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The State of the Department of Chemistry 2007

Paradoxically these are turbulent times for university funding despite a booming national economy. Yet again cut-backs have had a deleterious effect on the Department’s finances in 2007 with no respite being likely next year. A comparison between us and Chemistry at the University of Bergen is not to our advantage; although the departments are of similar size the latter receives a 20% larger grant.

The process of restructuring the scientific profile of the Department that was initiated in 2006 was carried over to 2007 by our Strategy Seminar at Jægtvolden. The process took into consideration the vision of the University Governing Board that NTNU will be the highest ranked Norwegian university and amongst the ten best in Europe within 2020. The question was raised: is this commendable goal actually achievable for a university operating in an increasingly restrictive economic climate? Under the current situation this ambition is simply not commensurate with current economics and indeed creates considerable irritation amongst the staff.

Cutbacks

Of course although our response to the economic realities must be to cut back on costs we are doing our utmost to maximise support to research. In this regard we are particularly cognisant of our commitments to our PhD students. Therefore, economic necessity led to seven courses being cancelled over the past few years. An important factor is to achieve an overall 50:50 split between teaching load and research. In particularly, cost-cutting has impacted negatively on the implementation of the Government’s Quality Reform in Higher Education – but then, sufficient funds supporting this have not been forthcoming. We have also implemented measures to stimulate those activities that generate external income whilst balancing this against the requirement that the Department carries out quality basic research. The effects of such initiatives take time before they bear fruit.

Figure: Everything is being done to maximise the Departments activities.
Opportunities and production
Nevertheless, the past year has also been one of opportunities and we have published 65 papers in international journals. Other activities include:

• Working with StatoilHydro on an ambitious project that includes a Canadian university. The subject of the project is connected to the company’s shale oil interests.

• An International Masters Degree course involving StatoilHydro, SINTEF and others with the focus being environmental chemistry of polar regions.

• Secondment of Professor Signe Kjelstrup to the Centre of Advanced Studies in Oslo as Head of the Chemical Process Design Group

• Started organising The Nordic Synchrotron Radiation Initiative Kick-off Meeting to be held at Jægtvolden Fjord Hotel in April 2008.

• The Department has a proactive approach to recruiting women. We have an initiative in place for identifying and encouraging external female applicants to apply for vacant academic positions.

• A project financed by the 7th Framework Programme of the European Union, DeCarbit. This is a collaboration between Air Liquid France, SINTEF, the Department of Chemistry and ten other partners throughout Europe.

• Forum for Research Collaboration between the Faculty’s departments.

• Action Plan from the Jægtvolden Stategy Seminar

• The number of student applicants to the BSc programme was reduced from 40 to 30 in order to focus on the better qualified students.

• The Department produced 19 MSc and 7 PhDs.

• Three promising areas for innovation were carried over from the previous year. NTNU’s Technology Transfer Office (TTO) is integral to this process.

Strategic Plan - Implementation
Appointing new members of the academic staff is the most strategic long-term implementation of the Strategic Plan. An important question concerning the level of staffing is: What should the size of the Department be? The overriding factor that defines this is teaching. Positions falling vacant are subjected to critical review and, since teaching is research-based and we aim for a 1:1 teaching:research ratio, it is the teaching load borne by the Department as a whole that dimensions the Department. However, economic realities force us to balance this against the fact that over 90% of the Department’s grant from NTNU is already consumed by salaries. For this reason, the Department has not (yet) been fully compensated for the shortfall as staff retire. Nevertheless, in 2007 we did appoint three new associate professors: Annette Lykkenes, Chemical Education; Morten Bjørgen, Physical Chemistry and Nebojsa Simic, Organic Chemistry.

There are currently eight women amongst the 30 academic staff and two female Emeritus Professors.

We congratulate two of our female staff (Lise Kvittingen and Vassilia Partali) on their promotions to full professor.

As always, the Head’s job is made easier by dedicated staff and collaborative colleagues, and I am grateful to all those who have assisted me.

David G. Nicholson
Head of Department
The PryJector: A device to make the invisible visible

In many situations there is an interest in knowing the spatial distributions of compounds and properties. Typical example applications can be found in the medical, forensic and military fields. For example, locating the presence of blood on surfaces in crime scene analyses or the detection of explosive residues in anti-terrorism work.

The most effective way to extract chemical information from a surface without using wet-chemical analyses, is to employ spectroscopy. Of particular interest is the use of vibrational spectroscopies such as Raman, near and mid-infrared although UV and X-ray spectroscopies are also possible. Light interacts with matter to generate chemical (and physical) signals that contain information. It is often the case that extracting this information is so complex that advanced data analytical techniques are necessary. Various methods for this task are available within the field of chemometrics. These perform by a process of “unmixing” from which the concentrations and spectral profiles of individual mixed components can be inferred. In most realistic situations this is necessary because mixtures cannot be assumed to contain a single wavelength selectivity for the compounds of interest.

So how can spectroscopy be applied to whole surfaces? The answer is to combine imaging and spectroscopy into one single instrument – a so-called hyperspectral camera. This is a technology which originates from the field of remote sensing and is increasingly being applied to many other areas such as medicine, the food industry and specific areas of chemistry.

The result from a hyperspectral camera is a stack of grey scale images, one for each wavelength. This “hypercube” of data can then be analysed with e.g. chemometric methods to extract the chemical information that is contained in each pixel. The result is a chemical image which looks like an ordinary image except that the intensity of every pixel is related to e.g. the concentration or presence (absence) of a particular chemical compound (or property). Consequently, the chemical image identifies locations in the original scene where the chemical information of interest is present.

The PryJector device is basically a modified hyperspectral camera with an image projector. The projector may be an ordinary colour computer projector or a laser. The PryJector takes the chemical image and projects it back onto the surface which was analysed. This means the PryJector makes the chemical information available in situ which is an advantage in situations where inspection of the results on a computer monitor is not optimal. Two applications are given to illustrate this:

- **Surgery.** The surgeon is in need of information about the chemical and biological state of tissue surfaces. Averting his eyes to a monitor is possible, however current modern operating theatres are already close to overloading medical staff with information. In addition, when several surgeons and nurses need to rapidly access the same information obtained from a hyperspectral instrument, the use of ordinary computer monitors can be a hindrance.

- **Crime scene investigation.** Forensic experts inspecting a crime scene need to access a wide range of chemical compounds and biological material on complex surfaces. Manual inspection is important and the use of a portable computer monitor is impractical in many situations. If the processed results from a hyperspectral camera are available as projected false coloured spots on surfaces, it will facilitate the process of localising potentially useful evidence material.

A patent application for the PryJector has been submitted via our Technology Transfer Office (TTO) at NTNU. However, projection is not the only part of the invention. There is also described a solution which enables the hyperspectral camera to process chemical images almost in real time. The reason for this is that in order for the PryJector to be useful in field work where the scene under study is changing rapidly, the current slow hyperspectral technology cannot be used. The invention therefore includes a proposal for speeding up the process by connecting the prediction of chemical images together with the scanning process. This means that the very large “hypercube” is never stored, something which will reduce scanning time significantly.

Bjørn K. Alsberg
Cage hydrocarbons. The molecular structure of tricyclo[3.3.2.02,8]decane (Hexahydrobullvalene; 3b) – A Gas-Phase Electron Diffraction (GED) Study

In relation to unbridged tertiary carbocations, bridgehead carbenium ions in bicyclic and higher oligocyclic systems are generally destabilised, since a severely increasing angle strain prevents them from adopting the preferred trigonal planar configuration. As has been demonstrated earlier, the bridgehead cations with a bicyclo[2.2.2]octyl and a tricyclo[3.3.2.02,8]decyl (hexahydrobullvalenyl) skeleton are stabilised significantly, when three cyclopropyl groups are annelated across the two-carbon bridges adjacent to the bridgehead carbenium ion centre. In absolute terms, the solvolysis rate of the bridgehead chloride of trishomobullvalene 4b is 3070 times as high as that of 1-chlorotris-homo-barrelene 2b. Yet the rate due to the three \( \alpha \)-cyclopropyl groups in 1-chlorotris-homobullvalene 4b relative to 5-chlorotricyclo[3.3.2.02,8]decane (3b) is only enhanced by a factor of 3.9x10\(^6\), whereas the rate ratio is 2.8x10\(^8\) for 1-chloro-bicyclo[2.2.2]octane (1b).

