.02.08)

PhD candidates
Ahmad Rafiee (from 06.10.08)
Ali Zakeri (from 21.07.08)
Ardi Hartono
Eddie Setekleiv
Ellen M. Flaten
Erik Troøien Hessen
Federico Sporleder (from 21.01.08)
Hanna Knuutila
Hans Kristian Rusten
Håvard Lindborg (until 26.05.08)
Inger Lise Alsvik (from 01.09.08)
Ingvild Eide-Haugmo
Inna Kim
Kalim Deshmukh (from 16.06.08)
Kando Kalifa Janga (from 27.03.08)
Kumar Ranjjan Rout (from 12.08.08)
Lei Shao (until 30.06.08)
Liyuan Deng
Luciano Patruno
Marius Sandru
Martin Votrubec (from 25.08.08)
Mehdi Karimi (from 06.06.08)
Mohammad Washim Uddin (from 15.01.08)
Pablo Dupuy
Peter Bruder (from 01.07.08)
Ralf Beck
Rune Engeskaug
Silje Kufaas Tellefsen (from 01.02.08)
Tom Dagstad
Tone Borge
Ugochukwu Edwin Aronu
Xiao Luo
Xuezhong He
Zhengjie Zhu
Zhongxi Chao (from 28.02.09)

Guests
Feng Qin (PhD student from Tsinghua University, China)
Sinead Mc Dermott (PhD fra National University of Ireland, Maynooth, Ireland)

The two former groups in Separation and Environmental Technology and in Reactor Technology joined forces in 2008. The merger was motivated by similar research and teaching activities with respect to environmental engineering issues, especially in gas separation and capture of carbon dioxide. Joint projects and relocation in chemistry building 4 will serve to consolidate this cooperation in new laboratory facilities. Environmental engineering and reactor technology is the largest research group in the department covering interests in the fields of chemical reactor research, process design, acid gas absorption, membrane research, and crystallization and particle design.

Second row: Yuefa, Hallvard, Ameeya, Jens-Petter, Zhengjie, Marius, Eddie, Washim, Arne, Tom-Nils, Martin, Magne, Hugo Nils, Peter, Jon Arvid, Xiao, Ralf, Feng
First row: Adrian, Qiang, Kumar, Kalim, Xuezhong, Inger Lise, Cathrine, Ellen, Ingvild, Andrea, Hanna, Inna, Arlinda, Erik, May-Britt, Taek-Joong, Pablo, Arshad, Ugochukwu, Mehdi, Ahmad, Ali

Chemical Reactor Research

The activity on reactor engineering has been concentrated in fields directly supporting the design and development of chemical reactors and reactive separations. The most important research areas are:

- Mathematical modeling of chemical reactors.
- Multiphase flow modeling.
- Design of novel solution methods and algorithms.
- Experimental analyses of fluid flow, and heat- and mass transfer phenomena in chemical reactors.
- Experimental validation of numerical models.
- Analysis and design of reactors for environmentally friendly chemical processes.

The research in these fields comprises both experimental and theoretical studies and we have a large range of well instrumented cold flow multi-phase reactors, as well as in-house software for multi-phase reactor simulations.

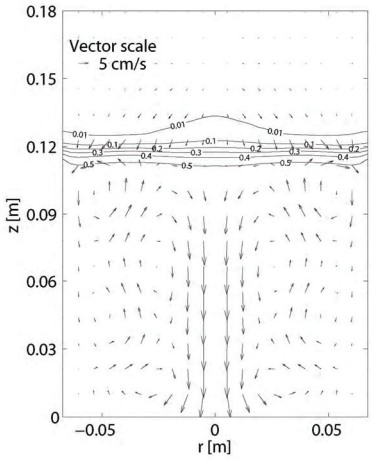
We are active users of Matlab, however, the computationally demanding models are implemented in FORTRAN 90 and C++. Application areas are special chemicals reactors, polymer production, sorption enhanced steam methane reforming, conventional synthesis gas and methanol synthesis, membrane reactors, wood gasification and chemical looping combustion.

A stirred tank used for studies of heat transfer and flow phenomena.

Educationally the main objective of our group is to educate MSc for the Norwegian industry and to raise the national scientific competence in our field of research through PhD studies.

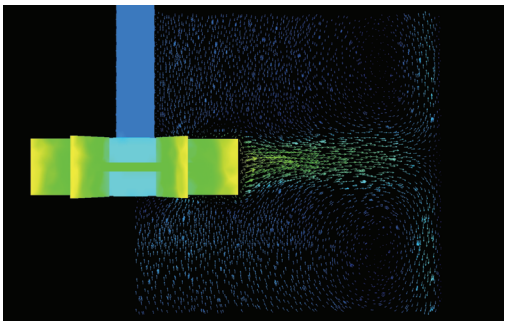
Research activities
The most important research projects are described in the following paragraphs. For a more comprehensive description, see our home pages: (http://www.chemeng.ntnu.no/research/reactmod/).

Modeling of multi-phase reactors
We have for more than 20 years been developing in-house CFD codes for simulating multiphase flows in chemical reactors. Lately, our main focus has been put on developing modules for bubble/droplet break-up and coalescence within the population balance equation (PBE) framework.
The PBEs are solved accurately by efficient spectral and spectral-element methods designed for this particular purpose.



Flow pattern in a bubbling fluidized bed.

We are also investigating the performance of chemical reactive systems like fluidized beds, fixed bed reactors and agitated tanks. At present we are working with the design of suitable reactors for sorption enhanced reaction processes (SERP) like steam reforming with absorbents for CO_2.



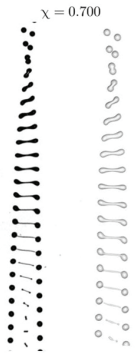
Simulation of the flow pattern from a turbine impeller.

The conventional 1D and 2D steady-state reactor models are normally run on standard PCs whereas the more computationally demanding dynamic 2D and 3D single and multiphase flow simulations are run on the national super-computers located at the university.

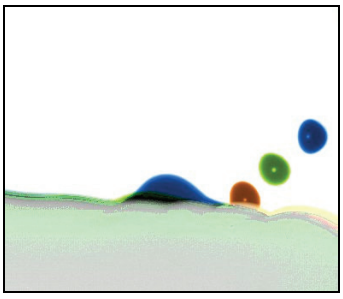
Advanced Modeling and Simulation of Chemical Reactors
The activity in this area is mainly founded by the Norwegian Research Council through the GassMaks program. The work in this project is focused on modeling of chemical reactors like stirred tanks, fixed packed bed-, bubble column-, and fluidized bed reactors by the complete multifluid model containing a population balance equation for the fluid particle size distribution for the multiphase reactors. The model equations are solved by the modern least squares spectral element method. In the next phase of the project the novel in-house codes will be applied analyzing the chemical reactor processes utilizing natural gas as feedstock.

CO_2 capture and droplet removal

Removal of droplets from high pressure gases
An area of great importance for the Norwegian gas producing industry is the separating out of droplets from high pressure gases. Downstream process equipment e.g. compressors, separation processes or chemical reactors suffer disturbed operation or break-down if gases are not droplet free. Today's units are not good enough at high pressures, and robust and reliable solutions must be found in particular for sub-sea completions. The projects HiPGaS and now HiPGLS were established for studying the phenomena governing such separations. In collaboration with ten industrial partners separation rigs have been established for both low and high (<150 bar) pressures at NTNU and at the StatoilHydro research center. Tests within the project have also been performed at semi-industrial scale at the K-lab facility at Kårstø. Results from the high pressure rigs are unique and form a basis for model validation. In addition a laser laboratory is built for the study of droplet/droplet and droplet/surface collisions and for studies on the stability and break-up of liquid surfaces leading to re-entrainment of droplets. The studies are performed with a strong interaction between experiments and numerical models which run in either desktop computers or the national High Performance Computing resources.

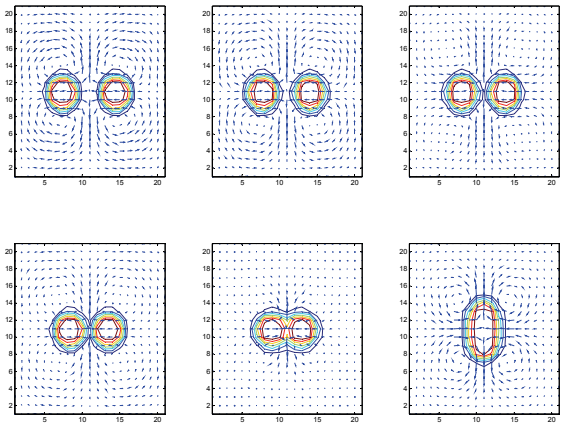


Droplet collision leading to break-up. Experimental result to the left and model right.



Droplet generation from liquid film re-entrainment. Fake colors to identify different time steps.

CO_2 capture from exhaust gases and natural gas.
One of the most fundamental problems facing the earth today is global warming. The emissions of CO_2, the most important greenhouse gas must be reduced, e.g. by CO_2 Capture and Storage (CCS). The research in this



Droplet collision leading to coalescence.

area comprises many projects, funded by the Research Council of Norway, the industry, and the European Union. Our work is concentrated along two axes, one studying CO_2 capture from off gases from fossil fueled power plants and from the iron and steel-making industry, and the other directed toward the removal of acid gases from natural gas. We have been heavily involved the EU FP6 projects, e.g the Integrated Project CASTOR, being in charge of developing new solvent systems for CO_2 capture from exhaust gases from coal and natural gas fired power stations. This work continues in the EU FP7 CESAR project. This work involves all the steps from theoretical screening by use of computational chemistry, through experimental screening, characterization of equilibria, thermal properties, transport properties and kinetics, to testing in a laboratory pilot plant. In parallel we develop rigorous thermodynamic models and improved models for combined mass and heat transfer. In addition we have developed a full rate based simulator for the whole absorption/desorption process, CO2SIM. In the EU FP6 project CAPRICE, finished beginning of 2009, we are in charge of pilot plant data collection and simulation software validation. The largest project on CO_2 capture is SOLVit, a JIP with Aker Clean Carbon (ACC). Other projects in this area are EU FP6 ULCOS, and the Norwegian Research Council financed BIGCO2, now BIGCCS. In the CCERT project, a JIP with four industrial partners, fundamental problems are addressed.

Laboratory pilot plant for CO_2 capture by absorption

Process Design

A process design is to a large extent a consequence of developments on catalyst, choice of reaction routes, selection of solvent system, fluid type etc. At this level of development the structure of the chemical system and the kinetics are determined. Much research is focused on these topics because even incremental improvements may have large economical consequences. The next major step is to find a suitable reactor and process in which to deploy the system on a larger scale. The traditional way of doing design of new processes is by selecting reactor type and process configuration based on comparison to a similar known system. Design choices are often made on the basis of past experience or trial-and-error using laboratory tests and repeated simulations. These activities are necessary. However, it is not likely that the traditional way alone will lead to the best possible process configuration and design. Complementary tools and methods are needed to lead the design engineer onto the path of optimal design. Deviations from the optimal design will lead to unnecessary loss of product yield, unnecessary large volumes and loss of energy. Within the conceptual process design activity some of the most important choices are made, which have large consequences on the profitability and environmental loads of the final process technology. According to Douglas (1988)[1] the conceptual design of an integrated plant can be broken down into a hierachy of decisions and organized into different levels of activities. Among the levels of activities are reactor-separator-recycle structures, heat integration, and separation train sequence design. A method in focus here is a systematic procedure based on shortcut models. A path is a line of production on which basic operations or functions take place. Reactants pass through a series of functions or basic operations to form the desired products. The basic operations are represented by design functions on the volume path. The design functions are fluid mixing (dispersion), distribution of extra feed points, distribution of heat transfer area and coolant temperature, catalyst dilution distribution and more. The conceptual reactor design problem is solved as an optimal control problem. Parameterization of the design functions and the state variables are applied. The realization is a staged process string of multifunctional units.

Douglas, J. M., Conceptual Design of Chemical Processes, McGraw Hill, 1988.

Membrane Research

Membranes for gas separation and osmotic processes

(more information about the Memfo (Membrane Research activities): www.chemeng.ntnu.no/memfo

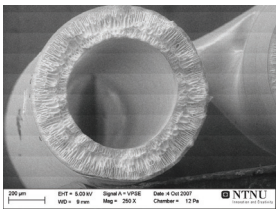
The membrane research programs have extensive activities both on basic membrane material development, as well as membrane gas separation processes, modelling and simulations. The main focus for the research is CO_2 capture by membranes (from flue gas, natural gas sweetening, biogas upgrading) and hydrogen recovery from various mixed gas streams. In addition to these energy focused gas applications, there is also ongoing research on membranes for chlorine separation. The membrane materials in focus are various types of polymers, nano-composites, carbon membranes, and modified glass membranes.
The international network is extensive, with co-operation both within EU-projects, USA, Japan, the Nordic countries and Russia.

Brief description of sample gas separation projects

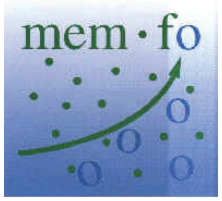
a) EU FP6 project NaturalHy (www.naturalhy.net)
The project involves about 40 partners, and the main idea is to investigate the possibility of using the European gas network for co-transport of hydrogen with natural gas. Realising that the society only slowly will convert to hydrogen based energy, the idea is that hydrogen may be injected into the gas net at various places where it is produced, and then separated from the natural gas at points along the line where pure hydrogen is needed (e.g. for fuel cells). The task into which Memfo is doing research, is development of a suitable membrane for hydrogen recovery. Carbon molecular sieve membranes are investigated for this purpose. One post doc is engaged in the research, and very promising results have been documented. The project continues for 1 more year. The project co-ordinator is Gasunie in the Netherlands.

b) KMB RENERGI / NFR project CEPEME
Membrane development for selective CO_2 capture
The membrane material being developed in this project contains a specific "carrier" which makes it selective for CO_2 while other gas components are being retained. The material is based on a polymer containing fixed amine groups as carriers. A significant progress has been achieved during the last couple of years, both with respect to CO_2-flux and selectivity compared to the other components in a mixed gas. The obtained results have drawn international attention. The membrane is patented, and there are big expectations for the further development; for CO2 capture from coal fired or gas fired power plants as well as other CO2 containing gas streams. The project ended in 2008. Preparation for small scale pilot scale testing is now being done. One research scientist and one PhD student have been working on the project. A focus on process development has also been initiated. Project partners further are NFR and StatoilHydro; negotiations with membrane producers are ongoing for the scale up. There is also interest from industry on other applications where CO_2 is present in the gas stream (natural gas sweetening, CO_2 removal from anaesthetic gas...)

c) EU FP6 project NanoGloWa (www.nanoglowa.com)
The project started November 2006 and is focusing on "Nano-structured membranes against Global Warming" (NanoGloWa). Memfo is a major partner in the project; task leader for two work packages focusing on development of carbon membranes and polymeric materials for CO_2 capture from power plants. The project also includes spinning of hollow fibres, module development and durability tests. One Post.doc. and one PhD student were attached to the project in 2008. The project coordinbator is KEMA in The Netherlands.



SEM-picture showing a membrane. DO-DI: 1 -0.6 mm cut through a hollow fibre



Memfo = Membrane Forskning (Membrane Research)

Bundle of hollow fibre membranes in an industrial module–packing densities can be up to 30 000 m^2/m^3

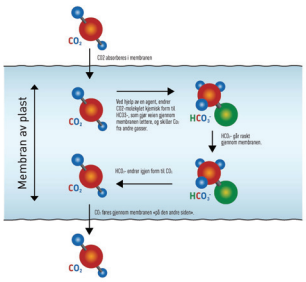


Illustration of the mechanism in the patented CO_2 facilitated transport membrane

d) EU FP7 project DECARBit
The project is coordinated by Sintef and had kick-off in Feb 2008. The focus is pre-combustion separation of CO_2 and H_2 at high temperatures (>300°C). Carbon membranes are being tailored for this separation. The project also includes module development and durability tests. The project coordinator is SINTEF Energy

e) KMB GASSMAKS / NFR project RECCO2
The project started late 2007. The objective is CO_2 removal from high pressure natural gas streams using a polymeric blend membrane; using as one of the polymers in the blend the patented PVAm facilitated transport membrane. The project includes material development, pilot construction, durability tests and simulations. The main challenge in this project is the performance at high pressures (→100 bar). Special restrictions for HMS is needed in this operating range. Industrial partner is StatoilHydro.

f) KMB NANOMAT / NFR project development of nanocomposite membranes
These projects are in cooperation with Sintef and North Carolina State University. The material development for hydrogen – CO_2 separation are in focus. There were one PhD-student on the US-side; one PhD and one Post doc on the NTNU-side. The materials studied at NTNU were nano-composites (mixed matrix of high free volume polymers and nanoparticles) and block copolymers on the US-side – very challenging research work. Within this project a NASA award was granted during 2005 for a US patent. The project ended in 2008.

g) FP / NFR Development of hybrid membrane for chlorine purification
Memfo is one of very few groups in the world doing research on membranes for the purification of chlorine gas. This is probably for security and safety reasons, and the challenge of handling this poisonous gas. The project is extremely challenging, but if successful, it will be a major step towards simplification of expensive and complicated unit operations for recovery of chlorine from various process streams. Chlorine is one of the major chemicals used in chemical process industry worldwide. The materials in focus are glass and perfluorinated polymers. There is co-operation with Japanese research in this project. Small steps forward have been documented during 2008, and one post doc finished his work on this project in 2008. There is a major interest from industry in this project.

Brief description of a sample liquid separation project
KMB NANOMAT / NFR project: Membranes for osmotic processes – POPMOP
Reverse osmosis is today one of the major methods for desalting ocean water into freshwater. Osmotic effects demands that a high pressure on the saltwater side of the membrane modules must be applied to override the osmotic pressure difference between sea water and freshwater. If the applied pressure in the cells is lower than the osmotic pressure the water flow is reversed and freshwater flows into the saltwater compartment, thus increasing the volume of moderately pressurized saltwater. This is the principle of Pressure Retarded Osmosis (PRO), which may be used to produce electric energy as the surplus water on the saltwater side may be run through turbines for power production. The potential for power production at the outlet of every river that flows into the ocean is very large.
Towards the end of 2007 Memfo was granted a KMB project from Nanomat/NFR supported by Aqualyng, Statkraft and StatoilHydro. The project is aiming at studying and optimizing the synthesis of polymers for osmotic processes. This development includes both ptimisation of the support membrane as well as the thin film membrane itself. Two PhD students and one research scientist have been working on the project in 2008

Various
The Memfo researchers work very much as a team in addition to be dedicated to individual projects. Hence the simulation of processes is handled whenever needed by those who have the competence. Likewise; the concern for environmental issues, leads to the focus also on biogas upgrading to vehicle fuel quality (biomethane). Carbon membranes has proved to be suitable for upgrading of biogas; documented by experiments and discussed in publications.

A collaboration with University of Dar es Salaam (UDSM), Tanzania, has resulted in a project funded by NUFU. The focus is on bioenergy; with certain aspects of the production of bioethanol and biodiesel from local raw materials. There are 2 PhDs at UDSM and 1 at NTNU attached to this project.

There are several well equipped laboratories available for the membrane research; both for membrane material development as well as membrane characterization. The membrane research on CCS is especially strong, and completes the research on CCS activities in collaboration within the environment and reactor group.

A spin-off company from the research on carbon molecular sieve membranes was established in 2008 with the support of the Technology Transfer Office (TTO) at NTNU. The name of the company is *MemfoACT* (= Membranes for Advanced Clean Technology, http://www.memfoact.no)

Crystallizaton and Particle Design

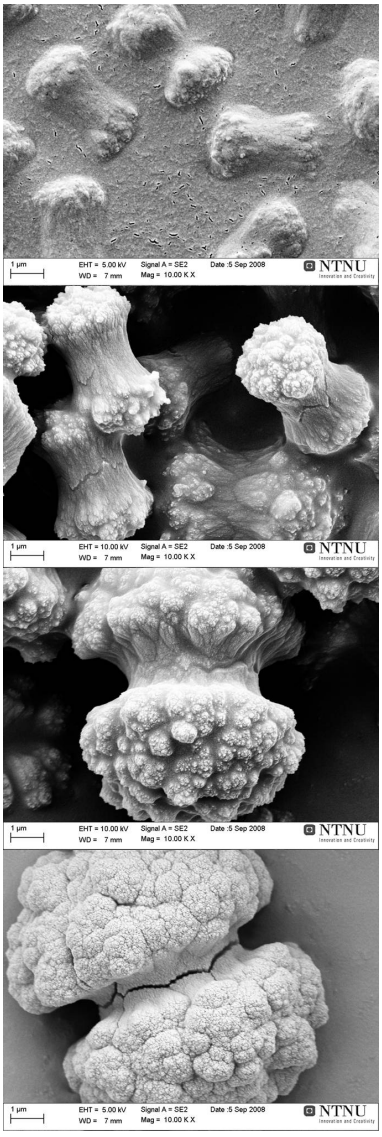
The research within crystallization is focused at kinetics of nucleation, crystal growth, and agglomeration in order to predict and control the particle size distribution and shape of crystalline particulate products for scale prevention, improved solid-liquid separation, CO_2-capture in precipitating systems, and for nano-particle production. The crystallization group also investigates fundamental mechanisms in the early formation of solid particles as well as mechanisms for growth of polycrystalline particles.

Optimisation of Glycol Loop Design and Operation
The aim of the project is to develop a simulation tool for glycol loops in processing of natural gas. This necessitates a deep understanding of the precipitation and crystallisation behaviour of salts and scale-forming carbonates in ethylene glycol (MEG) and water mixtures. Kinetics of calcium carbonate precipitation in the glycol injection point off-shore and the crystallization and separation of salts in the on-shore glycol reclamation units will be the main research tasks. The project is in collaboration with Institute of Energy Technology, Norway (IFE) and financed by several international oil and gas companies and the Research Council of Norway (NFR). Glycol injection point off-shore and the crystallization and separation of salts in the on-shore glycol reclamation units will be the main research tasks. Studies performed in the crystallization group in 2008 have shown that the MEG significantly affects the precipitation of calcium carbonate by lowering the growth rate, promoting nucleation and by shifting the polymorphic composition. Kinetic expressions have been developed to be implemented into computer simulator for particle formation control within glycol loops.

Industrial Crystallization and Powder Technology
The goal of this project is to relate solid/liquid separation characteristics and resulting dry powder flow properties to the underlying growth and agglomeration phenomena. It involves studies of inorganic salts and pharmaceuticals, and the primary target for the activity at NTNU is to link the parameters in the crystallisation process to the subsequent filtration step by focusing on common mechanisms for these selected systems. The project is in collaboration with POSTEC at Tel-Tek and is financed by the Research Council of Norway (NFR) and Norwegian industry partners.

In 2008 we have investigated the effect of supersaturation and temperature on the particle design of pharmaceutical compounds. We have identified a general mechanism of crystal growth switching whereby the particle shape is dramatically altered. This is illustrated for the precipitation of sodium glutamate by switching from the well-known needle crystals of β-glutamic acid to spherical particles of the same polymorph. Filtration resistance measurements as well as powder flow properties measured by uniaxial testing has shown that these spherical particles are unwanted, and in some cases the conditions can be met to avoid their formation.

Investigations of spherulitic growth in solutions – a mechanism for polycrystalline particles
During 2008 we have collected experimental proof for spherulitic growth from solutions in contrast to literature claims of nano-aggregation as responsible for the same type of particles. Spherulitic growth is usually associated with melt crystallization but our findings show that it is a general mechanism is solid material formation. The time-dependent evolution of spherulitic growth is shown for calcium carbonate in the figure below (the scale bar equals one micrometer) and work is in progress to prove the validity of this growth process for numerous crystalline compounds, irrespective of the chemical nature of the consituents.



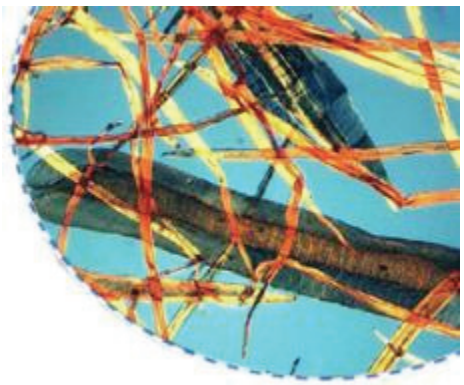
The evolution of spherulitic growth of polycrystalline particles of calcium carbonate 15, 25, 45, and 140 minutes after nucleation.

PAPER AND FIBRE TECHNOLOGY GROUP

Academic staff
Professor Øyvind W. Gregersen
Associate professor Størker Moe
Professor emeritus Torbjørn Helle

Post docs
Asuka Yamakawa (from 01.10.08)
Marco Iotti (from 16.06.08)
Øyvind Eriksen (until 30.09.08)

PhD candidates
David Vaaler (until 30.05.08)
Galina Rodionova (from 01.12.08)
Håkon Nordhagen
Marianne Lenes
Marius Rusu
Mihaela Tanase (from 01.01.08)
Sara Paunonen



The size distributions of fibres and fines are essential for the papermaking properties of a pulp.

Teaching

The Paper and Fiber Technology group provides chemical engineers and PhDs for the Norwegian pulp and paper industry. The estimated need from the industry is 8-10 engineering graduates and about 2 PhD candidates per year. During 2006 3 MSc and 4 PhD candidates graduated from our group. We also gave two industry courses in Pulp and Paper technology and a course in pulp and paper technology at The Norwegian University of Life Sciences (UMB).

Partners

The Paper and Fibre group, Paper and Fibre research Institute (PFI) and parts of the Ugelstad laboratory (colloid and surface chemistry) are located in the same building on the NTNU Gløshaugen campus and are working in close cooperation. We also cooperate closely with pulp and paper industry partners such as Norske Skog, Södra Cell, Borregaard, Peterson and Voith.

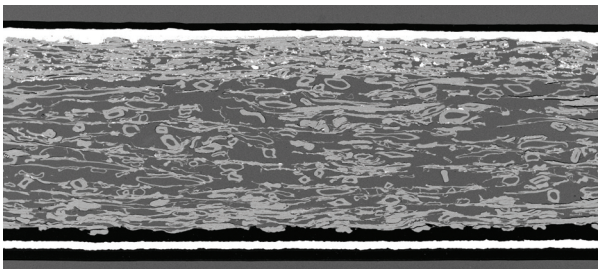
Research

Our research is focused on improvements in the pulp and paper process and on improved end product quality. Examples are:

- Improved runnability of printing paper by use of fracture mechanics as a tool in paper quality optimization.
- Reduced energy consumption and/or better fibre properties of mechanical pulp through high intensity refining, co-refining of different raw materials or pre-treatment of wood chips.
- Reduced print through defect in newsprint by optimized sheet structure
- Better strength and surface properties of wood-containing paper by use of micro-fibrillar cellulose as an additive.
- The influence of paper structure on mechanical, optical and surface properties of paper.

Trends

The last years a new activity on use of cellulose based particles in composite materials have started. Both better oxygen barrier and mechanical properties may be obtained by using cellulose fibres or fibrils as reinforcement in thermoplastic composites. Together with PFI a new research activity on the use of wood based bio-fuel production have also started. The goal is cost effective production of bio-diesel and ethanol from wood. Further, energy effective production is one of the primary concerns of the pulp and paper industry and thus also an important research area now and in the future.



The mechanical and barrier properties of a paper material depend on the material choice and structure. The SEM image of the cross section of a liquid board shows (from top) a Polyethylene (PE), mineral coating, kraft pulp, CTMP, kraft pulp, PE, Aluminium layer and PE.

CHAPTER 3: PUBLICATIONS

PUBLICATIONS IN REFEREED JOURNALS

1. **Amirkhani, Masoud; Volden, Sondre; Zhu, Kaizheng; Glomm, Wilhelm; Nyström, Bo.** Adsorption of cellulose derivatives on flat gold surfaces and on spherical gold particles. *Journal of Colloid and Interface Science* 2008 ;Volum 328.

2. **Antoine, Christine; Gregersen, Øyvind Weiby.** On the three component quantification of print-throud. Part 2: Effect of the ink vehicle extraction on print optical properties. *Nordic Pulp & Paper Research Journal* 2008 ;Volum 23.(1) s. 29-33

3. **Araujo, Antonio Carlos Brandao; Skogestad, Sigurd.** Control structure design for the ammonia synthesis process. *Computers and Chemical Engineering* 2008 ;Volum 32.(12) s. 2920-2932

4. **Aske, Elvira Marie B; Strand, Stig; Skogestad, Sigurd.** Coordinator MPC for maximizing plant throughput. *Computers and Chemical Engineering* 2008 ;Volum 32. s. 195-204

5. **Aske, Elvira Marie B; Strand, Stig; Skogestad, Sigurd.** Implementation of coordinator MPC on a large-scale gas plant. *Elsevier IFAC Publications / IFAC Proceedings series* 2008 s. -

6. **Baldea, M; Araujo, Antonio Carlos Brandao; Skogestad, Sigurd; Daoutidis, P.** Dynamic considerations in the synthesis of self-optimizing control structures. *AIChE Journal* 2008 ;Volum 54. s. 1830-1841

7. **Bar, Nadav; Lale, Rahmi.** Modeling and Control of the Protein Synthesis process in Eukaryotic cells. *IEEE Proceedings : Conference on Decision and Control (CDC)* 2008

8. **Beck, Ralf; Malthe-Sørenssen, Didrik; Andreassen, Jens-Petter.** Polycrystalline Growth in Precipitation of an Aromatic Amine Derivative and L-Glutamic Acid. *Journal of Crystal Growth* 2008

9. **Berger, RJ; Kapteijn, F; Moulijn, JA; Marin, GB; De Wilde, J; Olea, M; Chen, De; Holmen, Anders; Lietti, L; Tronconi, E; Schuurman, Y.** Dynamic methods for catalytic kinetics. *Applied Catalysis A : General* 2008 ;Volum 342. s. 3-28

10. **Bichon, P; Haugom, G; Venvik, Hilde Johnsen; Holmen, Anders; Blekkan, Edd Anders.** Steam reforming of ethanol over supported Co and Ni catalysts. *Topics in catalysis* 2008 ;Volum 49. s. 38-45

11. **Bilkova, Katerina; Gulbrandsen, Egil.** Kinetic and mechanistic study of CO2 corrosion inhibition by cetyl trimethyl ammonium bromide. *Electrochimica Acta* 2008 ;Volum 53.

12. **Borg, Øyvind; Dietzel, Pascal; Spjelkavik, Aud I.; Tveten, Erik Zakarias; Walmsley, John C.; Diplas, Spyridon; Eri, Sigrid; Holmen, Anders; Rytter, Erling.** Fischer-Tropsch synthesis: Cobalt particle size and support effects on intrinsic activity an product distribution. *Journal of Catalysis* 2008 ;Volum 259. s. 161-164

13. **Borg, Øyvind; Fossan, Åse-Lill; Lindvåg, Odd Asbjørn; Myrstad, Rune; Eri, Sigrid; Rytter, Erling; Holmen, Anders.** Fischer-Tropsch synthesis on Co supported on modified alumina. *Preprints - American Chemical Society. Division of Petroleum Chemistry* 2008

14. **Borg, Øyvind; Walmsley, John C.; Dehghan-Niri, Roya; Tanem, Bjørn Steinar; Blekkan, Edd Anders; Eri, Sigrid; Rytter, Erling; Holmen, Anders.** Electron Microscopy Study of γ-Al2O3 Supported Cobalt Fischer-Tropsch Synthesis Catalysts. *Catalysis Letters* 2008 ;Volum 126.(3-4) s. 224-230

15. **Cai, Junping; Jensen, Jørgen Bauck; Skogestad, Sigurd; Stoustrup, J.** On the Trade-off between Energy Consumption and Food Quality Loss in Supermarket Refrigeration System. *American Control Conference (ACC)* 2008 s. 2880-2885

16. **Chytil, Svatopluk; Haugland, Lise; Blekkan, Edd Anders.** On the mechanical stability of mesoporous silica SBA-15. *Microporous and Mesoporous Materials* 2008 ;Volum 111.

17. **Dahl-Olsen, Håkon; Narasimhan, Sridharakumar; Skogestad, Sigurd.** Optimal output selection for control of batch proecesses. *American Control Conference (ACC)* 2008 s. -

18. **Dorao, Carlos Alberto; Jakobsen, Hugo Atle.** hp-adaptive least squares spectral element method for population balance equations. *Applied Numerical Mathematics* 2008 ;Volum 58.(5) s. 563-576

19. **Dorao, Carlos Alberto; Lucas, Dirk; Jakobsen, Hugo Atle.** Prediction of the evolution of the dispersed phase in bubbly flow problems. *Applied Mathematical Modelling* 2008 ;Volum 32.(9) s. 1813-1833

20. **Dorao, Carlos Alberto; Patruno, Luciano E; Dupuy, Pablo Matias; Jakobsen, Hugo Atle; Svendsen, Hallvard Fjøsne.** Modeling of droplet–droplet interaction phenomena in gas–liquid systems for natural gas processing. *Chemical Engineering Science* 2008 ;Volum 63.(14) s. 3585-3592

21. **Dudasova, Dorota; Flåten, Geir Rune; Sjøblom, Johan; Øye, Gisle.** Study of asphaltenes adsorption onto different minerals and clays. Part 2. Particle characterization and suspension stability. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2008

22. **Dudasova, Dorota; Silset, Anne; Sjøblom, Johan.** Quartz crystal microbalance monitoring of asphaltene adsorption/deposition. *Journal of Dispersion Science and Technology* 2008 ;Volum 29.