This difference in the rate ratios correlates very well with the difference in the torsional angles between the planes of the \( \alpha \)-cyclopropyl groups and the axes of the empty bridgehead orbitals in the cationic intermediates, and the absolute difference in solvolysis rates of 4b and 2b relates to the flattened bridgehead in the skeleton 4a. Such a flattening along with a greater flexibility should also be observed for the inner skeleton of 4a, the hexahydrobullvalene 3a. In order to rigorously prove this hypothesis, we tried to determine the bridgehead bond angles in tetrahydrobullvalene, 3a, by X-ray crystallography and by gas-phase electron diffraction.

References:

Marit Trætteberg

Attempted crystal structure determinations failed, probably because the 3a molecules have a nearly spherical shape and form plastic phases in which the molecules are orientationally disordered, thus a gas-phase electron diffraction study is the method of choice for determining the structural parameters of 3a.

The molecular structure of tricyclo[3.3.2.02,8]-decane (hexahydrobullvalene) has been determined experimentally by gas-phase electron diffraction as well as by quantum chemical calculations. The bond lengths in the skeleton 1.496(7) in the cyclopropane ring, 1.527(10) adjacent to it, 1.550(22) \( \AA \) for the bonds originating from the singular bridgehead all can be explained in terms of the features of this cage hydrocarbon. All three C,C,C-valence angles [113.0(8)° at the singular bridgehead, 112.8(12)° adjacent to it and 122.3(20)° adjacent to the skeletal cyclopropane ring] are larger than the regular tetrahedral angle on an sp\(^3\)-hybridized carbon atom. The two-carbon bridges between the skeletal cyclopropane ring and the opposite bridgehead are twisted with a dihedral angle of 43°, i.e. significantly smaller than the 60° in n-butane in its synclinal (gauche) conformation.

At first glance it may appear puzzling that the cyclopropyl C-C bond in 3a (1.496 Å) is found to be somewhat shorter than in cyclopropane itself (1.542 Å) \[5\] and in trishomobullvalene (4a) (1.542 Å) \[4\]. On second thoughts, however, the difference in this bond length for 3a on one side and bullvalene as well as 4a on the other can be rationalised as being a consequence of the larger bonding angles of 126.3° and 123.8° on the ethylene and cyclopropane bridges, respectively, in the latter two cage hydrocarbons, which must exert a stretching effect on the bonds in the skeletal three-membered ring.

References:

Making gasoline from coal or natural gas: Hints to rational catalyst design from fundamental mechanistic insights

Methanol to hydrocarbons - MTH
The current high oil prices have sparked interests in technologies that utilize natural gas, coal or even biomass rather than liquid petroleum for production of transportation fuels and raw materials for the petrochemical industry.

Methanol, which may be manufactured from any gasifiable carbonaceous material constitutes a convenient intermediate in this respect, because it can be converted into gasoline and polymer grade alkenes over solid acidic catalysts.

The breakthrough in MTH chemistry came by the pioneering work in the seventies by researchers at Mobil who (accidentally!) discovered that methanol is converted with high efficiency into gasoline over their new zeolite ZSM-5. Later, processes designed for gasoline- and alkene production from methanol have been demonstrated on pilot- and industrial scale.

The MTH catalyst: Zeolites
The MTH reaction is zeolite facilitated. Zeolites are naturally occuring, highly porous crystalline aluminosilicates with sharply defined channels and pores of molecular dimensions (Figure1).

Zeolite frameworks are overall anionic, and charge compensating protons are located in the nano pores to maintain overall electrical neutrality. Thus, protonated zeolites are solid Brønsted acids, and their acidic strength is in line with that of 80 % sulfuric acid. The importance of zeolites in chemical industries can hardly be overestimated and in the petroleum refining industry, catalytic cracking is by far the largest application, followed by hydrocracking.

How can possibly two or more methanol molecules combine and form alkenes by the aid of a zeolite?
Despite of more than 20 mechanism proposals, the answer to this question is most likely that they can't. So far, no studies have evidenced that methanol molecules can be coupled directly into hydrocarbons at rates significant for the steady state operating catalyst. An indirect reaction route, known as "the hydrocarbon pool mechanism", was conceptually introduced in the early 1990s and has gradually been generally accepted. The hydrocarbon pool can be described as a catalytic scaffold, constituted by larger organic molecules (adsorbed in the working zeolite) to which methanol is added, and alkenes are eliminated from in a closed catalytic cycle. The hydrocarbon pool species identified up to now have been hexamethylbenzene (or its protonated counterpart) and the heptamethylbenzenium cation. Both these species are able to split off light alkenes under formation of the corresponding lower polymethylbenzene homologue. The lower polymethylbenzene is then methylated by methanol repeatedly until the higher active species has been formed and the catalytic cycle has been closed.

The specifics of the MTH reaction mechanism over zeolite H-ZSM-5.
Quite early in our research on H-ZSM-5, the experiments showed that the previously suggested hydrocarbon pool mechanism could not be valid for this catalyst. Hexamethylbenzene were certainly present in copious amounts in H-ZSM-5 during the MTH reaction, but in stark contrast to all previous conclusions, hexamethylbenzene turned out to be virtually inert when confined in the ZSM-5 channels. As a direct implication of this, a hydrocarbon pool mechanism involving hexamethylbenzene, proven to be all dominating for other zeolites, cannot be applicable for H-ZSM-5. Rather, we found that...
ethene is formed exclusively from the trimethylbenzenes whereas propene and higher alkenes are mainly formed from an additional cycle involving alkene methylations and – interconversions. These two statements, implying that the ethene formation is mechanistically separated from the formation of propene and higher alkenes, are of utmost importance for understanding and possibly controlling the ethene/propene selectivity in MTH catalysis. Our findings lead to an interesting question both regarding mechanistic understanding and selectivity control: Do the cycle for ethene formation run completely independently of the cycle for higher alkene formation? We believe that this is not the case, as the higher alkenes continuously form new aromatic species. On the contrary, the cycle for ethene formation is probably not required for the higher alkene cycle to run. So in conclusion, if it is possible to completely separate the two cycles by sterically suppressing the formation of the larger aromatics, formation of the undesired ethene might be avoided in an industrial methanol-to-propene (MTP) application.

References:

This is a PhD program in structural physical chemistry, and a part of the “Storforsk” project entitled “Transport on a nanoscale; at surfaces and contact lines in PEM fuel cells” led by Signe Kjelstrup with Astrid Lund Ramstad as PhD supervisor. The project includes theoretical and experimental work. In this PhD program we focus on the diffusion of hydrogen in the carbon material that is used in the PEM fuel cell.

Our first neutron experiment
In this work, we are studying the interactions between the surface of Vulcan XC-72R, an amorphous carbon and the hydrogen molecules that pass through the graphite matrix. The aim is to find the diffusion coefficient of hydrogen molecules on the surface of this material. This is fundamental to understanding the PEM fuel cell, and the transport phenomena of reactants to the catalyst particles.

In November 2006 we performed our first quasi-elastic neutron scattering experiment by using the Time-of-flight (TOF) spectrometer IN5 at the Institute Laue-Langevin (ILL) in Grenoble. The TOF spectrometer measures the velocity of neutrons before and after interaction with our carbon and hydrogen sample, thereby providing information on the exchange of energy and momentum between atoms and neutrons. In turn, this gives information about the different types of energy barriers that the atoms inside the samples must overcome, and how they are moving. Neutron spectrometry was chosen to investigate hydrogen diffusion because the characteristics of hydrogen in a neutron beam make it easy to detect and observe. Also this method has been used before to find hydrogen diffusion coefficients in different systems [1], [2]. The measurements were conducted at temperatures ranging from 2 K to 275 K at a pressure of 0.5 bars at 298 K, corresponding to a monolayer of H2 on our sample volume at 2 - 70K. The reason for measuring over such a large temperature range was to construct an Arrhenius plot which could be extrapolated up to realistic PEM fuel cell operating temperatures [3].

Results from the experiment
From the experiment we could indeed find diffusion coefficients on the surface of the carbon as well as other properties of the dynamics of the system. Fig. 1 shows how the experimental data fit the model of Chudley and Elliot, from 40, 50, 60 and 70 Kelvin for Q values up to 1.0 Å⁻¹.

This figure shows the variation of the inverse of the measured HWHM as a function of Q⁻². The values of the diffusion coefficients, D, the residence times, τ₀, and jump lengths, l₀, are presented in Table 1. The HWHM increases with increasing Q. The self diffusion coefficients found for 40, 50, 60 and 70 Kelvin are plotted in an Arrhenius plot in Fig. 2. From the slope of the Arrhenius plot in Fig. 2 the D₀ and E/kB coefficients was found to be, D₀=1.9•10⁻⁷ ± 0.2•10⁻⁷ m²s⁻¹and
E/k = 112 ± 5 K (1030 ± 50 Jmol⁻¹). Comparing with liquid hydrogen which have the Arrhenius coefficients D₀ = 8.58 ± 5.8 · 10⁻⁸ m²s⁻¹ and E/kB = 44.8 ± 1.6 K (372.5 ± 13.3 Jmol⁻¹) [4]. Using these Arrhenius coefficients to estimate the change in the self diffusion coefficient at higher temperatures, we found a self diffusion coefficient of 1.4·10⁻⁷ m²s⁻¹ at 398 Kelvin, a typical fuel cell temperature. In Fig. 4 the values of the natural logarithm of the surface diffusion coefficient, from this work together with the data from Bienfait et al. and Narehood et al. [5, 1], is plotted versus the inverse of the temperature are plotted.

Table 1: Parameters obtained from the fit of the Chudley and Elliot model to the experimental data at 40, 50, 60 and 70 Kelvin.

<table>
<thead>
<tr>
<th>T /K</th>
<th>τ₀ /10⁻¹² s</th>
<th>Error /10⁻¹² s</th>
<th>D /10⁻⁸ m²/s</th>
<th>Error /10⁻⁸ m²/s</th>
<th>l₀ /10⁻¹⁰ m</th>
<th>Error /10⁻¹⁰ m</th>
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</thead>
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<tr>
<td>40</td>
<td>1.5 ± 0.21</td>
<td>±0.21</td>
<td>1.1 ± 0.13</td>
<td>±0.13</td>
<td>1.3 ± 0.11</td>
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<tr>
<td>50</td>
<td>1.2 ± 0.13</td>
<td>±0.13</td>
<td>2.1 ± 0.25</td>
<td>±0.25</td>
<td>1.6 ± 0.10</td>
<td>±0.10</td>
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<tr>
<td>60</td>
<td>1.0 ± 0.13</td>
<td>±0.13</td>
<td>3.0 ± 0.51</td>
<td>±0.51</td>
<td>1.7 ± 0.19</td>
<td>±0.19</td>
</tr>
<tr>
<td>70</td>
<td>0.9 ± 0.11</td>
<td>±0.11</td>
<td>3.7 ± 0.65</td>
<td>±0.65</td>
<td>1.8 ± 0.21</td>
<td>±0.21</td>
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Chemists are inspired by nature

Professor Signe Kjelstrup is on a quest to find inspiration for new, more energy-efficient chemical processes by studying nature. She need not look far, e.g. the human body is an impressive chemicals factory which engages in processes from which we can learn a great deal.

Professor Signe Kjelstrup has studied energy conversion in natural and industrial systems for more than 20 years, and she has collected an imposing list of merits. She has, for example, headed the theoretical computation of a design for a distillation column that is 40 per cent more energy efficient than those currently used in the petroleum industry. The principle is shown in Fig. 1. No less than 10 per cent of the USA's energy consumption goes to separating crude oil to produce fuel for cars in the US. Obviously, then, a more efficient distillation column could save huge amounts of energy and have an impact on the global climate.

For the moment, the new distillation column exists on paper only, but several foreign research groups have indicated their interest in the technology. The University of Delft in the Netherlands has appointed Kjelstrup to a professorship at the Centre for Sustainable Development. Moreover, the French industrial enterprise Air Liquide is interested in her technology and was recently granted funding through an EU project which aims to use the technology to develop a better process for air separation.

![Fig.1. The conventional adiabatic distillation column (left) is much less energy efficient than the diabatic distillation column with distributed heating (right).](image)

Basic research and innovation

Kjelstrup's group will be working with innovation at the Centre for Advanced Study 2007-2008 from a platform based on the natural sciences. "We want to understand natural chemical processes better, and we believe that physics and mathematics will help us improve our descriptions of these processes. This may later lead to better models for energy optimal technical design. Otherwise, innovation is something that must take place in continuous interaction between scientists and users", points out Kjelstrup.

Professor Kjelstrup is especially interested in making theoretical descriptions of chemical processes, and the new distillation column is the result of a prolonged study of the processes at play when molecules in a liquid change and become a gas. The work was supported by the Research Council of Norway's Storforsk programme (Large-scale researcher-initiated projects), which was established to fund large-scale independent basic research projects entailing high risk and scientific boldness.

The development of the distillation columns has now progressed past the stage of basic research, and Kjelstrup is looking for new challenges. She has found one such challenge in the human body, which converts several kilos of chemical reagents to keep us going every single day.

A molecular pump

"Cellular respiration in the human body and other organisms is a chemical reaction that takes place inside the cells. It involves converting glucose and oxygen to carbon dioxide, water and energy. The energy from this reaction is initially stored in a molecule called ATP (adenosine triphosphate). Synthesis takes place in the body's power plant, the mitochondria. The ATP molecule can, in fact, be part of a new chemical reaction that releases a high-energy phosphate ion, and this energy can then be used to run the different processes in the body's machinery. Just look, I'm lifting my arm, meaning I used a lot of ATP", continues Kjelstrup.

Kjelstrup and her colleagues have constructed a mathematical model of a large enzyme that uses the ATP molecule for an energy-intensive process. The enzyme is complex and weighs roughly the equivalent of 110 000 hydrogen atoms. "Ca-ATPase, as the enzyme is called, is quite simply a sort of molecular pump, in the sense that it pumps calcium ions up to higher energy levels. We are trying to understand this pump, which consists of a single molecule and is capable of transforming chemical energy for the transportation of ions. This is a highly efficient chemical process. If we can understand it better, we may possibly be able to use the knowledge to develop other effective chemical processes at the nano level", postulates Kjelstrup.

A better understanding of the Ca-ATPase molecule could give us new insight into obesity, a growing problem in many affluent countries. "Obesity and overweight are associated with the body's ability to regulate heat and work, and there is a good chance that it is calcium pumps that regulate those functions. We believe that Ca-ATPase is a heat pump in addition to being an ion pump", suggests Kjelstrup.
A brain heater
Ca-ATPase is found not only in the human body, but also in the vast majority of living organisms, including animals and bacteria. Professor Kjelstrup's co-workers have found an especially interesting application of Ca-ATPase in the brain of swordfish, which often dive down to great depths in waters down to temperatures of 4 °C to hunt for prey. The swordfish brain would have functioned poorly at such low temperatures, had it not contained a sort of electrical heater that turns on automatically when the fish dives down into the briny deep. Humans and many other animals can stay warm by increasing muscular activity, for example, by flailing their arms or shivering. Swordfish, on the other hand, gear up their brain metabolism.