23. **Dudasova, Dorota; Simon, Sebastien Charles; Hemmingsen, Pål Viggo; Sjøblom, Johan.** Study of asphaltenes adsorption onto different minerals and clays. Part 1. Experimental adsorption with UV depletion detection. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2008 ;Volum 317. s. 1-9

24. **Enger, Bjørn Christian; Lødeng, Rune; Holmen, Anders.** A review of catalytic partial oxidation of methane to synthesis gas with emphasison reaction mechanisms over transition metal catalysts. *Applied Catalysis A : General* 2008 ;Volum 346. s. 1-27

25. **Enger, Bjørn Christian; Walmsley, John C.; Bjørgum, Erlend; Lødeng, Rune; Pfeifer, Peter; Schubert, Klaus; Holmen, Anders; Venvik, Hilde Johnsen.** Performance and SEM characterization of Rh impregnated microchannel reactors in the catalytic partial oxidation of methane and propane. *Chemical Engineering Journal* 2008 ;Volum 144. s. 489-501

26. **Eriksen, Øyvind; Syverud, Kristin; Gregersen, Øyvind Weiby.** The use of microfibrillated cellulose produced from kraft pulp as strength enhancer in TMP paper. *Nordic Pulp & Paper Research Journal* 2008 ;Volum 23.(3) s. 299-304

27. **Foss, Martin Smedstad; Gulbrandsen, Egil; Sjøblom, Johan.** Alteration of Wettability of Corroding Carbon Steel Surface by Carbon Dioxide Corrosion Inhibitors - Effect on Carbon Dioxide Corrosion Rate and Contact Angle. *Corrosion* 2008 ;Volum 64.(12) s. 905-919

28. **Grainger, David Ryan; Hagg, May-Britt.** Techno-economic evaluation of PVAm CO2-selective membrane in an IGCC power plant with CO2 capture. *Fuel* 2008 ;Volum 87. s. 14-24

29. **Grainger, David Ryan; Hagg, May-Britt.** The recovery by carbon molecular sieve membranes of hydrogen transmitted in natural gas networks. *International journal of hydrogen energy* 2008 ;Volum 33. s. 2379-2388

30. **Hartono, Ardi; Juliussen, Olav; Svendsen, Hallvard Fjøsne.** Solubility of N2O in Aqueous Solution of Diethylenetriamine. *Journal of Chemical and Engineering Data* 2008 ;Volum 53. s. 2696-2700

31. **Hori, Eduardo Shigueo; Skogestad, Sigurd.** Selection of Controlled Variables: Maximum Gain Rule and Combination of Measurements. *Industrial & Engineering Chemistry Research* 2008 ;Volum 47. s. 9465-9471

32. **Huber, Florian; Venvik, Hilde Johnsen; Rønning, Magnus; Walmsley, John C; Holmen, Anders.** Preparation and characterization of nanocrystalline, high-surface area Cu-Ce-Zr mixed oxide catalysts from homogeneous co-precipitation. *Chemical Engineering Journal* 2008 ;Volum 137. s. 686-702

33. **Huber, Florian; Walmsley, John C.; Venvik, Hilde Johnsen; Holmen, Anders.** The effect of platinum in Cu-Ce-Zr and Cu-Zn-Al mixed oxide catalysts for water-gas shift. *Applied Catalysis A : General* 2008 ;Volum 349. s. 46-54

34. **Jakobsen, Jana Poplsteinova; Da Silva, Erik Falck; Krane, Jostein; Svendsen, Hallvard Fjøsne.** NMR study and quantum mechanical calculations on the 2-[(2-aminoethyl)amino]-ethanol-H2O-CO2 system. *Journal of magnetic resonance (San Diego, Calif. 1997 : Print)* 2008 ;Volum 191. s. 304-314

35. **Jaschke, Johannes; Narasimhan, Sridharakumar; Skogestad, Sigurd.** Explicit real-time optimization. *Elsevier IFAC Publications / IFAC Proceedings series* 2008

36. **Jensen, Jørgen Bauck; Skogestad, Sigurd.** Problems with specifying Delta T-min in the design of processes with heat exchangers. *Industrial & Engineering Chemistry Research* 2008 ;Volum 47.

37. **Kim, Inna; Hoff, Karl Anders; Hessen, Erik Tro¿ien; Haug-Warberg, Tore; Svendsen, Hallvard Fjøsne.** Enthalpies of absorption of CO2 with alkanolamine solutions predicted from reaction equilibrium constants. *Chemical Engineering Science* 2008

38. **Kim, Inna; Svendsen, Hallvard Fjøsne; Børresen, Eli.** Ebulliometric determination of vapour-liquid equilibria for pure water, monoethanolamine, N-methyldiethanolamine, 3-(metylamino)- propylamine and their binary and ternary solutions. *Journal of Chemical and Engineering Data* 2008 ;Volum 53. s. 2521-2531

39. **Kvande, Ingvar; Chen, De; Yu, Zhixin; Rønning, Magnus; Holmen, Anders.** Optimization and scale-up of CNF production based on intrinsic kinetic data obtained from TEOM. *Journal of Catalysis* 2008 ;Volum 256. s. 204-214

40. **Kvande, Ingvar; Øye, Gisle; Hammer, Nina; Rønning, Magnus; Raaen, Steinar; Holmen, Anders; Sjøblom, Johan; Chen, De.** Deposition of Au colloids on plasmachemically modified carbon nanofibers. *Carbon* 2008 ;Volum 46. s. 759-765

41. **Lersbamrungsuk, V; Srinophakun, T; Narasimhan, Sridharakumar; Skogestad, Sigurd.** Control structure design for optimal operation of heat exchanger networks. *AIChE Journal* 2008 ;Volum 54.

42. **Lesaint, Cedric Michel; Glomm, Wilhelm; Borg, Øyvind; Eri, Sigrid; Rytter, Erling; Øye, Gisle.** Synthesis and characterization of mesoporous alumina with large pore size and their performance in Fischer-Tropsch synthesis. *Applied Catalysis A : General* 2008 ;Volum 351. s. 131-135

43. **Lesaint, Cedric Michel; Kleppa, Gøril; Arla, David; Glomm, Wilhelm; Øye, Gisle.** Synthesis and characterization of mesoporous alumina materials with large pore size prepared by a double hydrolysis route. *Microporous and Mesoporous Materials* 2008

44. **Less, Simone; Hannisdal, Andreas; Bjorklund, E; Sjøblom, Johan.** Electrostatic destabilization of water-in-crude oil emulsions: Application to a real case and evaluation of the Aibel VIEC technology. *Fuel* 2008 ;Volum 87. s. 2572-2581

45. **Less, Simone; Hannisdal, Andreas; Sjøblom, Johan.** An electrorheological study on the behavior of water-in-crude oil emulsions under influence of a DC electric field and different flow conditions. *Journal of Dispersion Science and Technology* 2008 ;Volum 29. s. 106-114

46. **Liapis, AI; Grimes, Brian Arthur.** On film mass transfer coefficient expression in ion-exchange chromatography systems. *Separation and Purification Technology* 2008 ;Volum 59. s. 342-345

47. **Lid, Tore; Skogestad, Sigurd.** Data reconciliation and optimal operation of a catalytic naphtha reformer. *Journal of Process Control* 2008 ;Volum 18.

48. **Lid, Tore; Skogestad, Sigurd.** Scaled steady state models for effective on-line applications. *Computers and Chemical Engineering* 2008 ;Volum 32.

49. **Lindbråthen, Arne; Hagg, May-Britt.** Membrane separation of chlorine gas. *Chemical Engineering and Processing* 2008 ;Volum 48. s. 1-16

50. **Magnusson, Helene Konstansia; Hanneseth, Ann-Mari Dahl; Sjøblom, Johan.** Characterization of c80 naphthenic acid and its calcium naphthenate. *Journal of Dispersion Science and Technology* 2008 ;Volum 29. s. 464-473

51. **Manum, Henrik; Narasimhan, Sridharakumar; Skogestad, Sigurd.** A new approach to explicit MPC using self-optimizing control. *American Control Conference (ACC)* 2008 s. 435-440

52. **Manum, Henrik; Narasimhan, Sridharakumar; Skogestad, Sigurd.** Explicit MPC with output feedback using self-optimizing control. *Elsevier IFAC Publications / IFAC Proceedings series* 2008 s. 6956-

53. **Matam, Santhosh Kumar; Chen, De; Walmsley, John C; Holmen, Anders.** Dehydrogenation of propane over Pt-SBA-15: Effect of Pt particle size. *Catalysis communications* 2008 ;Volum 9. s. 747-750

54. **Mejdell, Astrid Lervik; Klette, Hallgeir; Ramachandran, Amutha; Borg, Anne; Bredesen, Rune.** Hydrogen permeation of thin, free-standing Pd/Ag23% membranes before and after heat treatment in air. *Journal of Membrane Science* 2008 ;Volum 307. s. 96-104

55. **Moe, Størker.** Biodrivstoff: Hva, hvorfor og hvordan. *GD : Gudbrandsdølen Dagningen* 2008 s. 42-

56. **Moller, AC; Blom, R; Swang, O; Hannisdal, Andreas; Rytter, E; Støvneng, Jon Andreas; Piel, T.** On the nonsingle-site character of bis(2-dimethylsilyl-indenyl)zirconium(IV) dichloride/MAO and bis(2-trimethylsilyl-indenyl)zirconium(IV) dichloride/MAO: Polymerization characteristics and mechanistic implications. *Journal of Physical Chemistry A* 2008 ;Volum 112.

57. **Nordgård, Erland; Landsem, Eva; Sjøblom, Johan.** Langmuir films of asphaltene model compounds and their fluorescent properties. *Langmuir* 2008 ;Volum 24. s. 8742-8751

58. **Nordgård, Erland; Sjøblom, Johan.** Model compounds for asphaltenes and C-80 isoprenoid tetraacids. Part I: Synthesis and interfacial activities. *Journal of Dispersion Science and Technology* 2008 ;Volum 29. s. 1114-1122

59. **Nordhagen, Håkon Ottar; Eriksen, Øyvind; Gregersen, Øyvind Weiby.** Strength variations in paper containing a sharp notch. *Nordic Pulp & Paper Research Journal* 2008 ;Volum 23.(2) s. 189-194

60. **Ochoa-Fernandez, Esther; Rønning, Magnus; Yu, Xiaofeng; Grande, Tor; Chen, De.** Compositional effects of nanocrystalline lithium zirconate on its CO2 capture properties. *Industrial & Engineering Chemistry Research* 2008 ;Volum 47. s. 434-442

61. **Paso, Kristofer Gunnar; Helberg, Ragne Marie Lilleby; Raaen, Steinar; Sjøblom, Johan.** Hydrophobic monolayer preparation by Langmuir-Blodgett and chemical adsorption techniques. *Journal of Colloid and Interface Science* 2008 ;Volum 325. s. 228-235

62. **Paso, Kristofer Gunnar; Kompalla, Thomas; Aske, Narve; Sjøblom, Johan.** A quartz crystal microbalance characterization of metal-oil interfaces and interactions with wax molecules. *Journal of Dispersion Science and Technology* 2008 ;Volum 29. s. 775-782

63. **Rossetti, I; Fabbrini, L; Ballarini, N; Oliva, C; Cavani, F; Cericola, A; Bonelli, B; Piumetti, M; Garrone, E; Dyrbeck, Hilde; Blekkan, Edd Anders; Forni, L.** V2O5-SiO2 systems prepared by flame pyrolysis as catalysts for the oxidative dehydrogenation of propane. *Journal of Catalysis* 2008 ;Volum 256.

64. **Rydén, Magnus; Lyngfelt, Anders; Mattisson, Tobias; Chen, De; Holmen, Anders; Bjørgum, Erlend.** Novel oxygen-carrier materials for chemical-looping combustion and chemical-looping reforming: LaxSr1-xFey-yO3-δ perovskites and mixed-metal oxides of NiO, Fe2O3 and Mn3O4. *International Journal of Greenhouse Gas Control* 2008 ; 2. s. 21-36

65. **Sanz-Navarro, Carlos F.; Åstrand, Per-Olof; Chen, De; Rønning, Magnus; van Duin, Adri C. T.; Mueller, Jonathan E.; Goddard III, William A..** Molecular Dynamics Simulations of Carbon-Supported Ni Clusters Using the Reax Reactive Force Field. *The Journal of Physical Chemistry C* 2008 ;Volum 112. s. 12663-12668

66. **Sanz-Navarro, Carlos; Åstrand, Per-Olof; Chen, De; Rønning, Magnus; van Duin, Adri C. T.; Jacob, Timo; Goddard III, William A..** Molecular Dynamics Simulations of the Interactions between Platinum Clusters and Carbon Platelets. *Journal of Physical Chemistry A* 2008 ;Volum 112. s. 1392-1402

67. **Shao, Lei; Samseth, Jon; Hagg, May-Britt.** Crosslinking and stabilization of high fractional free volume polymers for gas separation. *International Journal of Greenhouse Gas Control* 2008 ;Volum 2. s. 492-501

68. **Shao, Lei; Samseth, Jon; Hagg, May-Britt.** Crosslinking and Stabilization of High Fractional Free Volume Polymers for Gas Separations. *International Journal of Greenhouse Gas Control* 2008 ;Volum 2.(4) s. 492-501

69. **Shao, Lei; Zhao, Tiejun; Chen, De; Hagg, May-Britt.** Poly(4-methyl-2-pentyne) and Carbon Nanotube Mixed Matrix Membranes for Gas Separation. *American Chemical Society Symposium Series (ACS)* 2008 ;Volum 99. s. 180-182

70. **Silva, Eirik Falck da; Svendsen, Hallvard Fjøsne.** Comment on "Reaction Kinetics of CO2 in Aqueous Ethylenediamine, Ethyl Ethanolamine, and Diethyl monoethanolamine Solutions in the Temperature Range of 298-313 K, Using the Stopped-Flow Technique". *Industrial & Engineering Chemistry Research* 2008 ;Volum 47.(3) s. 990-

71. **Simon, Sebastien Charles; Nordgård, Erland; Bruheim, Per; Sjøblom, Johan.** Determination of C-80 tetra-acid content in calcium naphthenate deposits. *Journal of Chromatography A* 2008 ;Volum 1200. s. 136-143

72. **Stenstad, P; Andresen, Martin; Tanem, Bjørn Steinar; Stenius, Per.** Chemical surface modifications of microfibrillated cellulose. *Cellulose (London)* 2008 ;Volum 15.(1) s. 34-45

73. **Tobiesen, Finn Andrew; Juliussen, Olav; Svendsen, Hallvard Fjøsne.** Experimental validation of a rigorous desorber model for CO2 post-combustion capture. *Chemical Engineering Science* 2008 ;Volum 63.(10) s. 2641-2656

74. **Tucho, Wakshum Mekonnen; Arstad, Bjørnar; Klette, Hallgeir; Walmsley, John C; Bredesen, Rune; Venvik, Hilde Johnsen; Holmestad, Randi.** Microstructural characterization of self-supported 1.6µm Pd/Ag membranes. *Journal of Membrane Science* 2008 ;Volum 310. s. 337-348

75. **Venvik, Hilde Johnsen; Blekkan, Edd Anders.** Selected papers from the EUROPACAT VIII Hydrogen Society Session, Turku, Finland, 26-31 August 2007 Preface. *Catalysis Today* 2008 ;Volum 138.(3-4) s. 123-123

76. **Vrålstad, Torbjørn; Fossen, Martin; Sjøblom, Johan; Randhol, Preben.** Influence of interfacial tension on seeded calcium carbonate scale precipitation: Effect of adsorbed asphaltenes. *Journal of Dispersion Science and Technology* 2008 ;Volum 29. s. 440-446

77. **Xiong, JM; Borg, Øyvind; Blekkan, Edd Anders; Holmen, Anders.** Hydrogen chemisorption on rhenium-promoted gamma-alumina supported cobalt catalysts. *Catalysis communications* 2008 ;Volum 9. s. 2327-2330

78. **Yu, Zhixin; Chen, De; Rønning, Magnus; Tøtdal, Bård; Vrålstad, Torbjørn; Ochoa-Fernandez, Esther; Holmen, Anders.** Large-scale synthesis of carbon nanofibers on Ni-Fe-Al hydrotalcite derived catalysts. II: Effect of Ni/Fe composition on CNF synthesis from ethylene and carbon nonoxide. *Applied Catalysis A : General* 2008 ;Volum 338. s. 147-158

79. **Yu, Zhixin; Chen, De; Rønning, Magnus; Vrålstad, Torbjørn; Ochoa-Fernandez, Esther; Holmen, Anders.** Large-scale synthesis of carbon nanofibers on Ni-Fe-Al hydrotalcite derived catalysts. I. Preparation and characterization of the Ni-Fe-Al hydrotalcites and their derived catalysts. *Applied Catalysis A : General* 2008 ;Volum 338. s. 136-146

80. **Yu, Zhixin; Fareid, Lars Erik; Moljord, Kjell; Blekkan, Edd Anders; Walmsley, John C.; Chen, De.** Hydrodesulfurization of thiophene on carbon nanofiber supported Co/Ni/Mo catalysts. *Applied Catalysis B: Environmental* 2008 ;Volum 84.(3-4) s. 482-489

81. **Zheng, Jun-Sheng; Zhang, Xin-Sheng; Li, Ping; Zhou, Xing-Gui; Chen, De; Liu, Ye; Yuan, Wei-Kang.** Oxygen reducton reaction properties of carbon nanofibers: Effect of metal purification. *Electrochimica Acta* 2008 ;Volum 53. s. 3587-3596

82. **Zhu, Jun; Zhao, Tiejun; Kvande, Ingvar; Chen, De; Zhou, Xinggui; Yuan, Weikang.**
Carbon Nanofiber-Supported Pd Catalysts for Heck Reaction: Effect of Support Interaction. *Chinese Journal of Catalysis* 2008 ;Volum 29.(11) s. 1145-1151

83. **Zhu, Jun; Zhou, Jinghong; Zhao, Tiejun; Zhou, Xinggui; Chen, De; Yuan, Weikang.**
Carbon nanofiber-supported palladium nanoparticles as potential recyclable catalysts for the Heck reaction. *Applied Catalysis A : General* 2008 ;Volum 352. s. 243-250

84. **Zhu, Zhengjie; Dorao, Carlos Alberto; Jakobsen, Hugo Atle.** A least-squares method with direct minimization for the solution of the breakage-coalescence population balance equation. *Mathematics and Computers in Simulation* 2008 ;Volum 79. s. 716-727

BOOKS

1. **Jakobsen, Hugo Atle.**
Chemical Reactor Modeling. Multiphase Reactive Flows. Springer 2008 (ISBN 978-3-540-25197-2) 1244 s.

2. **Skogestad, Sigurd.**
Chemical and Energy Process Engineering. CRC Press 2008 (ISBN 978-1-4200-8755-0) 436 s.

3. **Smidsrød, Olav; Moe, Størker.**
Biopolymer Chemistry. Tapir Akademisk Forlag 2008 (ISBN 978-82-519-2384-2) 398 s.

JOURNALS

Johan Sjöblom, Editor-in-Chief:
Journal of Dispersion Science and Technology, Volume 28. New York: Taylor & Francis Books 2008. 8 issues in 2008

CHAPTERS IN BOOKS

1. **Beck, Ralf; Malthe-Sørenssen, Didrik; Andreassen, Jens-Petter.**
The Unstable Nature of β-L-Glutamic Acid Spherulites.2.
The effect of HEDP on calcium carbonate precipitation. I: *BIWIC 2008*. Shaker Verlag 2008 ISBN 978-3-8322-7505-1. s. 17-24

3. **Hagg, May-Britt.**
Membranes in Gas Separation. I: *Handbook of Membrane Separations : Chemical, Pharmaceutical, Food, and Biotechnological Applications*. CRC Press 2008 ISBN 978-0-8493-9549-9. s. 65-105

4. **Håkonsen, Silje Fosse; Holmen, Anders.**
Oxidative Dehydrogenation of Alkanes. I: *Handbook of Heterogeneous Catalysis*. Wiley-VCH Verlagsgesellschaft 2008 ISBN 978-3-527-31241-2. s. 3384-3400

5. **Paso, Kristofer Gunnar; Braathen, Bjarne; Vitala, T.; Aske, Narve; Rønningsen, H. P.; Sjøblom, Johan.**
Wax Deposition Investigations with Thermal Gradient Quartz Crystal Microbalance. I: *Handbook of Surface and Colloid Chemistry*. CRC Press 2008 ISBN 978-0-8493-7327-5. s. 567-584

CONFERENCE CONTRIBUTIONS

1. **Andreassen, Jens-Petter; Flaten, Ellen Marie; Beck, Ralf.**
Investigations of spherulitic growth in industrial crystallization. SIC 17 (17th INTERNATIONAL SYMPOSIUM ON INDUSTRIAL CRYSTALLIZATION; 2008-09-14 - 2008-09-17

2. **Aronu, Ugochukwu Edwin; Svendsen, Hallvard Fjøsne.**
Solvent Development for CO2 Capture. Austin CO2 seminar; 2008-01-10

3. **Aronu, Ugochukwu Edwin; Svendsen, Hallvard Fjøsne; Hoff, Karl Anders; Juliussen, Olav.**
Solvent selection for carbon dioxide absorption. GHGT9; 2008-11-16 - 2008-11-20

4. **Bakhtiary, Hamidreza Davijany; Hayer, Fatemeh; Venvik, Hilde Johnsen; Holmen, Anders.**
Kinetics and Reactor Modeling of Methanol Synthesis from Synthesis Gas in the Fixed-Bed Reactor. 13th Nordic Symposium on Catalysis; 2008-10-05 - 2008-10-07

5. **Bar, Nadav.**
Dynamic model of Fish Growth. Systems biology meeting Stuttgart; 2008-11-07 - 2008-11-09

6. **Bar, Nadav.**
Feedback Control in the Translational Process in Eukaryotic cells.. Systems biology meeting KTH; 2008-10-16 - 2008-10-17

7. **Bar, Nadav.**
Modeling, Analysis and Control of the Translational Initiation Regulation Process. Kolloquium Technische Kybernetik; 2008-06-16 - 2008-06-17

8. **Bar, Nadav.**
Modeling, Analysis and Control of the Translational Initiation Regulation Process. 1. International Workshop on Systems Biology; 2008-06-23 - 2008-06-24

9. **Bar, Nadav.**
Modeling, Analysis and Control of the Translational Initiation Regulation Process in Eukaryota. International Conference on Systems Biology; 2008-08-22 - 2008-08-29

10. **Bar, Nadav.**
Modeling, Analysis and Control of the Translational Initiation Regulation Process in Eukaryotic Cells. International Workshop on Systems Biology; 2008-08-18 - 2008-08-21

11. **Bar, Nadav.**
Modeling, Analysis and Control of the Translational Initiation Regulation Process in Eukaryotic Cells. Winter 2008 Systems Biology Seminar Series; 2008-02-29 - 2008-03-01

12. **Beck, Ralf.**
Crystallization and Filtration of 3 Crystallizing Systems. Seminar in Industrial Crystallization. Seminar in Industrial Crystallizaton; 2008-11-27

13. **Beck, Ralf.**
The influence of tailor-made crystal properties and particle breakage on filtration and powder flow. POSTEC ANNUAL MEETING; 2008-11-03 - 2008-11-04

14. **Beck, Ralf; Malthe-Sørenssen, Didrik; Andreassen, Jens-Petter.**
The influence of Process Parameters and Resulting Crystal Properties on Constant pressure Filtration of L-Glutamic Acid and an Aromatic Amine. ISIC 17 (17th INTERNATIONAL SYMPOSIUM ON INDUSTRIAL CRYSTALLIZATION),; 2008-09-14 - 2008-09-17

15. **Beck, Ralf; Malthe-Sørenssen, Didrik; Andreassen, Jens-Petter; Häkkinen, Antti; Louhi-Kultanen, Majata.**
The Influence of Morphology and Size on Constant Pressure Filtration for two Crystallizing Systems.. 10th World Filtration Congress,; 2008-04-14 - 2008-04-18

16. **Beck, Ralf; Malthe-Sørenssen, Didrik; Andreassen, Jens-Petter; Nysæther, Trude; Enstad, G. G..**
Influence of Crystal Properties on Powder Flow Behaviour. International Symposium Reliable Flow of Particulate Solids IV (RELPOWFLO IV),; 2008-06-10

17. **Blekkan, Edd Anders.**
Biofuels. MIT seminar MIT; 2008-11-28 - 2008-11-29

18. **Blekkan, Edd Anders.**
Chemistry of heavy oil upgrading. VISTA-seminar; 2008-10-12

19. **Blekkan, Edd Anders.**
Fischer-Tropsch synthesis. Gas Technology Center, Lunch Seminar; 2008-06-17

20. **Blekkan, Edd Anders.**
Norwegian downstream technology - education, research and industrial development. Gassmaks/Research Council Seminar on “New business opportunities in a changing gas market; 2008-09-23 - 2008-09-24

21. **Blekkan, Edd Anders; Borg, Øyvind; Frøseth, Vidar.**
The effects of water on supported cobalt catalysts in the Fischer-Tropsch synthesis. 14th International Congress on Catalysis; 2008-07-13 - 2008-07-18

22. **Borg, Øyvind; Fossan, Åse-Lill; Enger, Bjørn Christian; Eri, Sigrid; Rytter, Erling; Holmen, Anders.**
Fischer-Tropsch synthesis on Co suppported on Al2O3 modified with Mg, Zn or Ni. 14th International Congress on Catalysis; 2008-07-13 - 2008-07-18

23. **Chen, De.**
Applications of carbon nanotube/nanofiber based composites. 3rd NanoLab User Meeting; 2008-03-06

24. **Chen, De; Kvande, Ingvar; Hammer, Nina; Zhao, Tiejun; Yu, Zhixin; Rønning, Magnus; Holmen, Anders; Sanz-Navarro, Carlos; Åstrand, Per-Olof.**
Engineering of metal nanoparticles on carbon nanofibers. 1st Nanotechnology@; 2008-09-11 - 2008-09-12

25. **Chytil, Svatopluk; Glomm, Wilhelm; Walmsley, John C.; Blekkan, Edd Anders.**
Platinum supported on mesoporous silica SBA-15: preparation, characterization and catalytic properties. 1st International Workshop NAPEN 2008; 2008-10-12 - 2008-10-15

26. **Dahl-Olsen, Håkon; Narasimhan, Sridharakumar; Skogestad, Sigurd.**
Optimal output selection for control of batch processes. American Control Conference 2008; 2008-06-11 - 2008-06-13

27. **de Graaf, Stefan C.; Kittilsen, Pål; Preisig, Heinz A..**
Reduction of Computational load Associated with the Integation of DAE Systems. 18th European Symposium on Computer Aided Process Engineering - ESCAPE 18; 2008-06-01 - 2008-06-04

28. **den Breejen, Johan P.; Radstake, Paul Bernard; Bezemer, G. L.; Frøseth, Vidar; Holmen, Anders; Bitter, Johannes H.; de Jong, Krijn.**
Cobalt on carbon nanofibers as model caalyst: On the origin of the cobalt particle size effect in Fischer-Tropsch synthesis. 3. International Symposium on Carbon for Catalysis; 2008-11-09 - 2008-11-12

29. **Deng, Liyuan; Hagg, May-Britt.**
Capture of CO_2 from natural gas with PVAm/PVA blend FSC Membrane. the 11th nordic filtration symposium; 2008-08-25

30. **Deng, Liyuan; Hagg, May-Britt.**
PVA/PVAm Blend FSC Membrane for Biogas Upgrading. (ICOM 2008) International Congress on Membranes and Membrane Processes; 2008-07-12 - 2008-07-18

31. **Dones, Ivan; Preisig, Heinz A..**
An Initialization Procedure for Steadyy-State Models. Example: Distillation Column. 18th European Symposium on Computer Aided Process Engineering - ESCAPE 18; 2008-06-01 - 2008-06-04

32. **Dupuy, Pablo Matias; Fernandino, Maria; Jakobsen, Hugo Atle; Svendsen, Hallvard Fjøsne.**
Two-phase flow fractional step lattice Boltzmann model. 17th International Conference on the Discrete Simulation of Fluid Dynamics (DSFD2008); 2008-08-04 - 2008-08-08

33. **Dupuy, Pablo Matias; Fernandino, Maria; Jakobsen, Hugo Atle; Svendsen, Hallvard Fjøsne.**
Using Cahn-Hilliard mobility to simulate coalescence dynamics. 5th International Conference for Mesoscopic Methods in Engineering and Science (ICMMES 2008); 2008-06-16 - 2008-06-20

34. **Dupuy, Pablo Matias; Patruno, Luciano E; Fernandino, Maria; Jakobsen, Hugo Atle; Svendsen, Hallvard Fjøsne.**
Experiments and numerical simulations addressing droplet deposition and formation at high pressures. 18th International Congress of Chemical and Process Engineering (CHISA); 2008-08-24 - 2008-08-28

35. **Dupuy, Pablo Matias; Patruno, Luciano E; Fernandino, Maria; Jakobsen, Hugo Atle; Svendsen, Hallvard Fjøsne.**
Towards the construction of lattice Boltzmann models for two phase flow simulation at high pressures. 6th International Conference on Computational Fluid Dynamics in the Oil & Gas, Metallurgical and Process Industries (CFD2008); 2008-06-10 - 2008-06-12

36. **Dupuy, Pablo Matias; Patruno, Luciano E; Fernandino, Maria; Jakobsen, Hugo Atle; Svendsen, Hallvard Fjøsne.**
2D droplet-droplet interaction at high pressures. Mexican Congress on Chemical Reaction Engineering (MCCRE 2008); 2008-06-15 - 2008-06-19

37. **Dyrbeck, Hilde; Østli, Kristian; Blekkan, Edd Anders.**
Selective hydrogen combustion in the presence of hydrocarbons: Catalysts supported on hydrotalcite-like materials. 14th Int. Congress on Catalysis; 2008-07-13 - 2008-07-18

38. **Eide-Haugmo, Ingvild; Brakstad, Odd Gunnar; Hoff, Karl Anders; Sørheim, Kristin Rist; Silva, Eirik Falck da; Svendsen, Hallvard Fjøsne.**
Environmental impact of amines. GHGT9; 2008-11-16 - 2008-11-20

39. **Eide-Haugmo, Ingvild; Hoff, Karl Anders; Brakstad, Odd Gunnar; Sørheim, Kristin R.; Svendsen, Hallvard Fjøsne.**
Environmental impacts and aspects of absorbents used for CO_2 capture. Austin CO_2 seminar; 2008-01-10

40. **Eide-Haugmo, Ingvild; Hoff, Karl Anders; Brakstad, Odd Gunnar; Sørheim, Kristin R.; Vang, Siv-Hege; Hansen, Bjørn Henrik; Altin, Dag; Svendsen, Hallvard Fjøsne.**
An environmental outlook on absorption chemicals in offshore applications. StatoilHydro Summit;

41. **Eiras, Sara Boullosa; Zhao, Tiejun; Lind, Anna Maria; Chen, De; Holmen, Anders.**
Multi-functional oxides with core-shell nanostructure as promising catalyst supports. 13th Nordic Symposium on Catalysis; 2008-10-05 - 2008-10-07

42. **Enger, Bjørn Christian; Lødeng, Rune; Holmen, Anders.**
Methane activation and syngas formation on low-loading Ni catalysts. 14th International Congress on Catalysis; 2008-07-13 - 2008-07-18

43. **Enger, Bjørn Christian; Lødeng, Rune; Holmen, Anders.**
Modified nickel catalysts in the partial oxidation of methane at moderate temperatures. 13th Nordic Symposium on Catalysis; 2008-10-05 - 2008-10-07

44. **Eriksen, Øyvind; Gregersen, Øyvind Weiby; Syverud, Kristin.**
The effect of MFC on handsheet surface and printing properties. Progress in Paper Physics; 2008-06-01 - 2008-06-05

45. **Flaten, Ellen Marie.**
Nucleation and crystal growth determinations for CaCO3. Crystallization seminar, Crypow; 2008-11-27

46. **Flaten, Ellen Marie; Andreassen, Jens-Petter.**
Induction time studies of calcium carbonate in ethylene glycol and water. ISIC 2008; 2008-09-14 - 2008-09-17

47. **Flaten, Ellen Marie; Andreassen, Jens-Petter.**
Investigations of spherulitic growth in industrial crystallization. ISIC2008; 2008-09-14 - 2008-09-17

48. **Flaten, Ellen Marie; Fostenæs, Siv Monica; Andreassen, Jens-Petter.**
The effect of HEDP on calcium carbonate precipitation. BIWIC2008; 2008-09-10 - 2008-09-12

49. **Flaten, Ellen Marie; Seiersten, Marion; Andreassen, Jens-Petter.**
Nucleation and crystal growth determination for CaCo3. Crystallization seminar. Crypow; 2008-11-27

50. **Flaten, Ellen Marie; Watterud, Geir; Andreassen, Jens-Petter; Seiersten, Marion.**
Precipitation of iron and calcium carbonate in pipelines at varying MEG contents. 2008 SPE Ninth International Conference on Oilfield Scale; 2008-05-28 - 2008-05-29