Professor Kjelstrup is heading the research group Chemical process design inspired by nature at the Centre for Advanced Study in 2007-2008. The group will spend the autumn semester concentrating on gaining a better understanding of ion pumps, especially Ca-ATPase. "We believe we can use that knowledge to design better chemical processes in general. During the spring semester, we'll take a closer look at the reaction between hydrogen and oxygen in fuel cells. The common denominator between the ATP project and the fuel cell project is that we need to develop a better understanding of the processes and a thermodynamic description at the nano level", adds Kjelstrup.

Mathematics is the language of nature, and Professor Kjelstrup uses mathematical modelling as an important tool. The mathematical computations for modelling are sometimes heavy-going. It helps that the CAS group has access to computing resources at Riken research institute in Japan, Imperial College in England and the Spanish supercomputer system Mare Nostrum in Barcelona.

Kjelstrup's computer contains a model of Ca-ATPase that shows how the 'pump' vibrates before abruptly spitting out a high-energy calcium ion from the one end. Vibrations occur at the pico-second level, i.e. vibrations take about 0.000000000001 second. But the calcium transport takes milliseconds. It is a great problem to link these scales.

"It is fantastic to get be at CAS for a whole year. We will have a unique opportunity to delve deeply into details. During the course of this year, I hope that we will manage to develop some methods that we can use for research in the decades ahead", reports Kjelstrup.
Variation of polarizability in the \([4n + 2]\) annulene series: from \([22]-\) to \([66]-\)annulene

Using correlated ab initio methods, the polarizability of large \([4n + 2]\)-annulenes is determined, showing that there exists an almost linear relation between the exaltation of magnetic susceptibility (a measure of aromaticity) and an equivalent enlargement of polarizability.

Introduction

According to the pioneering definition by Sondheimer,\(^1\) annulenes are fully conjugated hydrocarbon monocycles. Benzene, \([6]\)-annulene, in addition to being the most prominent aromatic molecule, is the smallest representative of the neutral \([4n + 2]\) series, while cyclobutadiene represents the absolute smallest annulene. Like benzene, annulenes have been extensively used as model systems to study aromaticity. In fact, the last decades have seen a renewed interest in this kind of compounds, partly motivated by a number of synthetic findings. Moreover, \([4n + 2]\)-annulenes may serve as prototypes of one-dimensional metals\(^2\) and some annulenes show very interesting properties from a nanotechnological perspective.\(^3\) For instance, Pak et al. have reported a series of site-specific electron-donor and/or acceptor-functionalized \([18]\)-annulenes,\(^4\) some of them presenting nonlinear optical properties.\(^5\)

In addition, dehydrobenzo\([20]\)annulenes can form ordered onion- and tube-type nanostructures.\(^6\) For some recent review on the chemistry of annulenes, see the paper by Haley and coworkers.\(^7\) All these findings make research in this kind of systems very interesting. In this context, theoretical methods provide a cheap way of predicting such properties, including molecules of higher molecular weight. Among these properties, polarizability has an essential function in a variety of physical and chemical processes. In this work, we report an ab initio study of static and dynamic polarizabilities of \([4n + 2]\)-annulenes for \(n = 5, 6, 7, 10, 13,\) and \(16\) computed using a CC2 linear response approach.\(^8\)

Conclusions

We have reported the polarizabilities of large \([4n + 2]\)-annulenes in both localized and delocalized structures computed at the CC2/aug-cc-pVDZ level of theory. As in the case of small annulenes, we have found a linear behavior of the perpendicular component of the polarizability with respect to the number of double bonds. Moreover, an almost linear relationship between the exaltations of magnetic susceptibility and electric polarizability has been determined.

References:

Optically Active Amphiphiles

Cell membranes, nucleic acid multiplexes, proteins and protein complexes with nucleic acids or membranes and the function of enzymes are due to supramolecular assemb- lies that consist of mesoscopic superstructures in the 10-1000 nm size range. They are spatio-taneously self-assembled into these structures due to non-covalent interactions such as electrostatic-, dipole-dipole interaction, hydrogen bonding, dispersion-, and hydrophobic forces. Controlled and directed self-organization through mastering the non-covalent interact-tions is an important instrument for the control at the molecular level.

We synthesize and study the behavior of amphiphilic compounds, which are struc-tures containing both a hydrophilic and a hydrophobic part. Typical examples of amphi-philes are the lipids found in biologic mem-branes. In biologic systems most molecules are chiral. Chirality is therefore an important factor for the understanding of how such systems self-assemble into superstructures.

Optically active amphiphiles are therefore components of interest for the use in supramolecular chemistry and for the fabrication of micelles, liposomes, vesicles and membranes. Many of these find practical applications in for instance time controlled delivery systems of therapeutic agents, for transport of genetic material, ultrasound diagnostic, production of nano-sized particles, semiconductors, electro-optical devices, metallic and magnetic nano-materials and for separation methods.

Our work was focused on the supramolecular chemistry of optically active amphiphiles. Tartaric acid was selected as the general source of chirality. All of the tartaric acid stereoisomers are inexpensive and readily available. The studies concentrated on the hydrolytically robust amide derivatives, such as analogs of N-mono-alkyltartramides, N,N-di-alkyltartramides, and the more soluble disul-fates. Representative constructions are struc-tures 1-3. These compounds were all predicted to be readily biodegradable.

Syntheses were developed for the construction of a number of such systems, in which the alkyl substituents were varied together with the chirality of the tartaric acid portion of the molecules. The surface active properties of these products have been studied together with how they assembled into micelles and vesicles.

Light microscopy showed that they may formed vesicles, for example cell-like structures or liposomes, as shown in Figure 1.

Using polarized light microscopy, Figure 2, the characteristic “Maltese cross” was observed, indicating an anisotropic nature of the vesicles.

For some of the monoamides of type 1, interesting dynamic vesicle behaviour was observed. Thus, one product initially formed spherical vesicles which, however, upon standing “buds”, which grew into spiral formed vesicles, Figure 3.

The structures of the vesicles have also been studied by Transmission Electron Microscopy, SEM. In Figure 4 is shown a SEM picture of an aggregate formed from an amide of type 1. The vesicle was grown in a neutral buffer solution, and clearly shows formation of a laminar structure.

Studies of amphiphiles of type 2 and 3 are currently in progress. They exhibit promising properties which are investigated in collabora-tion with a group at University of Perugia, Italy.

Susanna Villa Gonzalez, Qiang Yu and Per Carlsen
The Nitropyridine group

Background:
In heterocyclic chemistry pyridines are essential, being one of the most abundant and best known groups of aromatic heterocycles. The pyridine ring system is incorporated into the structure of pharmaceuticals, natural products, agrochemicals, ligands in transition metal catalyst complexes and commercial products. Nitro-pyridine derivatives are suitable substrates for the preparation of novel heterocyclic products; many of these heterocyclic systems may have biological activity.

• We are investigating the chemistry of nitropyridine derivatives.
• We utilize nitropyridines derivatives as substrates for the formation of new products with potential biological activity, including bis-heterocycles.
• We are developing new synthetic routes to fused heterocycles.

1. Pyridyl malonate chemistry
Tjosås, F.; Pettersen, N. M.; Fiksdahl, A. “α-(3-Pyridyl)malonates; Preparation and Synthetic Applications”; Tetrahedron 63(48) (2007) 11893

Alkylation of aromatic rings is a major challenge in organic syntheses since more complex carbon skeletons can be constructed. The alkylation of pyridine by nucleophilic aromatic subst. of the nitro group in methyl 3-nitro-4-pyridylcarboxylate by malonic ester was successful. The versatility of the α-(3-pyridyl)malonate product was demonstrated by the formation of a number of novel compounds:

The results demonstrate that the nitropyridine- α-pyridylmalonate pathway may represent a convenient strategy both for the preparation of 3-alkylpyridines and more complex carbon skeletons, such as fused bis-heterocycles.