51. **Glomm, Wilhelm.**
Protein - gold Constructs : Interaction, structure and function. Polymer Meeting; 2008-03-10 - 2008-03-12

52. **Gregersen, Øyvind Weiby; Guldbjørnsen, Johan A..**
The effect of wet strain on properties of wood-containing printing paper. Progress in Paper Physics; 2008-06-02 - 2008-06-05

53. **Hammer, Nina; Chen, De; Rønning, Magnus.**
Carbon as a support for AuTiO2 catalysts. InGAP/CATMAT seminar on Metal/support catalysts; 2008-05-21

54. **Hammer, Nina; Schubert, Marco Peter; Chen, De; Rønning, Magnus.**
Carbon-Carbon Composite Material as a Catalytic Reactor. Carbon 2008; 2008-07-13 - 2008-07-18

55. **Hartono, Ardi; Svendsen, Hallvard Fjøsne.**
Kinetics reaction of Primary and Secondary Amine Group in Aqquous Solution of Diethylenetriamine (DETA) with Carbon Dioxide. GHGT9; 2008-11-16 - 2008-11-20

56. **Hartono, Ardi; Svendsen, Hallvard Fjøsne.**
Kinetics Study of Reactions of CO2 in aqueous solution of Diethylenetriamine (DETA). Austin CO2 seminar; 2008-01-10

57. **Hayer, Fatemeh; Bakhtiary, Hamidreza Davijany; Myrstad, Rune; Venvik, Hilde Johnsen; Holmen, Anders.**
A Numerical Study of Dimethyl Ether Synthesis in Packed Bed Reactor. COMSOL Conference; 2008-11-04 - 2008-11-06

58. **He, Li; Beinset, Morten; Berntsen, Helene; Zhao, Tiejun; Blekkan, Edd Anders; Chen, De.**
Sorption Enhanced Steam reforming of Ethanol over Co-Ni/HT for H2 production. 14th Int. Congress on Catalysis; 2008-07-13 - 2008-07-18

59. **He, Li; Beinset, Morten; Berntsen, Helene; Zhao, Tiejun; Chen, De.**
Multifunctional Reactor for Hydrogen Production from Multifuels. 12th APCChE Congress; 2008-08-04 - 2008-08-06

60. **He, Xuezhong; Hagg, May-Britt.**
Gas Separation through Hollow Fibre Carbon Membranes. NYM 10th conference; 2008-09-18 - 2008-09-19

61. **He, Xuezhong; Lie, Jon Arvid; Sheridan, Edel; Hagg, May-Britt.**
CO2 Capture by Hollow Fibre Carbon Membranes: Experiments and Process Simulations. 9th International Conference on Greenhouse Gas Control Technologies (GHGT-9); 2008-11-16 - 2008-11-20

62. **He, Xuezhong; Lie, Jon Arvid; Sheridan, Edel; Hagg, May-Britt.**
Preparation and Characterization of Hollow Fibre Carbon Membranes based on a Cellulosic Precursor. 2008 International Congress on Membranes and Membrane Processes (ICOM 2008); 2008-07-12 - 2008-07-18

63. **Hessen, Erik Tro¿ien; Haug-Warberg, Tore; Svendsen, Hallvard Fjøsne.**
Thermodynamic models for CO_2-H_2O-alkanolamine systems, a discussion. GHGT9; 2008-11-16

64. **Hessen, Erik Tro¿ien; Svendsen, Hallvard Fjøsne.**
Thermodynamic models for CO_2-alkanolamine-water system. Austin CO_2 seminar; 2008-01-10

65. **Holmen, Anders.**
The effect of particle size/structure/composition on catalyst performance for some Ni and Co catalysts. InGAP/CATMAT seminar on Metal/support catalysts; 2008-05-21

66. **Huang, Fan; Vanhaecke, Estelle Marie M.; Chen, De.**
In-situ polymerization of a composite PANI/carbon nanostructures. III International Symposium on Carbon for Catalysis (CarboCat III); 2008-11-09 - 2008-11-12

67. **Jelle, Bjørn Petter; Holme, Jonas; Hovde, Per Jostein; Nilsen, Tom Nils.**
Attenuated Total Reflectance (ATR) Fourier Transform Infrared (FTIR) Radiation Studies of Wood Rot Decay and Fungus Growth on Building Materials. 11th International Conference on Durability of Building Materials and Components; 2008-05-11 - 2008-05-14

68. **Jelle, Bjørn Petter; Nilsen, Tom Nils; Hovde, Per Jostein; Gustavsen, Arild.**
Accelerated Climate Ageing of Building Materials and Application of the Attenuated Total Reflectance (ATR) Fourier Transform Infrared (FTIR) Radiation Experimental Method. 8th Symposium on Building Physics in the Nordic Countries; 2008-06-16 - 2008-06-18

69. **Jelle, Bjørn Petter; Rüther, Petra; Hovde, Per Jostein; Nilsen, Tom Nils.**
Attenuated Total Reflectance (ATR) Fourier Transform Infrared (FTIR) Radiation Investigations of Natural and Accelerated Climate Aged Wood Substrates. 11th International Conference on Durability of Building Materials and Components; 2008-05-11 - 2008-05-14

70. **Kim, Inna; Hoff, Karl Anders; Hessen, Erik Tro¿ien; Haug-Warberg, Tore; Svendsen, Hallvard Fjøsne.**
Enthalpies of absorption of CO_2 in aqueous alkanolamine solutions from modified e-NRTL model. GHGT-9; 2008-11-16 - 2008-11-20

71. **Kim, Inna; Svendsen, Hallvard Fjøsne.**
Ebulliometric determination of Vapour-Liquid equilibria for pure alkanolamines and their aqueous solutions. 11th Int. network for CO_2 capture; 2008-05-20 - 2008-05-21

72. **Kim, Inna; Svendsen, Hallvard Fjøsne.**
Thermal measurements: Heat of absorption of CO_2 and Vapour-Liquid Equilibria in alkanoamine-water solutions. Austin CO_2 seminar; 2008-01-10

73. **Kim, Inna; Svendsen, Hallvard Fjøsne.**
Thermal measurements: Heat of absorption of CO_2 and Vapour-liquid equilibria in alkanolamine-water solutions. Research Review Meeting; 2008-01-10

74. **Kim, Taek Joong; Hagg, May-Britt.**
Challenges related to upscaling of membrane from lab-size to pilot scale - Case study: Facilitated transport membrane for CO_2 separation. 2008 International Congress on Membranes and Membrane Processes (ICOM 2008); 2008-05-25 - 2008-05-28

75. **Knuutila, Hanna; Svendsen, Hallvard Fjøsne.**
CO_2 capture with sodium carbonate. Austin CO2 seminar; 2008-01-10

76. **Knuutila, Hanna; Svendsen, Hallvard Fjøsne; Juliussen, Olav.**
Kinetics of carbonate based CO_2 capture systems. GHGT9; 2008-11-16 - 2008-11-20

77. **Kvande, Ingvar; Briskeby, Stein Trygve; Rønning, Magnus; Holmen, Anders; Chen, De; Walmsley, John C.; Sunde, Svein.**
CO adsorption and desorption behaviour of carbon nanofiber supported platinum catalysts. 3. International Symposium on Carbon for Catalysis; 2008-11-09 - 2008-11-12

78. **Kvande, Ingvar; Briskeby, Stein Trygve; Tsypkin, Mikhail; Tunold, Reidar; Sunde, Svein; Chen, De.**
Carbon nanofiber supported catalysts. 5th Funmat meeting; 2008-06-05 - 2008-06-05

79. **Kvande, Ingvar; Rønning, Magnus; Chen, De.**
Structure - Properties - Performance Relationship of Carbon Nanofiber Supported Pt Catalysts. Carbon 2008; 2008-08-13 - 2008-08-18

80. **Li, Ping; Huang, Yi-Li; Chen, De; Zhou, Xing-Gui; Zhao, Tiejun.**
Hydrogen evolution from decalin over precious metal catalysts supported on carbon nanofibers. Carbon 2008; 2008-07-13 - 2008-07-18

81. **Lögdberg, Sara; Borg, Øyvind; Järås, Sven; Blekkan, Edd Anders; Holmen, Anders.**
Activity response upon external water addition to a narrow-pore CoRe/γ-Al_2O_3 Fischer-Tropsch catalyst. 14th International Congress on Catalysis; 2008-07-13 - 2008-07-18

82. **Lögdberg, Sara; Borg, Øyvind; Tristantini, Dewi; Blekkan, Edd Anders; Gevert, Börje; Järås, Sven; Holmen, Anders.**
Fuel Production by Fischer-Tropsch synthesis with CO/H_2 from different feeds. 5th International Conference on Environmental Catalysis; 2008-08-31 - 2008-09-03

83. **Lu, Wenxin; Sui, Zhijun; Zhou, Jinghong; Li, Ping; Zhou, Xinggui; Chen, De.**
Effect of hydrogen on the Synthesis of Carbon Nanofibers by CO Disproportionation on Ultra-Fine Fe3O4. 12th APCChE Congress; 2008-08-04 - 2008-08-06

84. **Lualdi, Matteo; Lögdberg, Sara; Nassos, S; Järås, Sven; Holmen, Anders.**
Direct use of H_2-poor syngas in the Fischer-Tropsch synthesis. lisroel@chemeng..no; 2008-10-05 - 2008-10-07

85. **Luo, Xiao; de Montigny, D.; Sanpasertparnich, T.; Idem, R.; Gelowitz, D.; Notz, R.; Hoch, S.; Hasse, H.; Lemaire, E.; Alix, P.; Tobiesen, Finn Andrew; Juliussen, Olav; Köpcke, M.; Svendsen, Hallvard Fjøsne.**
Comparison and validation of simulation codes against sixteen sets of data from four dirrerent pilot plants. GHGT9; 2008-11-16 - 2008-11-20

86. **Luo, Xiao; Svendsen, Hallvard Fjøsne.**
Combined Heat and Mass Transfer Model in Amines System. Seminar StatoilHydro; 2008-02-08

87. **Lødeng, Rune; Bjørgum, Erlend; Enger, Bjørn Christian; Holmen, Anders; Krogh, Bente; Børresen, Børre; Rytter, Erling.**
Oxidative catalytic conversion of CH_4 to H_2 at low temperatures. 14th International Congress on Catalysis; 2008-07-13 - 2008-07-18

88. **Ma'mun, Sholeh; Svendsen, Hallvard Fjøsne.**
Solubility of N_2O in Aqueous Monoethanolamine and 2-(2-Aminoethyl-amino)ethanol Solution from 298 to 343 K. GHGT9; 2008-11-16 - 2008-11-20

89. **Mejdell, Astrid Lervik; Jøndahl, Mari; Peters, Thijs A.; Bredesen, Rune; Venvik, Hilde Johnsen.**
Experimental investigation of a microchannel membrane reactor. Norwegian Hydrogen Seminar 2008; 2008-09-25 - 2008-09-26

90. **Mejdell, Astrid Lervik; Jøndahl, Mari; Peters, Thijs A.; Bredesen, Rune; Venvik, Hilde Johnsen.**
Experimental investigation of thin Pd/Ag23 wt% membranes employed in a microchannel configuration. 10th International Conference on Inorganic Membranes (ICIM 10); 2008-08-18 - 2008-08-22

91. **Mejdell, Astrid Lervik; Jøndahl, Mari; Peters, Thijs A.; Bredesen, Rune; Venvik, Hilde Johnsen.**
Influence of CO and CO_2 on a ~3 µm Pd/Ag membrane supported by microchannels – effect of temperature and concentration. Symposium on Catalysis; 2008-10-05 - 2008-10-07

92. **Mejdell, Thor; Hoff, Karl Anders; Kim, Inna; Svendsen, Hallvard Fjøsne.**
Simplified solvent equilibrium modelling using both equilibrium and calorimetric measurements for post combustion capture. GHGT9; 2008-11-16 - 2008-11-20

93. **Nordhagen, Håkon Ottar; Gregersen, Øyvind Weiby; Mäkelä, Petri.**
Verification of fracture mechanics theory and aspects of its practical use. Progress in Paper Physics; 2008-06-02 - 2008-06-05

94. **Olderøy, Magnus Østgård; Strand, Berit Løkensgard; Andreassen, Jens-Petter; Sikorski, Pawel.**
Alginate Gel Beads as Model System for Biomineralization. Nanotechnolog 2008; 2008-09-11 - 2008-09-12

95. **Olderøy, Magnus Østgård; Strand, Berit Løkensgard; Andreassen, Jens-Petter; Sikorski, Pawel.**
Biomineralization: Nanoscale Control of Mineral Deposition Within Polysaccharide Gel Networks. Nanotech Northern Europe 2008; 2008-09-23 - 2008-09-25

96. **Olderøy, Magnus Østgård; Strand, Berit Løkensgard; Andreassen, Jens-Petter; Sikorski, Pawel.**
Nanoscale Control of Mineral Deposition Within Polysaccharide Gel Networks. Biofysikkmøtet Kongsvold 2008; 2008-02-27 - 2008-02-29

97. **Paso, Kristofer Gunnar; Kompalla, Thomas; Braathen, Bjarne; Aske, Narve; Rønningsen, Hans Petter; Viitala, Tapani; Sjøblom, Johan.**
A quartz crystal microbalance characterization of metal-oil interfaces and interactions with wax molecules. The 9th International Conference on Petroleum Phase Behavior and Fouling; 2008-06-15 - 2008-06-19

98. **Patruno, Luciano E; Dorao, Carlos Alberto; Svendsen, Hallvard Fjøsne; Jakobsen, Hugo Atle.**
Modelling and Simulation of Droplet Distribution from Entrained Liquid Film in Gas-Liquid Systems. The Fifth International Conference on Computational Fluid Dynamics; 2008-07-07 - 2008-07-11

99. **Patruno, Luciano E; Dorao, Carlos Alberto; Svendsen, Hallvard Fjøsne; Jakobsen, Hugo Atle.**
Population Balance Modelling Applied to the Study of Droplet Behaviour. 6th International Conference on Computational Fluid Dynamics in the Oil & Gas, Metallurgical and Process Industries; 2008-06-10 - 2008-06-12

100. **Paunonen, Sara Inkeri; Gregersen, Øyvind Weiby.**
Effect of moisture on elastic properties of solid board. Progress in Paper Physics; 2008-06-02 - 2008-06-05

101. **Preisig, Heinz A..**
Three Principle Model Reductions Based on Time-Scale Considerations. 18th European Symposium on Computer Aided Process Engineering - ESCAPE 18; 2008-06-01 - 2008-06-04

102. **Rusu, Marius; Liukkonen, Sari; Gregersen, Øyvind Weiby.**
The effect of wood raw material and energy input on the cross-sectional properties of TMP fibres. 6th Fundamental Mechanical Pulp Research Seminar; 2008-05-22

103. **Rønning, Magnus.**
Characterisation of catalysts at their working conditions. InGAP seminar; 2008-11-04 - 2008-11-05

104. **Rønning, Magnus.**
Combining results from XAS, Raman, STEM and TEOM to obtain reliable information about propane dehydrogenation catalysts. Swiss-Norwegian workshop on Simultaneous Raman-X-ray diffraction/absorption studies for the in situ investigations; 2008-06-18 - 2008-06-19

105. **Rønning, Magnus.**
Nanomaterials in Catalysis -Activities at . Nanotechnology Workshop; UC Berkeley-Statoilhydro-; 2008-09-01

106. **Rønning, Magnus; Hammer, Nina; Kvande, Ingvar; Borg, Øyvind; Chen, De; Holmen, Anders.**
Nanostructured materials in environmental catalysis. 1st Nanotechnology@; 2008-09-11 - 2008-09-12

107. **Sandru, Marius; Kim, Taek Joong; Hagg, May-Britt.**
Fixed-site-carrier membrane for CO_2 capture – membrane material and separation process optimisation. ICOM 2008; 2008-07-12 - 2008-07-18

108. **Sandru, Marius; Kim, Taek Joong; Hagg, May-Britt.**
Fixed-site-carrier PVAm membranes optimisation for CO_2 capture. Engineering with membrane 2008; 2008-05-25 - 2008-05-28

109. **Shao, Lei; Hagg, May-Britt.**
Crosslinking and Stabilization of MgO Filled PTMSP Nanocomposite Membranes for Gas Separation. 2008 International Congress on Membranes at Membrabe Process (ICOM 2008); 2008-07-12 - 2008-07-18

110. **Silva, Eirik Falck da; Hoff, Karl Anders; Svendsen, Hallvard Fjøsne.**
Can we improve upon MEA as a solvent for CO_2 capture ?. GHGT9; 2008-11-16 - 2008-11-20

111. **Sjøblom, Johan.**
Role of Asphaltenes, Resins and Naphthenic Acids in Emulsion Formation. International Symposium Chinese University of Petroleum, Beijing 55 years; 2008-09-28

112. **Sjøblom, Johan.**
Setting the Scene: The Current Understanding and Role of different Naphthenates. SPE Applied Technology Workshop; 2008-03-10

113. **Sjøblom, Johan.**
Surface Active Compounds in Crude Oils. Surface Chemistry without Borders. International Symposium in homour of Professor Per Stenius 70 years; 2008-09-04

114. **Sjøblom, Johan.**
Surface Chemistry without Borders. Surface Chemistry without Borders. International Symposium in homour of Professor Per Stenius 70 years; 2008-09-04

115. **Sporleder, Federico; Dorao, Carlos Alberto; Jakobsen, Hugo Atle.**
Spectral element method for simulation of natural gas conversion processes. 6th International Conference of Computational Methods in Science and Engineering; 2008-09-25 - 2008-09-30

116. **Sun, Yun-Fei; Sui, Zhi-Jun; Zhou, Jing-Hong; Li, Ping; Chen, De; Zhou, Xing-Gui.**
A Kinetic Study on Catalytic Decomposition of Methane over Supported Ni Catalysts. 12th APCChE; 2008-08-04 - 2008-08-06

117. **Sun, Yun-Fei; Sui, Zhi-Jun; Zhou, Jing-Hong; Li, Ping; Chen, De; Zhou, Xing-Gui.**
Catalytic Decomposition of Methane over Supported Ni Catalysts with Different Particle Sizes. 12th APCChE; 2008-08-04 - 2008-08-06

118. **Svendsen, Hallvard Fjøsne.**
Absorption methods in gas purification. DNV kurs; 2008-05-28

119. **Svendsen, Hallvard Fjøsne.**
Absorption methods in gas purification. Lecture series Universidad Simon Bolivar; 2008-02-06

120. **Svendsen, Hallvard Fjøsne.**
CCS Technologies for the future. Lecture series Univesidad Simon Bolivar; 2008-02-06

121. **Svendsen, Hallvard Fjøsne.**
CO2-innfanging - hva innebærer det ?. Realfagskonferansen; 2008-04-14

122. **Tanase, Mihaela; Stenius, Per Johan; Johansson, Lars; Hill, Jan.**
Removal of resin during RT Pretreatment of softwood chips. 6th Fundamental Mechanical Pulp Research Seminar; 2008-05-22

123. **Tobiesen, Andrew Finn; Mejdell, Thor; Hoff, Karl Anders; Knudsen, J.; Svendsen, Hallvard Fjøsne.**
Process modeling and model validation. Connon Technical Training Workshop; 2008-01-22 - 2008-01-24

124. **Toven, Kai; Gorski, Dmitri; Gregersen, Øyvind Weiby.**
Fracture resistance of reinforced SC paper. Progress in Paper Physics; 2008-06-02 - 2008-06-05

125. **Tucho, Wakshum Mekonnen; Venvik, Hilde Johnsen; Walmsley, John C; Bredesen, Rune; Holmestad, Randi.**
Permeation and microstructure studies of Pd-Ag membranes for H2 separation. 3rd Nanolab User Meeting; 2008-03-06 - 2008-03-06

126. **Vanhaecke, Estelle Marie M.; Chen, De; Rønning, Magnus.**
Synthesis and optimization of carbon nanostructures on foils. III International Symposium on Carbon for Catalysis (CarboCat III); 2008-11-09 - 2008-11-12

127. **Vanhaecke, Estelle Marie M.; Chen, De; Rønning, Magnus.**
Sythesis of carbon nanostructures on foils. E-MRS Fall meeting; 2008-09-15 - 2008-09-19

128. **Volden, Sondre; Beck, Ralf; Opedal, Nils; Zhu, Kaizheng; Nyström, Bo; Andreassen, Jens-Petter; Glomm, Wilhelm.**
Low Temperature Synthesis of Gold Nanoparticles using Ascorbic Acid and Cellulose Derivates. 1st Nanotechnology@; 2008-09-11 - 2008-09-12

129. **Volden, Sondre; Opedal, Nils; Andreassen, Jens-Petter; Nyström, Bo; Glomm, Wilhelm.**
Polymer assisted nanoparticle synthesis. Polymer Meeting; 2008-03-10 - 2008-03-12

130. **Volden, Sondre; Zhu, Kaizheng; Nyström, Bo; Glomm, Wilhelm.**
Temperature-Dependent Optical Properties of PNIPAAM-Protected Gold Nanoparticles. 1st Nanotechnology@; 2008-09-11 - 2008-09-12

131. **Wangen, Espen Standal; Hoff, Anne; Blekkan, Edd Anders.**
Upgrading of vacuum residue from Athabasca bitumen. 13th Nordic Symposium on Catalysis; 2008-10-05 - 2008-10-07

132. **Zhao, Tiejun; Boullosa, Eiras Sara; Lind, Anna Maria; Chen, De; Holmen, Anders.**
Multifunctional mixed oxides derived core-shell nanostructures as promising catalyst support. Nanocatalysis:Fundamentals and applications, A Pre-conference of 14 ICC; 2008-07-09 - 2008-07-12

133. **Zhao, Tiejun; Ochoa-Fernandez, Esther; Rønning, Magnus; Chen, De.**
Comparison study on nanocrystalline alkali and alkali-earth based materials as high-temperature CO_2 acceptors. 236 ACS national meeting; 2008-04-06 - 2008-04-10

134. **Zhao, Tiejun; Zhu, Jun; Kvande, Ingvar; Holmen, Anders; Chen, De; Zhou, Xinggui; Yuan, Wei-Kang.**
Towards the growth mechanism of well controlled platelet carbon nanofibers. 3. International Symposium on Carbon for Catalysis; 2008-11-09 - 2008-11-12

135. **Zhao, Tiejun; Zhu, Jun; Yu, Zhixin; Kvande, Ingvar; Chen, De; Zhou, Xinggui; Yan, Wei-Kang.**
Universal mechanism in catalytic synthesis of carbon nanostructures. 14th International conference on catalysis; 2008-07-13 - 2008-07-18

136. **Zhao, Tiejun; Zhu, Jun; Yu, Zhixin; Kvande, Ingvar; Chen, De; Zhou, Xinggui; Yuan, Wei-Kang.**
Universal Mechanism in Catalytic Synthesis of Bibrous Carbon Nanotructures. 1st Nanotechnology@; 2008-09-11 - 2008-09-12

137. **Zhao, Tiejun; Zhu, Ye; Kvande, Ingvar; Rønning, Magnus; Chen, De.**
Self-supported platelet carbon nanofiber-graphite felt composites. 13 Nordic symposium on catalysis; 2008-10-05 - 2008-10-07

138. **Zhu, Yi-An; Zhou, Xing-Gui; Chen, De; Yuan, Wei-Kang.**
First principles study of CH3 dissociation on Ni (100). 12th APCChE Congress; 2008-08-04 - 2008-08-06

139. **Zhu, Zhengjie; Dorao, Carlos Alberto; Jakobsen, Hugo Atle.**
Modelling of bubble column with bubble number density equation using least-squares method. 6th International Conference on CFD in Oil & Gas, Metallurgical and Process Industries; 2008-06-10 - 2008-06-12

140. **Zhu, Zhengjie; Patruno, Luciano E; Dorao, Carlos Alberto; Lucas, Dirk; Jakobsen, Hugo Atle.**
Simulation of bubble coalescence in bubble column using the least-squares method. 11th International Conference on Multiphase Flow in Industrial Plants; 2008-09-07 - 2008-09-10

CHAPTER 4: EDUCATION

Chemical Engineering

The specialization in Chemical Engineering starts in the third year with the basic technological courses in Separation Technology, Reaction Engineering, Thermodynamics and Process Design. In the fourth year the students elect further specializations for the remaining of the studies. The students choose between 5 specializations: Petrochemistry and Catalysis, Colloid and Polymer Chemistry, Environmental Engineering and Reactor Technology, Process Systems Engineering and Paper and Fibre Technology.

The goal of the education is a Master (MSc) at a high international level in Chemical Engineering.

Students with a bachelor degree in a relevant area from colleges can be admitted to the fourth year of the MSc-degree programme (2 year MSc programme). The degree provides the candidates qualifications for jobs in a wide range of industries, as well as the public sector and in research. It is also the basis for admission to the PhD-studies in Chemical Engineering.

Master courses given in 2008:

Course code	Course title	Credits	Year	Registered	Passed
TKP4100	Fluid Flow and Heat Transfer	7.5	2	79	65
TKP4105	Separation Technology	7.5	3	56	44
TKP4110	Chemical Reaction Engineering	7.5	3	74	55
TKP4115	Surface and Colloid Chemistry	7.5	3	79	68
TKP4120	Process Engineering	7.5	2	129	113
TKP4125	Paper and Fiber Technology	7.5	4	5	4
TKP4130	Polymer Chemistry	7.5	4	17	14
TKP4135	Chemical Process Dynamics and Optimization	7.5	4	6	4
TKP4140	Process Control	7.5	4	35	31
TKP4145	Reactor Technology	7.5	4	10	9
TKP4150	Petrochemistry and Oil Refining	7.5	4	24	22
TKP4155	Reaction Kinetics and Catalysis	7.5	4	47	37
TKP4160	Transport Phenomena	7.5	4	30	23
TKP4165	Process Design	7.5	4	25	22
TKP4170	Process Design, Project (autumn)	7.5	4	24	24
TKP4171	Process Design, Project (spring)	7.5	4	8	8
TKP4175	Thermodynamic Methods	7.5	3	36	25
TKP4510	Catalysis and Petrochemistry, Specialization Project	15	5	7	7
TKP4511	Catalysis and Petrochemistry, Specialization Project	7.5	5	0	0
TKP4515	Catalysis and Petrochemistry, Specialization Course	7.5	5	10	10
TKP4520	Colloid and Polymer Chemistry, Specialization Project	15	5	3	3
TKP4521	Colloid and Polymer Chemistry, Specialization Project	7,5	5	1	1
TKP4515	Colloid and Polymer Chemistry, Specialization Course	7.5	5	4	4
TKP4530	Reactor Technology, Specialization Project	15	5	3	3
TKP4531	Reactor Technology, Specialization Project	7,5		0	0
TKP4535	Reactor Technology, Specialization Course	7,5	5	3	3
TKP4540	Separation and Environmental Technology, Specialization Project	15	5	9	9
TKP4541	Separation and Environmental Technology, Specialization Project	7.5	5	1	1
TKP4545	Separation and Environmental Technology, Specialization Course	7.5	5	14	14
TKP4550	Process Systems Engineering, Specialization Project	15	5	3	3
TKP4551	Process Systems Engineering, Specialization Project	7.5		0	0
TKP4555	Process Systems Engineering, Specialization Course	7.5	5	3	3
TKP4560	Paper and Fibertechnology, Specialization Project	15	5	1	1
TKP4561	Paper and Fibertechnology, Specialization Project	7.5		0	0
TKP4565	Paper and Fibertechnology, Specialization Course	7.5	5	1	1
TKP4850	Experts in Team, Interdisciplinary Project	7.5	4	18	18
TKP4500	Final Year Design, for Spanish students	60	5	3	3
TKP4900	Chemical Process Technology, Master Thesis	30	5	31	31

Master theses 2008 Total 32, 18 female and 14 male

Beinset, Morten
Sorption Enhanced Steam Glycerol Reforming
Supervisor: De Chen

Bekkevold, Jan Petter
Hydrogen sorption enhanced water-gas shift using metals forming hydrides as sorbents
Supervisor: Hilde Venvik

Braathen, Bjarne
Wax deposition in crude oil systems
Supervisor: Johan Sjöblom

Elde, Ingrid Elise
Model studies of inhibition of hydrotreating catalysts
Supervisor: Edd A. Blekkan

Ellingsen, Christian
Safety constraints in an artifical ß-cell: an implementation of Model Predictive Control (MPC) with Insulin-on-Board (IOB)
Supervisor: Sigurd Skogestad

Evensen, Trond
The use of gas hydrates for water purification
Supervisor: Jens-Petter Andreassen

Fagerbekk, Siri Albertsen
New solid acceptors for CO_2 Capture
Supervisor: De Chen

Fahadi, Jalal
Dynamic simulation for improved operation of the Snøhvit CO_2-removal section
Supervisor: Sigurd Skogestad

Fostenes, Siv Monica
The Effect of Scaling Inhibitors on the Precipitation of Calcium Carbonate in Solutions of Ethylene Glykol and Water.
Supervisor: Jens-Petter Andreassen

Frøseth, Fredrik
Partial oxidation of methane over perovskites
Supervisor: Anders Holmen

Fævelen, Erlend Schou
Kinetics of Nucleation and Crystal Growth of Calcium Carbonate in Mixtures of Mono Ethylene Glycol and Water
Supervisor: Jens-Petter Andreassen

Haukebø, Siv Hustad
Production and characerization of selective hollow fiber membranes for CO_2 capture
Supervisor: May-Britt Hägg

Husås, Ranveig
Characterization of asphaltenes and maltenes in feed and product oil samles from a pilot plant for heavy oil upgrading
Supervisor: Edd A. Blekkan

Jøndahl, Mari
Microchannel membrane reactor for production of hydrogen by methanol steam reforming
Supervisor: Hilde J. Venvik

Kleppa, Gøril
Synthesis and Characterization of Nano Structured Alumina Materials
Supervisor: Gisle Øye

Knudsen, Agnethe
Synthesis of nanostructurated monoliths for the Fischer-Tropsch catalyst
Supervisor: Gisle Øye

Kornberg, Anette
Dynamic Simulation and Control of Ethane/Carbon Dioxide Plant
Supervisor: Sigurd Skogestad

Lavalle Jambert, Maria
Testing and analysis of suitable membranes for osmotic power
Supervisor: May-Britt Hägg|

Lie, Marianne
Advanced characterization of particles in produced water
Supervisor: Gisle Øye

Machado Miguens, Carolina Andrea
Methanol Synthesis in Microchannel Reactor
Supervisor: Hilde Venvik

Opedal, Nils van der Tuuk
Synthesis of metallic nano structures
Supervisor: Gisle Øye

Pettersen ,Tone Sejnæs
Synamic mode of offshore processing plant with emphasis on estimating environmental impact
Supervisor: Sigurd Skogestad

Salamanca Parra, Jacobo Manuel
Studies of hydrogen production by catalytic steam reforming of biomass-related compounds
Supervisor: Edd A. Blekkan

Skog, Tom-Gøran
Durability of membrane material when exposed to impurities and higher hydrocarbons in natural gas
Supervisor: May-Britt Hägg

Skogestad, Hanne
Engineering membrane selectivity for CO_2 separation
Supervisor: May-Britt Hägg

Smedsrud, Helge
Dynamic modelling and Control of Brobekk Incineration Plant
Supervisor: Sigurd Skogestad

Spets, Øyvind
Crude oil properties: Relation between viscosity and conductivity
Supervisor: Johan Sjöblom

Tveten, Erik Zakarias
Studies of alumina based cobalt Fischer-Tropsch catalysts
Supervisor: Anders Holmen

Vatneberg, Stine Vemmestad
Scaling of Calcium Carbonate on Metal Surfaces in Mixtures of Mono Ethylene Glycol and Water
Supervisor: Jens-Petter Andreassen

Uwarwema, Theogene
Use of dynamic degrees of freedom for thighter bottleneck control
Supervisor: Sigurd Skogestad

Zhu, Ye
Synthesis of nano crystalline oxides – carbon nanofibers composite
Supervisor: De Chen

Aarhoug, Kristin
Characterization of oil in produced water
Supervisor: Gisle Øye

5rd year students 2008/2009
Total 32, 22 female and 10 male

Aulie, Martin Håkon
Bergstedt, Elin
Biørn, Inger Lise
Bjartnes, Kirsti
Enaasen, Nina
Gran, Håvard Foss
Heskestad, Rita
Holsæter, Hege Christine
Høyen, Ragnhild
Haaversen, Linn Christine Loe
Johansen, Hege Døvle
Jonassen, Øystein
Kalstad, Tone
Catherine Hval Karlsen
Kolås, Kjersti Blytt-Tøsdal
Lin, Yi
Løvold, Ane Dyb
Munkebye, Knut-Arne Rademacher
Mæhle, Inger Roksvåg
Nenningsland, Andreas Lyng
Røsting, Kristine
Sjulstad, Johanne Schjellungen
Solsvik, Jannike
Storsæter, Kathrine
Trehjørningen, Kristin Rem
Tuvnes, Henrik J.
Tørneng, Eirik Fatnes
Vaktdal, Hanne Margrethe
Vattekar, Petter Tangen
Vik, Camilla Berge
Zhang, Xi
Aaserud, Jo