• The synthetic potential of the nitropyridyl substrate is thus demonstrated.
N-Aryl-2-pyridylamines were prepared. Due to the coordination ability of the pyridine-nitrogen atoms, a number of PdII complexes (i), (ii) below) were isolated when the pyridyl substrates were subjected to Pd(OAc)$_2$ complexations.

### i) N-phenylpyridylamine:
A new method for the preparation of the acetato-bridged 6-membered ring palladacycle complex was developed:

$$\text{N-phenylpyridylamine:}$$

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### ii) Dipyridylamines:
formed cis/trans bis-dentate acetato-bridged dimeric Pd$_2$Lig$_2$(OAc)$_2$
at room temperature:

and subsequently cis/trans Pd$_3$Lig$_2$(OAc)$_4$ complexes by heating:

NMR and ESI-MS was used for determination of complex compositions. $^1$H and $^{13}$C NMR characterisation of all the individual cis and trans isomers of bis-dentate acetato-bridged dimeric Pd$_2$Lig$_2$(OAc)$_2$ and Pd$_3$Lig$_2$(OAc)$_4$ complexes are reported.

Anne Fiksdahl
The Fluoro-organic group: Synthesis and utilization of α-fluoroacetophenones

Background:
The importance of fluorinated compounds in relation to pharmaceuticals, agrochemicals and material sciences has been thoroughly recognised. As a consequence fluorinated building blocks are required. The current work is the starting point of a technology platform for synthesis of new biological active compounds based on already existing hydrogen analogues.

1. Synthesis of α-fluoroacetophenones
Erik Fuglseth, Thor Håkon Krane Thvedt, Bård Helge Hoff; submitted.

Being in need of a series of α-fluoroacetophenones, it was recognised that literature mainly covers reactions toward the parent compound 2-fluoro-1-phenylethanone (1c), and few systematic studies on effect of substrate structure on yield had been performed. The aim of this work was to compare electrophilic and nucleophilic fluorination using Selectfluor (F-TEDA-BF4, 1-chloromethyl-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis-(tetrafluoroborate)) and tetrabutylammonium hydrogen difluoride (TBAHF2) for the synthesis of α-fluoroacetophenones.

The yields of all routes were affected by substrate structure. In general, electrophilic fluorination of trimethylsilylenol ethers (Route A), gave higher yield than for the other methods tested. Route B was advantageous in terms of simplicity, however prolonged reaction times limits its usefulness. Nucleophilic fluorination (Route C) is not competitive with electrophilic strategies due to low yield especially when electron withdrawing R-groups are introduced. The loss in yield is mainly due to condensation reaction of the Aldol and Darzen type.

2. Asymmetric reduction of α-fluoroacetophenones
Erik Fuglseth, Eirik Sundbya, Bård Helge Hoff; manuscript in preparation

Enantiopure compounds are of uttermost importance when dealing with biological active molecules. Asymmetric reduction of the prochiral fluoroketones leads to enantioenriched 1,2-fluoroalcohols. Reduction using the proline base catalyst (R)-MeCBS, has been optimised with respect to reaction solvent, addition rate and reaction temperature. The optimised conditions were then compared with the performances of Bakers yeast (Saccharomyces cerevisiae) and Geothricum candidum.

All the 1,2-fluoroalcohols were synthesised in decent yields and with good to excellent enantiomeric excess. Six of these compounds have not been described in prior literature. The three reaction systems tested all gave a preference for the R-enantiomer, and is complementary if a high ee-value is the main target. The biocatalysts are easier to prepare than (R)-MeCBS. However, conversion rates and dilution factors favours the use the (R)-MeCBS system.

Figure 1. Routes tested for synthesis of α-fluoroacetophenones.

Figure 2. Asymmetric reduction using (R)MeCBS catalyst.

Bård Hoff
Asymmetric catalytic aziridination of 1,2-dihydronaphthalenes

(Melnes, S.; Aaseng, J. E.; Reian, G.; Gautun, O. R. to be published)

Numerous articles have been published during the past years concerning 2-aminotetralins 5 and their use as physiologically active reagents. However, no cost-efficient routes to optically pure 5 exist today. We are currently working with a general three steps method for preparation of different substituted and optically active 5 as shown below. The challenging step in this protocol is step a involving asymmetric aziridination of 1,2-dihydronaphthalenes 2.

Asymmetric aza-Diels-Alder reactions


The aza-Diels-Alder (aza-DA) reaction of imino dienophiles is a powerful tool for the rapid construction of highly functionalised six-membered nitrogen heterocycles such as piperidines and tetrahydroquinolines. We have demonstrated that optically active N-tert-butanesulfinyl α-imino ester 1 reacts with both activated and non-activated dienes in presence of BF₃·OEt₂. The aza-DA adducts were obtained in modest yields and in diastereoselectivities ranging from poor for the activated Danishefsky type dienes to excellent for the unactivated acyclic dienes (up to 99% de).

The configurations of the aza-DA adducts were established either by X-ray analysis or by chemical correlation to known compounds.

Odd Reidar Gautun
**Carotenoids and genes in the Middle East**

The group of Professor Vassilia Partali has been working on hydrophilic carotenoid derivatives for more than a decade and much progress have been made since the first experiments. The objective was originally to increase bioavailability and areas of application of the carotenoid derivatives. After being contacted by assistant Professor Michael D. Pungente at Weill Cornell Medical College in Qatar (WCMC-Q), attention was shifted towards synthesising cationic carotenoid derivatives for gene therapy experiments.

During my stay in Qatar I was given the privilege to supervise two students in the pre-medical program in the preliminary experiments with the compounds I had synthesised at NTNU. We were testing out methods to analyse the compounds’ affinity to DNA, and their abilities to protect the DNA from harmful effects that can be present in an organism. The results from these experiments were very promising, and they are at present being reproduced for validation.

Dr. Ronald Crystal, who is acknowledged as one of the leading authorities in the field of *in vivo* gene therapy, was visiting the university while I was there. Dr. Pungente was kind enough to arrange a meeting with Dr. Crystal, and we discussed the future potential of the project and also the possibility of extending the project further. Dr. Crystal was positive to the thought of conducting *in vivo* experiments with the cationic carotenoid derivatives if the preliminary results from WCMC-Q were promising.

**What is gene therapy?**

Gene therapy is basically described as the intracellular delivery of genetic material to generate a therapeutic effect by correcting an existing abnormality or providing cells with a new function. Chemically based delivery systems (hereunder cationic derivatives) are found to be the safest method for this treatment, and much effort is put into making the cationic derivatives more efficient.[1]

Being a master-student and now a PhD-student and get to work on this project has been both challenging and rewarding. When I was invited to go to WCMC-Q in June 2007 to supervise the first preliminary gene-therapy experiments and also present the development of these compounds this co-operation was finally concretised.

WCMC-Q is a joint initiative between the Qatar government and WCMC which has an objective to increase international influence. This is a result of Qatar’s aggressive work to improve the academic quality, and it is also obvious in the fact that more than 4.5% of the GDP is used for research and academic purposes every year.[2]

Being a country in the Middle East, Qatar still suffer from many limitations when it comes to rapid delivery of necessary chemicals or easy access to spectroscopic equipment. In many cases the universities and research institutions have to turn to one another in order to get their results, as I also experienced on several occasions.

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A research seminar was held in conjunction with my visit at the university. Scientific staff and students from WCMC-Q and other universities were invited to attend, and I held a lecture entitled; “Carotenoids, Antioxidants and Novel Gene-Transport Vectors”. Light lunch was served at the seminar, and after the lecture we discussed details of the research as well as the potential of these compounds as therapeutic agents.

In addition to working at the university I also spent some time exploring Qatar and the capital, Doha. The country is a melting pot of different cultures, and the strictly Muslim way of living is neatly combined with the more western lifestyle of many people. In Doha there are malls beyond imagination and breathtaking buildings are being built all over the city. Just a short drive from the busy capital is the desert which dominates the Arabian Peninsula. A desert safari with dune-surfing and dinner in nomad-tents at the beach was absolutely worth experiencing.