4rd year students 2008/2009
Total 22, 10 female and 12 male

Almeland, Silje Kreken
Eklud, Pål
Helberg, Ragne Marie Lilleby
Helgestad, Dag-Erik
Hesstvedt, Camilla
Hyllestad, Elisabeth Lovise R.
Jacobsen, Julie Berild
Jens, Christian Morten
Jensen, Martin Buus
Lillebø, Andreas Helland
Lunde, Magnus
Munkejord, June
Nergård, Liv-Turid
Ringstad, Renate
Roel, Carl Marius
Roll, Sebastian
Roset, Stine Thysnes
Røed, Anders Haukvik
Skarsgard, Torstein Gaarder
Skjeldestad, Kjetil
Tvedt, Arne Hetland
Østbye, Helene

3rd year students 2008/2009
Total 22, 12 female and 10 male

Barland, Astrid Odland
Berstad, Eivind
Bøhn, Kristian
Evenrud, Vegar
Graff, Vidar
Grimholt, Chriss Tony Robert
Haglund, Ola Kjølberg
Hareide, Henning
Heggvoll, Børge
Helgesen, Anette Hoel
Håseth, Jenny Kristin
Karlsen, Aina Elin
Karlsen, Stine
Kjos-Hanssen, Øyvind Jacob
Krossholm, Charlotte
Kvam, Torunn
Leithe, Anna Elise
Nergaard, Margrethe
Osmani, Kimete
Plünnecke, Katrine S. Biesterfeld
Shadman, Amir
Williams, Rebecca Sian

International master students 2008/2009
Total 9, 3 female and 6 male

Adedeji, Aderonke	Nigeria
Arthur, Theophilus	Ghana
Asif, Naveed	Pakistan
Gao, Bicheng	Kina
Gondal, Shahla	Pakistan
Haider, Shamim	Pakistan
Mba, Emmanuel	Nigeria
Osatiashtiani, Amin	Iran
Widarena, Trimaharika	Indonesia

Student exchange 2008

26 exchange students visited our Department (12 females and 14 males)

Bombardier, Marion	Ecole Nationale Supéure (ENSIACET) France	Reactor Technology Group
Cabonargi, Ander Bengoechea	University of Basque Country, Spain	Separation and Environmental Group
Cos, Francois	IUT A & Lille, France	Colloid- and Polymer Group
Diou, Odile	Ecole Nationale Superieure de Chimie et Physique, France	Colloid- and Polymer Group
Equzkiagirre, Ana Cagligas	Universidad del Pais Vasco, Spain	Separation and Environmental Group
Freeman, Stephanie	The University of Texas, Austin, USA	Reactor Technology Group
Garcia Borreguero, Jaime Hortelano	Universidad Autónoma de Madrid, Spain	Separation and Environmental Group
Gaya, Eva Mir	Universitat Politecnica de Catalunya, Spain	Paper and Fibre Technology Group
Gutierrez, Bartolome Lopez	Universidad de Granada, Spain	Catalysis and Petrochemistry Group
Hacquard, Sebastien	Université Franche-Comté Besancon, France	Colloid- and Polymer Group
Hebben, Nicole	University of Karlsruhe, Germany	Catalysis and Petrochemistry Group
Hoffmann, Martin	Technische Universität, Berlin, Germany	Reactor Technology Group
Ladner, Yoann	Université Franche-Comté Besancon, France	Colloid- and Polymer Group
Lavall Jambert, Maria	Universitat Politechnica de Cataluynya, Spain	Separation and Environmental Group
Leong, Chi Hoong	National University of Singapore, Singapore	Separation and Environmental Group
Mc Dermott, Sinead	National University of Ireland, Maynooth	Separation and Environmental Group
Miguens, Andrea C. M.	Universidad Simón Bolivar, Venezuela	Catalysis and Petrochemistry Group
Perez Aguilera, Luber C.	Simon Bolivar University, Venezuela	Process System Engineering Group
Repka, Martin	Brno University of Technology, Czech Republic	Separation and Environmental Group
Salamanca Parra, Jacobo	University of Valladolid, Spain	Catalysis and Petrochemistry Group
Salas, Jérémie	Université Franche-Comté Besancon, France	Colloid- and Polymer Group
Sauvage, Rémi	IUT A & Lille, France	Colloid- and Polymer Group
Schneider, René	Otto-von-Guericke University, Germany	Process System Engineering Group
Vera Lozada, Rafael	Simon Bolivar University, Venezuela	Catalysis and Petrochemistry Group
Vuillemin, Marlene	INSA, France	
Zscherpe, Tina	University of Karlsruhe, Germany	Catalysis and Petrochemistry Group

13 students from our Department (9 females and 4 males) on exchange

Name	**To Institution**	**Programme**	**Period**
Haaversen, Linn Christine Loe	University of Granada, Spain	Erasmus	15.08.07 – 30.06.08
Helgestad, Dag-Erik	University of Berkley, California, USA	Bilateral	21.08.08 – 21.05.09
Hesstvedt, Camilla	Curtin Univ. of Technology, Perth, Australia	Individ	01.07.08 – 01.07.09
Holsæter, Hege Christine	University of Bath, England	Erasmus	15.08.07 – 30.06.08
Jacobsen, Julie Berild	University of California, Santa Barbara, USA	Individ	22.09.08 – 30.06.09
Johansen, Hege Døvle	Curtin Univ. of Technology, Perth, Australia	Individ	01.01.08 – 30.06.08
Munkejord, June	University of California, Santa Barbara, USA	Individ	01.09.08 – 30.06.09
Skogestad, Hanne	University of Arizona, Tucson, USA	Individ	04.02. 08 – 20.07.08
Tørneng, Erik Fatnes	University of California, Santa Barbara, USA	Individ	01.09.07 – 30.06.08
Tuvnes, Henrik J.	University of California, Santa Barbara, USA	Individ	15.08.07 – 30.06.08
Vaktdal, Hanne Margrethe	Ecole Nationale Supéure (ENSIACET) France	Erasmus	15.08.08 – 30.06.08
Vattekar, Petter Tangen	University of Calgary, Canada	Individ	15.08.07– 30.06.08

PhD in Chemical Engineering

PhD courses given at Department of Chemical Engineering:

Cours code	Course title	Credits	Registered	Passed	Semester
KP8100	Advanced Process Simulation	7.5			
KP8102	Wood Chemistry in Pulping and Paper Making	7.5			
KP8104	Industrial Crystallization and Precipitation	9.0			Fall 08
KP8105	Methematical Modelling and Model Fitting	7.5	1	1	
KP8106	Gas Cleaning with Chemical Solvents	9.0	4	4	Spring 08
KP8107	Advanced Course in Membrane Separation Process	9.0			
KP8108	Advanced Thermodynamics: With applications to Phase and Reaction Equilibria	9.0	1	1	Fall 08
KP8109	Environmental Catalysis	6.0	4	4	Spring 08
KP8110	Membrane Gas Purification	9.0	2	1	Spring 08
KP8112	Applied Heterogeneous Catalysis	6.0	3	2	Spring 08
KP8113	Characterizaton of Heterogeneous Catalysts	6.0	22	22	Fall 08
KP8115	Advanced Process Control	7.5	4	3	Fall 08
KP8117	Paper Physics and Paper Chemistry	9.0	2	1	Spring 08
KP8118	Advanced Reactor Modelling	12.0			
KP8119	Surfactants and Polymers in Aquous Soutions	9.0	9	7	Fall 08
KP8120	Colloid Chemistry and Functional Materials	9.0			
KP8121	Surface, Colloid and Polymer Chemistry, Special Topics	6.0	9	7	Fall 08
KP8123	Colloid Chemistry for Process Industry	9.0	6	6	Spring 08
KP8124	Modelling of Catalytic Reactions	6.0	8	7	Fall 08
KP8125	Design and Preparation of Catalytic Materials	6.0			Fall 08
KP8901	Chemical Process System Engieering	7.5			Fall 08
KP8902	Reactor Technology	7.5			Fall 08
KP8903	Reaction Kinetics and Catalysis	7.5	3	2	Fall 08
KP8904	Transport Phenomena	7.5	1	1	Fall 08

PhD-Thesis 2008
Total 13, 6 female and 7 male

Dudasova, Dorota
Characterization of solid particle suspensions with organic coatings in oilfield produced water.
Supervisor: Johan Sjöblom

Enger, Bjørn Christian
Hydrogen production by catalytic partial oxidation of methane
Supervisor: Anders Holmen

Hammer, Nina
Au-TiO_2 catalysts supported on carbon nanostructures for CO removal reactions
Supervisor: Magnus Rønning

Håkonsen, Silje Fosse
Oxidative dehydrogenation of ethane at short contact times.
Supervisor: Anders Holmen

Jensen, Jørgen Bauck
Optimal Operation of Refrigeration Cycles.
Supervisor: Sigurd Skogestad

Less, Simone
Mechanisms of water-in-crude oil emulsion formation, stabilization and resolution by electrostatic means.
Supervisor: Johan Sjöblom

Lindborg, Håvard
Modeling and Simulations of Reactive Two-Phase Flows in Fluidized Beds.
Supervisor: Hugo A. Jakobsen

Løvfall, Bjørn Tore
Computer Realization of Thermodynamic Models Using Algebraic Objects
Supervisor: Tore Haug-Warberg

Meland, Hilde
Preparation and characterization of Cu- and Pt-based water-gas shift catalysts
Supervisor: Anders Holmen

Shao, Lei
Crosslinking and Stabilization of High Free Volume Polymers for Gas Separations
Supervisor: May-Britt Hägg

Silset, Anne
Emulsions (w/o and o/w) of Heavy Crude Oils. Characterization, Stabilization, Destabilization and Produced Water Quality
Supervisor: Johan Sjöblom

Sivertsen, Heidi
Stabilization of desired flow regimes using active control
Supervisor: Sigurd Skogestad

Vaaler, David
Yield-increasing additives in kraft pulping: Effect on carbohydrate retention, composition and handsheet properties.
Supervisor: Størker Moe

7 PhD exchange students visited our Department in 2008 (1 female and 5 male).

Name	University/Country	Group located
Bimbela, Fernando	Universidad de Zaragoza, Spain	Catalysis Group
den Breejen, Johan	Utrecht University, Belgium	Catalysis Group
Lögdberg, Sara	KTH, Sweden	Catalysis Group
Ousky, Jakub	Slovak University of Technology, Bratislava	Process Systems Engineering Group
Qin, Feng	Tsinghua University, Beijing, China	Reactortechnology Group
Skudas, Romas	Johannes Gutenberg Univ., Mainz, Germany	Catalysis Group
Lualdi, Mateo	KTH, Sweden	Catalysis Group

1 PhD student from our Department visited other Universities in 2008

Name	University/Country	Period
Patanou, Eleni	IRCE, Lyon, France	18.11.08 – 09.12.08

Suplementery education

EVU-course KP6002 Paper Technology, 14.01. – 18.01, and 11. 02. – 15.02.2008. There were 17 participants, those who passed the exam got 6 ECTS. Responsible for the course: Professor Øyvind Gregersen

Seminars and meetings organized by the Department in 2008

Seminars:

KinCat Seminar in Heterogeneous Catalysis:
"Biomass Fed Fischer-Tropsch System"
Dr. Farshild Owrang, Chalmers, Gothenburg, Sweden, 28.03.2008

KinCat Seminar in Heterogeneous Catalysis:
"Carbon only catalysis"
Dr. Dangsheng Su, Fritz Haber Institute of the Max Planck Society, 20.06.2008

KinCat Seminar in Heterogeneous Catalysis:
"Pressure Swing Reforming"
Dr. Frank Hershkowitz, ExxonMobil, Clinton, NJ, USA, 24.09.2008

KinCat Seminar in Heterogeneous Catalysis:
"The Nanoscience Revolution in Catalysis Science"
Professor Gabor A. Somorjai, Department of Chemistry, University of California, Berkeley, USA
06.11.2008

International Seminar: Recent Advances in Fibrillar Nanocellulose Research, 40 participants
Arranged by PFI, SINTEF and NTNU
12. - 13*.11.2008*

Guest lectures:

Ph.D. Stephen A. Bedell, The Dow Chemical Co
"Aqueous Amines as Reactive Solvents for Mercaptan Removal"
22.02.2008

Professor James Rawlings, Department of Chemical Engineering, University of Wisconsin
"Unreachable Setpoints and Economic Optimization in Model Predictive Control (MPC)"
02.04.2008

Professor Rakesh Agrawal, School of Chemical Engineering Purdue University, West Lafayette, IN, USA
"Energy Saving Opportunities in Multicomponent Distillation: Optimum Configuration and Thermal Coupling between Distillation Columns"
15.05.2008

Professor Rolf Findeisen, Max Plank Inst., Magdeburg, Germany
"New approaches for sensitivity analysis and identification in systems biology"
08.10.2008

Dr. Simon Holland, University of the Witwaterrand, Johannesburg, South Africa.
"Reducing CO_2 emmisions for coal to liquid",
24.11.2008

CHAPTER 5: ORGANIZATION - ECONOMY

Organization (also see cover page)

The Head of department is elected for a four-year period (mid 2005 – mid 2009). The scientific staff is divided in to five research groups. In 2008 the former groups Reactor technology and Separation and enviromental technology merged in to The Enviromental engineering and reactor technology group. Each research group has a representative in the management team. The management team has also representatives from the PhD's, the students and technical staff. The management team meets every second week and discusses running matters.

In addition to the scientific staff the department has 16 persons in a technical and administrative staff to support teaching and research of all the research groups.

Administrative responsibilities of faculty

Faculty Educational Committee (Department representatives)	Professor Edd Anders Blekkan, deputy: Associate Professor Jens-Petter Andreassen
Faculty Research Committee (Department representatives)	Professor Hallvard Fjøsne Svendsen, deputy: Professor Hugo Atle Jakobsen
Study Program Chemical Engineering and Biotechnology (Industriell kjemi og bioteknologi) (Department representatives)	Professor Øyvind W. Gregersen
Exchange of Norgwegian students taking courses abroad (approval of course program), and approval of course program for visiting exchange students.	Professor Øyvind W. Gregersen
International Master program	Associate Professor Jens-Petter Andreassen

Department Economy

The department has three main sources of income: regular funds from the University, strategic funding from the University and external projects. In terms of external funds, including contributions from the research Council and industry, the situation is very good. However, a recent change in the NT-faculty budgeting principles resulted that the amounts trasferred between faculty and department level has changed. The department now gets the regular funds according to several distribution formulas, set by the faculty. The gross regular funds from the University were about 33 million NOK in 2008. These funds are mainly used to pay salaries to the permanent staff. The big increase is due to a new pratice of charging ovehead from and to the external projects.
More details are shown in Table 1.