The benefit of this trip was both the scientific results we obtained in the preliminary experiments, as well as establishing a more formal co-operation between the group the researchers at NTNU and at WCMC-Q.

## The cationic carotenoid project
This project is highly interdisciplinary, and combines elements from organic chemistry, physical chemistry, physics, biology, biotechnology and medicine. In addition to giving the opportunity to get a broader platform of expertise it also gives a common basis for colleagues from different backgrounds to cooperate.

The involvement of several departments at NTNU in addition to international collaborators makes this project significant, especially with regard to future development.

The use of these compounds is not restricted to gene therapy purposes, and may also prove important in other areas of use, i.e. drug carriers or food colorants.

References:
BLUE / GREEN MACROCYCLES Studies of azaphthalocyanine derivatives

Phthalocyanines (Pcs) are some of the best known industrial pigments, and are produced in thousands of tons every year to meet the demand for blue and green colorants. The phthalocyanine structure consists of an aromatic 18 $\pi$-electron system. Metal complexes of Pcs can be formed with various metal ions, and substituents may be introduced to the periphery of these macrocycles in order to alter characteristics such as solubility, colour and aggregation.

Whereas Pcs have been subject to extensive studies for almost a century, the analogous azaphthalocyanines (AzaPcs) are less known, but may be of even more interest for various applications.

Several years ago, when AzaPcs caught our interest, we found that synthesis of heteroatom (O, N, S) substituted AzaPcs was not straightforward. The synthetic scheme involves cyclotetramerisation of substituted pyrazine-2,3-dicarbonitriles as monomers. Some substituents were labile, i.e. were exchanged with the strong nucleophiles used during the cyclotetramerisations, whereas other types of substituents hindered formation of AzaPcs due to strong electron donation. Carbon-bound substituents eliminated some of the synthetic problems, but targeted characteristics of the AzaPcs were not obtained in some instances. When unsymmetrically substituted pyrazine-2,3-dicarbonitriles are used, four constitutional isomers of AzaPcs can be obtained, and such isomer mixtures may be of special interest.

Presently we are studying AzaPcs of potential use in photodynamic therapy (PDT), or as diagnostic markers for medical purposes. Important characteristics of such compounds are: good solubility in organic solvents, low tendency to aggregation, major UV-vis absorption at approximately 700 nm. In addition the compounds should preferably be efficient sensitizers for singlet oxygen formation – or show strong red fluorescence in the near-IR region.

Our recent efforts towards these goals are shown in the enclosed list of publications. Both symmetrically and unsymmetrically substituted AzaPcs have been prepared, and some substitution patterns show good promise for further studies.

Unsymmetrically substituted zinc-azaptalocyanine

Eva H. Mørkved
Mercury speciation in the Norwegian arctic seasonal trends and (bio-) availability of deposited mercury

During spring 2007, Torunn Berg (professor) and Anne Orderdalen Steen (Ph.D student) started continuous mercury speciation measurements at Ny-Ålesund, Svalbard. The project is funded by the Norwegian Research Council (NFR) (MILJØ2015) and is an important contribution to the International Polar Year (IPY).

The aim of the project was to study so-called "Atmospheric Mercury Depletion Events" (AMDE). About 95% of the total atmospheric mercury is normally gaseous elemental mercury (GEM). During polar spring, however, a drop in the level of GEM is seen. This is due to oxidation of GEM to more reactive mercury species, which are absorbed on particles. AMDE was first observed in the Canadian Arctic in 1995 (Schroeder et al. 1998), at Ny-Ålesund in 2000 (Berg et al. 2003). Simultaneously with the drop in GEM elevated levels of the reactive mercury forms are observed. The oxidation takes place only during a few month period after polar sunrise and the reactive mercury forms are deposited to the snow covered surfaces. This may explain elevated mercury concentrations in Arctic marine food webs.

NTNU’s speciation data for 2007 is the longest time series which ever have been measured at Ny-Ålesund as well as for other measurement sites in the European Arctic. This work have resulted in new insight into this spectacular phenomenon. The overall budget for mercury at Ny-Ålesund was studied: Snow as well as fluxes of mercury between snow/soil and the atmosphere were analysed. Increased mercury concentrations in surface snow were observed during and after AMDE events, a result of deposition of reactive species of mercury from the atmosphere. Parts of the mercury in the snow were reemitted back to the atmosphere.

Further research is necessary to improve the knowledge on AMDE and the Arctic mercury budget, and a new campaign will be carried out at Ny-Ålesund in March-August 2008.
Trace elements in cerebrospinal fluid and blood from patients with Skogholt's disease, a rare neurodegenerative disease in Norway

A family with a rare neurological disease has recently been discovered in Hedmark county in Norway. The disease shows some similarity to multiple sclerosis, but also affects the peripheral nervous system, and is different from other similar disorders described in the literature (1,2). Thus, it seems that this is a distinct disease entity, and it has been named Skogholt's disease, after the local physician who first discovered the disease among members of this family. The disease has so far been diagnosed in 3 generations (Figure 1). The symptom onset varies from before 30 to after 50 years of age, and the disease is gradually progressive. Causes and mechanisms of this disease are unknown. Therefore, in collaboration with Dr. Skogholt and Sykehuset Innlandet (the hospitals in Kongsvinger and Elverum), we decided to investigate the possible role of trace elements in this disease.

![Figure 1. Pedigree (family tree) for the family with Skogholt's disease, showing the last 5 generations. Our study includes patients from generations II, III and IV. Squares indicate women, circles indicate men, dark fields indicate disease (certain) and angular lines indicate that the person is dead. The figure is from Annette Skogholt's M.Sc. thesis (2).](image)

Figure 1. Concentrations of copper, iron and zinc in cerebrospinal fluid (CSF) from 10 Skogholt patients, 9 multiple sclerosis (MS) patients and 13 controls.

![Figure 2. Concentrations of copper, iron and zinc in cerebrospinal fluid (CSF) from 10 Skogholt patients, 9 multiple sclerosis (MS) patients and 13 controls.](image)

Trace elements influence human health by a host of different mechanisms. Trace elements, and especially some transition metals, have been implicated in the development of several neurodegenerative diseases. All 10 Skogholt patients who were physically capable of travel to the hospital volunteered for sampling of cerebrospinal fluid (CSF) and blood. We also included 9 subjects diagnosed with multiple sclerosis and 13 individuals with no known neurological disease (the control group) in the study. The concentrations of 31 elements were determined by HR-ICP-MS in CSF, blood plasma and whole blood from all participants (3).
The main finding in our study was extremely high levels of Cu, Fe and Zn in CSF from patients with Skogholt's disease (Figure 2). All these three metals are known to bind to proteins in biological fluids. One of the distinct characteristics of Skogholt's disease is a highly increased protein level in the CSF, which was confirmed in this study. The increased protein level is probably due to a leakage defect in the blood-brain barrier (1). Thus, based on our results we hypothesize that a blood-brain barrier dysfunction is an early and presumably primary inherited defect, which causes the observed increases in metal concentrations (3). The resulting long-term exposure to increased metal levels may then contribute to brain tissue damage in Skogholt's disease.

References:


Kristin Gellein and Trond Peder Flaten
In the beginning of 1990s the ‘Iron Hypothesis’ lead to a radical paradigm shift in marine science. Prior to the iron hypothesis, many oceanographers were quite skeptical about large scale in situ enrichment of a patch of open ocean water with an element. Now, marine scientists are not just collecting samples and observing the oceans, but they have jointly started to perform mesoscale in situ experiments in various oceans in order to understand the effects of iron on biological processes and C cycles.