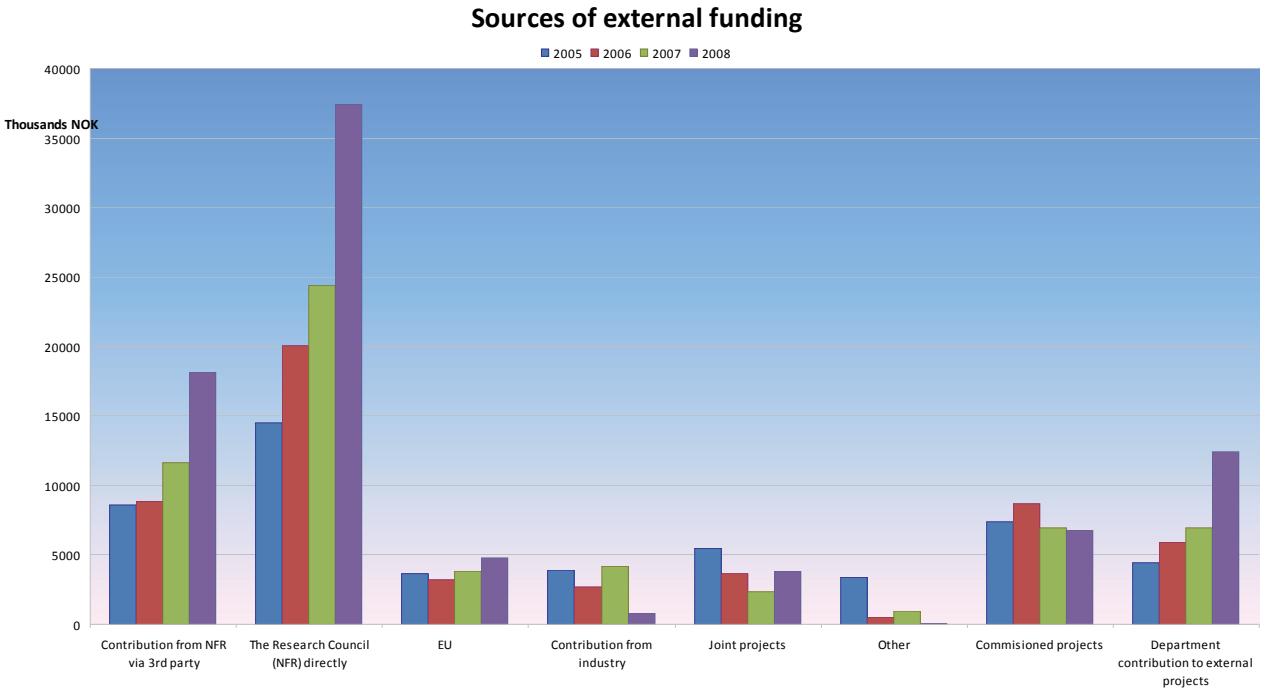
Accounts	2005	2006	2007	2008
Income:				
University funding	22 129 000	24 434 113	26 554 529	33 064 000
Overhead external projects	2 153 815	2 390 000	2 846 260	
Sum income	24 282 815	26 824 113	29 402 796	33 064 000
Expences:				
Wages	19 216 318	22 514 217	21 260 668	21 525 000
Investment			2 546 924	147 000
Operating expenses	3 660 005	3 818 963	3 472 929	2 778 000
NTNU contribution to ext. projects				9 053 000
Sum expenses	22 876 323	26 333 180	27 280 521	33 504 000
Result	1 406 492	490 933	2 120 268	-439 000

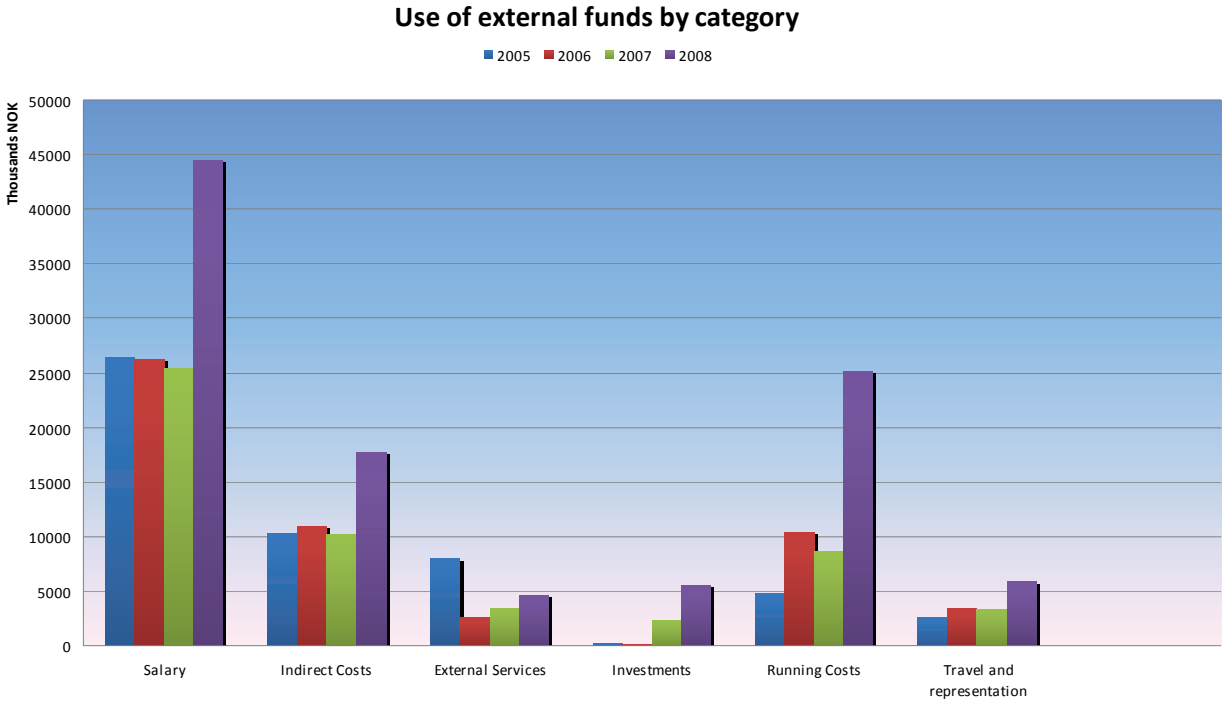
Table 1. Departments income from University and spending.

External funding

In addition to the funding shown in Table 1, the Department has a yearly income from external contributors of approx 72.9 million NOK. Details are shown in Tables 2 and 3. In the end of 2007 and in 2008 we got severalt big projects that have raised the income substatially. Most of the costs are related to salary for PhD candidates. The main contributor to the external research activity is The Norwegian Research Council (NFR). Most of these projects are at the Department, but the second largest external source is NFR projects where we contribute as a third party. Industrial contributions and commissioned research has been growing, but the level of funding has now stabilized. The growth in EU-funding is pleasant, and

is important because of The University focus on EU-funding that gives extra credit from the Ministry. We have several joint industrial programmes with industry partners from countries in Europe, North-America, South America and Asia. External funding from commissioned research was approx 9 % in 2008, and the customers comes from the mentioned areas and Africa.





Strategic funds from University

The third source of income is strategic funding from the University to support research and academic profile. These funds are used for investments in research equipment or PhD or Post doc. positions. In 2008 we did not get any new strategic projects, but concentrated to fill the positions we got the previous year because of the good evaluation we obtained on our application for Center of Excellence where 2 of the applications went to the final round.

Net funding from NTNU

From the numbers in Table 1 it seems like the funding from the University has increased heavily in the last few years. However, the departments contributes overhead on external project to the NT faculty, which

over the same period has increased from 2686 (2005), 3292 (2006), 3633 (2007), 12658 (2008) and 17800 (2009)(all in thousand NOK). The estimated jump by about 9 millions NOK in 2008 from 2007 to 2008 is because of a recent increase in overhead on salaries (from 15 % to 40 %.) Subtracting the overhead to the NT faculty, the net funding from the University to the Department over the last few years is 19443 (2005), 19550 (2006), 21764 (2007), 19582 (2008) and estimated 19577 (2009)(all in thousand NOK).

Some pictures of different activities at the Department

Our buildings, from right: K4, K5, Experimental halls and PFI-building (blue)

Cabinet minister for Energy, Åslaug Haga, visited the CO_2 absorption rig in April 2008. Here with Hallvard Svendsen

From the Department party April 2008

Eleni, Fredrik, Asbjørn, Magne and Marius

Esther Ochoa-Fernandez received the Exxon Mobil prize for best technical PhD thesis at NTNU in 2008

Camilla and Sigurd

Researchers night, September 2008. Arne, Kirsti and Nina

Renate, Li, Siv, Øyvind and Heinz

All students that work in the labs must attend a safety course

LIST OF TELEPHONE NUMBERS (03.04.2009)

94190	Ahmad, Jamil, PhD candidate	PFI-3402
50331	Alsvik, Inger Lise	K5-237
95878	Amiri, Asal, PhD candidate	PFI-3405
94209	Andreassen Jens-Petter, Associate Professor	K5-208
	Aronu, Ugochukwu Edwin, PhD candidate	K1-304
97018	Bakthiary Hamidreza, PhD candidate	K5-M12
50318	Barø Tove, Executive Officer	K5-101
92837	Beck Ralf, PhD candidate	K5-146
94138	Berge, Arvid, Professor Emeritus	K5-M11
94157	Blekkan Edd Anders, Professor	K5-429
90638	Borge, Tone, PhD candidate	K5-225
91664	Borthen Berit, Chief Engineer	PFI-2101
94141	Boullosa Eiras Sara, PhD candidate	K5-411
50326	Bruder, Peter, PhD candidate	K1-213
94144	Brun Harry, Engineer	K5-341
94125	Chao, Zhongxi, PhD candidate	K5-145
93149	Chen De, Professor	K5-407
94163	Ciftja, Arlinda, PhD candidate	K1-123
94159	Dagsgård, Camilla Israelsen	PFI-3407
94312	Dam, Anh Hoang, PhD candidate	Kh-108
93691	Dahl-Olsen Håkon, PhD candidate	K1-326
94125	Dar, Hassan Jamil, PhD candidate	K5-145
	Deng Liyuan, PhD candidate	K1-304
50331	Deshmukh, Kalim, PhD candidate	K5-237
93942	Dones Ivan, PhD candidate	K1-308
94110	Dupuy Pablo, PhD candidate	K5-244
91559	Dwivedi, Deeptanshu, PhD candidate	K1-224
50372	Eide-Haugmo, Ingvild, PhD candidate	K1-214
94120	Erga Olav, Professor Emeritus	K5-237
95878	Fan, Yanru, Post doctor	PFI-3405
50339	Farooq, Umer, PhD candidate	K5-340
92837	Flaten Ellen Marie, PhD candidate	K5-146
94143	Fossum Arne, Engineer	K5-019
94017	Gawel, Bartlomiej, Researcher	K5-336
94017	Gawel, Kamila, Researcher	K5-336
50372	Ghadrdan, Maryam, PhD candidate	K1-214
94158	Glomm Wilhelm R. Associate Professor	K5-336
98354	Gorelkin, Ilya, PhD candidate	K5-M4
94029	Gregersen Øyvind, Professor	PFI-2109
90338	Grimes Brian, Post doctor	K5-339
94108	Haug-Warberg Tore, Associate Professor	K1-314
93145	Hayer Fatemeh, PhD candidate	Kh-106
92839	He Li, PhD candidate	K5-421
94136	He, Xuezhong, PhD candidate	K5-225
94031	Helle Torbjørn, Professor emeritus	PFI-2109
50304	Helmersen Tom, Office Manager	K5-101
94113	Hertzberg Terje, Professor Emeritus	K1-223
50327	Hessen Erik Troøien, PhD candidate	K1-222
94122	Hillestad Magne, Professor	K5-213
94151	Holmen Anders, Professor	K5-401
94026	Hovin Odd Ivar, Engineer	Kh-155
50540	Håkonsen Signe, Senior Engineer	PFI3404
51128	Huang, Fan, PhD candidate	K5-443
94033	Hägg May-Britt, Professor	K5-204
91673	Iotti, Marco, Post doctor	PFI-3204
50537	Janga, Kando Kalifa, PhD candidate	PFI-3207
50327	Jacobsen, Magnus Glosli, PhD candidate	K1-222
94132	Jakobsen Hugo Atle, Professor	K5-209
93691	Jäschke, Johannes, PhD candidate	K1-326
50372	Karimi, Mehdi, PhD candidate	K1-214
50331	Karlsen, Cathrine Hval, Seniro Engineer	K5-237
94145	Kazi, Saima Sultana, PhD candidate	K5-443
94149	Keleşoğlu, Serkan, PhD candidate	K5-308
93138	Kim Taek-Joong, Researcher	K5-251
50325	Knudsen, Agnethe, PhD candidate	K5-333
91605	Králová, Iva, Chief Engineer	PFI-3403
	Lapaumier, Helene, Post doctor	K1-123
50540	Lesaint Caterina, Senior Engineer	PFI-3404
94105	Lesaint Cédric, Post doctor	K5-324
94114	Lie Jon Arvid, Post doctor	K5-247
50346	Linhart Andreas, PhD candidate	K1-212
	Luo, Xiao, PhD candidate	K1-304
94120	Malthe-Sørenssen Dick, Adjunct Professor	K5-238
93691	Manum Henrik, PhD candidate	K1-326
95498	Marchetti, Jorge Mario, Post doctor	K5-156
94153	Mathisen Torgrim, Higher Executive Officer	K5-101c
94073	Mihai, Oana, PhD candidate	K5-M6
94018	Mingot, Andrea, Senior Engineer	K1-309
94032	Moe Størker, Associate Professor	PFI-2108
94147	Moljord, Kjell, Adjunct Professor	K5-M11
94193	Muthuswamy, Navaneethan, PhD candidate	Kh-250
94148	Mørk Preben C., Professor	K5-M11
94022	Nayak, Ameeya Kumar, Post doctor	K5-156
94112	Nilsen Tom-Nils, Senior Researcher	K1-310
50325	Nordgård, Erland, PhD candidate	K5-306
94111	Noor, Tayyaba, PhD candidate	Kh-251
50924	Opedal, Nils van der Tuuk, PhD candidate	PFI-3408
91559	Panahi, Mehdi, PhD candidate	K1-224
94111	Patanou, Eleni, PhD candidate	Kh-251
93147	Paso Kristofer, Post doctor	K5-304
95879	Patruno Luciano, PhD candidate	K5-245
50397	Paunonen, Sara, PhD candidate	PFI-3103
94208	Phan, Xuyen Kim, PhD candidate	K5-M12
92807	Preisig Heinz A, Professor	K1-312
98354	Radstake, Paul, PhD candidate	K5-M4
50327	Rafiee, Ahmad, PhD candidate	K1-222
94156	Rane, Shreyas P., PhD candidate	Kh-105
91686	Rodionova, Galina, PhD candidate	PFI-3209
94139	Roel Jan Morten, Engineer	Kh-155
94150	Roel Lisbeth H B, Executive Officer	K5-101
94125	Rout, Kumar Ranjan, PhD candidate	K5-145
50536	Rusu, Marius, PhD candidate	PFI-3206
94147	Rytter Erling, Adjunct Professor	K5-M11
94121	Rønning Magnus, Associate Professor	K5-408
50318	Samseth, Jon, Adjunct Professor	K4-312
96646	Sandvik, Gerd, Executive Officer	K5-101c
93942	Sandru Marius, PhD candidate	K1-308
94073	Setekleiv Eddie, PhD candidate	K5-M6
50338	Shamsuzzoha, Mohammad, Post doctor	K1-323
91657	Simon, Sebastien, Post doctor	PFI-3406
95505	Sjöblom Johan, Professor	K5-344
93942	Skancke, Jørgen, PhD candidate	K1-308
93138	Skog, Tom-Gøran, PhD candidate	K5-251
94124	Skjøndal-Bar, Nadav, Associate Professor	K1-313
94154	Skogestad Sigurd, Professor	K1-322
94114	Sporleder, Federico, PhD candidate	K5-247
	Strandberg, Jens Petter, PhD candidate	K1-304
94106	Sundseth Frode, Engineer	K5-033
94187	Surma, Miroslav, PhD candidate	K5-M9
94100	Svendsen Hallvard, Professor	K1-301
50540	Sætran, May Grete, Senior Engineer	PFI3404
91668	Tanase, Mihaela, PhD candidate	PFI-3205
50346	Tellefsen, Silje Kufaas, PhD candidate	K1-212
94119	Thorsen Gunnar, Professor Emeritus	K5-M8
	Trollebø, Anastasia, PhD candidate	K1-304
50322	Tronstad, Ingvild, PhD candidate	Kh-109
94146	Tsakoumis, Nikolaos, PhD candidate	Kh-107
94136	Uddin, Mohammad, PhD candidate	K5-225
94182	Vanhaecke, Estelle, Post doctor	K5-430
90638	Veiga, Adrian Maroni, PhD candidate	K5-225
92831	Venvik Hilde, Associate Professor	K5-406
50346	Vevelstad, Solrun, PhD candidate	K1-212
94149	Volden Sondre, Post doctor	K5-308
94189	Voronov, Alexey, PhD candidate	Kh-104
50331	Votrubec, Martin, PhD candidate	K5-237
94193	Wang, Hongmin, Post doctor	K h-250
50372	Wang, Yuefa, Post doctor	K5-156
94078	Wangen, Espen, Post doctor	K5-432

50536	Xhanari, Klodian, PhD candidate	PFI-3206	94073	Zárubová, Šárka, PhD candidate	K5-M6
50537	Yamakawa, Asuka, Researcher	PFI-3207	94155	Zhao Tiejun, Post doctor	K5-432
93146	Yang, Jia, PhD candidate	K5-411	95879	Zhu Zhengjie, PhD candidate	K5-245
50326	Yelchuru, Ramprasad, PhD candidate	K1-213	94018	Øye Asbjørn, Chief Engineer	K1-309
94136	Yu, Qiang, Post doctor	K5-225	94135	Øye Gisle, Associate Professor	K5-307
50326	Zakeri, Ali, PhD candidate	K1-213			

Annual Report for Department of Chemical Engineering, NTNU

NTNU
Innovation and Creativity

NTNU – Innovation and Creativity
The Norwegian University of Science and Technology (NTNU) in Trondheim represents academic eminence in technology and the natural sciences as well as in other academic disciplines ranging from the social sciences, the arts, medicine, architecture to fine arts. Cross-disciplinary cooperation results in ideas no one else has thought of, and creative solutions that change our daily lives.

Address, contact information
Department of Chemical Engineering, NTNU
N-7491 Trondheim
NORWAY

E-mail: postmottak@chemeng.ntnu.no
Phone: (+47) 73594030

www.ntnu.no/kjempros