From 1993 to 2004 there have been 12 large scale iron enrichment experiments in different Oceans. These experiments and previous iron measurements have unequivocally shown that iron is the limiting element for biological production in almost one-third of the world ocean. Besides, iron supply controls also the biological pump, with the effect of drawing down the atmospheric CO2 level both in glacial periods and in modern days.

Due to the recent revelation of Iron’s crucial role in the biogeochemical cycles of carbon, nitrogen and sulfur and ultimately the Earth climate, Iron studies became hot topics in the climate and biogeochemical studies in marine science.

In close cooperation with IBI/TBS we started iron research in coastal waters in 1995 (1; 2) and in the Southern Ocean, Antarctica, in 1997 (3 ;4). We participa-ted in the largest and longest iron enrichment experiment (EIFEX) in the Southern Ocean in 2004 (5; 6). In 2006, 2007 and 2008 we have actively been involved in US-NOAA AMLR program that focuses on the coastal waters of Antarctica, Weddell Sea and Antarctic Circumpolar Current systems, aiming to understand the role of natural enrichment of iron on the biological productivity in these regions. In Norway, NTNU is the only institute performing research in this newly emerging area, in corporation with prominent international research groups.

We have recently started a collaboration with Chilean scientists aiming at the investigation of the interaction between macro nutrient rich and iron poor southern Humboldt current and the Chilean fjord system. Related to this, we have performed a short cruise and incubation experiment in December 2007 in Chile.

Additionally a mesocosm experiment has been performed (in autumn 2007) at the TBS research pool to test the effects of the organic matter on the iron bioavailability for phytoplankton, with collaboration with Turkish and German marine scientists.

References:

5. Croot, P. L., and Öztürk, M. Changes in the speciation and biogeochemical cycling of other trace metals during EIFEX. *Berichte Reports on Polar and Marine Research.* 500: 55-58

Murat V. Ardelan (previously M. Öztürk)
Changes in trace metal biogeochemistry in the sediment and sediment-water interface following CO2 seepage from saline aquifers (VISTA project).

The CO2-affected global warming and the means for environmentally acceptable disposal of CO2 has been a hot topic in recent years. One of the mitigation measures that has eagerly been suggested is the injection of large amounts of CO2 into deep saline aquifers.

In the North Sea a pioneering injection program has been carried out by the STATOIL company since 1996 at Sleipner Vest. The success of this disposal strategy is dependent on the permanent retention of CO2 in the aquifer. Therefore, the likelihood of the leakage of some fraction of the stored CO2 into the overlying sediment and the seawater as well as the possible effects associated with such a leakage need to be studied.

The leaking or seeping of CO2 into the sediment-water interface and further into the deep seawater may lead to a cascade of biogeochemical alterations with detrimental effects in the marine systems. A possible CO2 leakage from geological storage sites into the surface sediment and to the deep sea may cause a metal release to the pore water of the sediment and the sediment-water interface, followed by an enhanced metal flux to the water column. The acidic conditions due to CO2 seepage may effect dissolution and/or desorption of potentially hazardous trace metals harming marine organisms.

In 2006-2007 we developed a lab-scale non-pressurized reactor/chambers. We performed a number of small-scale tests involving a direct release of CO2 in a non-pressurized reactor in order to obtain data related to the possible effects of CO2 leakage on trace metal geochemistry in the sediment-water interface. Preliminary experimental results have been submitted for publication (1;2).

As a main part of this project, a high pressure tank was built exclusively in titanium, financed by STATOIL. For testing the biogeochemical effects of CO2 seepage under high pressure, we will perform our experiments also in the pressurized chamber in 2008, in collaboration with Dr. Erlend Kristiansen and Prof. Karl Erik Zachariassen, IBI. The experiments in the high pressure tank are divided into two different but integrated parts:

1) Chemical effects of a carbon dioxide leakage at 30 atm pressure.
2) Biological effects of carbon dioxide, pH and trace metals under low and high pressure.

This project has strong relevance also to another global environmental problem; “top-down” Ocean acidification due to increasing atmospheric CO2. Regarding the Ocean Acidification studies we have also cooperation with marine scientist from Analytical and Marine Chemistry Gothenburg University, Sweden, Leibniz Institute of Marine Sciences, IFM-GEOMAR, Kiel, Germany and from Bjerknes Centre for Climate Research, University of Bergen (3).

References:

1. Ardelan M.V., Steinnes E., and Linde, S. Effects of CO2 seepage on solubility and transport of seven trace metals in seawater and sediment pore water. Submitted to *Environmental Science and Technology*.

Murat V. Ardelan (previously M. Öztürk) and Eiliv Steinnes
Mercury in urine after dental restoration

These results were presented at a conference.¹ A major source for human exposure to inorganic mercury is dental amalgam. It has been established that amalgam fillings will slowly release mercury into the oral cavity. For a period of one year one of us (SL) removed 27 amalgam surfaces during 11 sessions in the dentistry. The surfaces were replaced with composite material. Urine samples were collected two hours prior to the dentist appointment and a new sample was collected the next morning. The first 100 ml of urine was discarded and the following 100-150 ml was collected for analyses of creatinin and trace elements. Trace elements were measured using high resolution ICP-MS (Element 2). A decline in urinary mercury level was observed.

Collection and preparation

Urine samples
- First morning urine samples were collected in polypropylene vials
- Within two hours samples were divided into two aliquots for creatinin and mercury analysis respectively
- Creatinin samples were kept at -20°C until analysis using standard clinical chemistry methods
- Mercury samples were preserved with 0.1 M HNO₃

Hair samples
- Hair samples were cut to a length of approx. 4cm and was further cut into 1 cm sections
- Samples were stored closed containers until further processing
- Prior to analysis the hair samples were washed twice with distilled water and then digested with 50% v/v HNO₃ using UltraClave (Milestone) at maximum temperature at 250°C. Digested samples were diluted to 0.6M HNO₃

Analytical procedure and quality control
- Samples were analyzed using HR-ICP-MS (Element 2, Bremen, Germany) equipped with Pt cones using low resolution for Hg measurements.
- Multielement standards in 0.1M HNO₃ were matrix matched for urine and hair samples respectively
- As reference materials Seronorm and human hair (GBW09101) were used and accuracy was values obtained were within 20% of the specified values.
- Analytical RSD during analysis was below 15% for all measurements

Comments
- The reduced mercury levels in urine are confirmed by the hair analysis. Thus we feel confident that the removal of dental amalgam fillings do indeed reduce the mercury body burden
- The urine mercury levels in samples taken after dental work appears to be higher than for samples taken immediately before restoration work. This has been observed also in earlier studies and indicate that the restoration work induce a short term inhalation exposure to the patient.
- The zinc and selenium values obtained in urine indicate no major changes in e.g. dietary habits during the study period.
- For copper there is a decline in urine values for samples taken prior to restoration work during the observation period. However, if we remove sample obtained at 11.05.06 the observed change is cancelled.

Dental restoration

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¹ Reference needed.
Illustrations

1. Ref.: International Society For Trace Element Research in Humans (ISTERH) Crete October 21-26 2007. S. Lierhagen, Department of Chemistry; T. Syversen, Department of Neuroscience.

Syverin Lierhagen
Continuous monitoring of heavy metals in groundwater as a tool for the detection and verification of earthquake precursors

Development of an automatic trace metal system has provided an opportunity to monitor earthquake precursor in basaltic rocks. The results clearly indicate changes in the groundwater prior to earthquake, revealing increased electroalabile concentrations of zinc and copper which was possible to monitor with the automatic monitoring station. Maximum values of both pH and electroalabile amounts of zinc and copper was observed 7-8 days before the earthquake. In areas with high earthquake activity new earthquakes can occur at any time - often with severe material damage and even loss of human lives. Development of earthquake warning systems is therefore a highly prioritized research field.

Iceland straddles the mid-Atlantic spreading ridge. Seismic activity occurs at shallow depths and is mainly concentrated to the two transform zones; the South Iceland Seismic Zone and the Tjörnes Fracture Zone. Húsavík is situated close to the Húsavík-Flatey Fault (HHF), which together with the Grimsey Lineament forms the offshore part of the Tjörnes Fracture Zone in northern Iceland.

In September 2006 an automatic system for detecting trace metals was installed at a groundwater source in Iceland, for early warning detection and continuously monitoring. The groundwater samples were analyzed automatically every third hour from the 1st of October 2006. On the 1st of November 2006 at 1:55 pm, a new earthquake of Mw 4.5 on Richter’s scale occurred in Húsavík. Continuous measurements showed significant changes in the electroalabile concentration for several metals 8 days before the earthquake while no metals were visible in the period before that as shown in Figure 1 for zinc and copper. Addition pH was observed to drop, which partly can explain the significant increase the electroalabile metal concentrations in the water. The incidental coincidence of earthquake activity in this area revealed the possible application of such systems for early warning indications of pre-seismic modification of crustal permeability changes which could occur prior to earthquakes.

Øyvind Mikkelsen, Tonje B. Østebród, Silje M. Skogvold, Kristina Strasunskiene, Knut. Schrøder, Fredrik Strand

Figure 1, The monitoring site and system
Effect of climate change on quantities of NOM and trace metals in water supply sources

This is a collaboration project between our group at Environmental and Analytical Chemistry, Geological Survey of Norway (NGU), Department of Hydraulic and Environmental Engineering (NTNU), Department of Chemistry and Geochemistry Colorado School of Mines, and the Department of Water and Environment at SINTEF. Additionally, two ERASMUS students supervised in our department have been working on this project. The principle objective of this activity is to study the effects of climate change on weathering processes and water quality, including studies on characterisation of natural organic matter (NOM) in surface waters, their variation in time and space, and how their interaction with inorganic weathering processes may vary as a function of changes in climate. This type of study is a prerequisite before making predictions for contents of NOM in drinking water supplies, but also the concentration levels and chemical species of inorganic and synthetic organic potentially toxic contaminants in particular or dissolved form in surface and groundwater. Results from this project will contribute to the understanding of which processes affect water quality in the drainage basin upstream of water supply sources to improve model prediction of future water quality in the wake of climate change. The local or regional characteristics of the e.g. geology, physiography and biology in the ecosystem may modify or enhance various effects of these changes or activities, and has also to be studied.

An interesting aspect in this project is the relationship between the concentrations of trace metals found in river water compared to the concentration found in foam fractions floating on top of the water body. Preliminary results shows significant higher amounts of trace metals in the foam fraction, indicating that the foam fraction acts like a metal collector strongly complexing and binding metals, and through this may be considered an important factor regarding the mobility of trace metals in the environmental. Type of vegetation, strongly linked to the climate, will produce different type of degradation product resulting in different amounts of NOM, and through this in different extent effect the NOM production, the mobility of trace metals, and the water quality.

Visiting professor Donald Macalady, Department of Chemistry and Geochemistry Colorado School of Mines, sampling foam samples from Jonsvatnet catchment area in Trondheim.
The combined electronic and magnetic properties exhibited by ferrite spinels have found applications in catalysis, magnetic media, memory cores, and high-frequency devices. Below a certain dimension, we enter a regime where these properties are affected by crystal or particle size. Over a very wide size range the properties of solid-state materials are constant and seemingly independent of particle size. These bulk, or macroscopic, properties are effectively dominated by the crystal structure from which all of the quantum forces stemming from the constituent atoms are averaged. However, as crystal sizes progressively decrease, a stage is reached below which this averaging is no longer valid. The size-dependent onset of quantum effects is due to the increasing fraction, and hence influences, of surface atoms relative to those within the interior. For most materials, 30-50% of the constituent atoms in 3 nm diameter spherical particles actually lie at the surface. It is around this size limit that surface energy dominates physiochemical properties. Hence, manipulating the dimensions of particles is a central aspect in designing useful materials.

The possible of designing nanophase ferrites through an environmentally friendly synthetic procedure and, at the same time, fast and continuous was the impetus behind a study on syntheses in near-critical and supercritical water. Heating a fluid toward its critical point causes major changes in its physical properties. In the case of water (critical point: Tc = 374°C; Pc = 218 atm) the transformation is especially significant because it changes from a polar liquid to one that is virtually non-polar and miscible with gases and organic compounds. These changes are spread over a fairly wide temperature range so that around 200°C (near critical) the change in properties is significant enough to make the system synthetically interesting.
A major reason for interest in the ferrite system stems from varying degrees of flexibility in distributing various cations within the overall spinel \( \text{AB}_2\text{O}_4 \) structure (see below). This distribution is mainly a function of the electronic configuration and valence state of the metals within the constraints of the structure, but also the method of preparation and of particle size (>10 nm) can be influential. Thus, depending on the metals, the two types of cation, A and B, frequently exhibit some disordering over two octahedral and one tetrahedral site per formula unit. The temperature dependency of this disorder for a number of spinels with different cation combinations has been extensively discussed in the literature. The cation distribution for a normal spinel can be formally represented by \((\text{A}^{2+})_{\text{tet}}(2\text{B}^{3+})_{\text{oct}}(\text{O}^2^-)_4\) and for a generalized disordered system by \((\text{A}_{1-x}\text{B}_x)_{\text{tet}}(\text{A}_x\text{B}_{2-x})_{\text{oct}}\text{O}_4\), where \(x\) is the inversion parameter. For the special case in which \(x = 1\) the spinel is termed "inverse". Included in this study is the ferrite \(\text{ZnFe}_2\text{O}_4\), which is reported to have a normal spinel structure in the bulk phase (no degree of inversion; \(x = 0\)), and \(\text{Fe}_3\text{O}_4\), \(\text{CoFe}_2\text{O}_4\), and \(\text{NiFe}_2\text{O}_4\), which in the bulk adopt the completely inverse spinel structure \([(\text{B}^{3+})_{\text{tet}}(\text{A}^{2+}\text{B}^{3+})_{\text{oct}}(\text{O}^2^-)_4]\).

XAS analyses have been used to study the local metal environments in some nanophase ferrites (\(\text{Fe}_3\text{O}_4\), \(\text{CoFe}_2\text{O}_4\), \(\text{ZnFe}_2\text{O}_4\), and \(\text{NiFe}_2\text{O}_4\)) prepared by hydrothermal syntheses in near-critical and supercritical water. For the purpose of comparison, a \(\text{CoFe}_2\text{O}_4\) sample was hydrothermally synthesised. XANES and EXAFS give useful information about the local metal surroundings in the ferrites. Both regions of the XAS together with calculations of the actual or apparent multiplicities of the different interactions in the model structures have been used to distinguish between the normal and inverse structures. The results of the Scherrer estimation of particle size is questioned because of discrepancies with the EXAFS. This is mainly attributed to the highly polydisperse nature of the products of this method of synthesis since the validity of the Scherrer method is founded on samples being near-monodisperse.

XANES and EXAFS results have shown the following:

1. The nearest surroundings of iron in nanophase \(\text{Fe}_3\text{O}_4\), compared to the model compound (bulk \(\text{Fe}_3\text{O}_4\)), remain unchanged in the nanophase.

2. Nanophase \(\text{CoFe}_2\text{O}_4\) adopts the inverse spinel structure independent of the synthetic procedure (supercritical water or conventional hydrothermal synthesis). However, the presence of smaller nanoparticles is reflected in the composite metal····metal interactions with lower multiplicities in the nanophase. These results are heavily weighted toward particle sizes around 10 nm in a polydisperse material.

3. Nanophase \(\text{NiFe}_2\text{O}_4\), synthesized under supercritical conditions at 200ºC and 400ºC, yields products of inverse spinel and metallic nickel. The nickel biproduct is much higher at the lower synthesis temperature.

4. Nanophase \(\text{ZnFe}_2\text{O}_4\), synthesized under supercritical conditions, consists of a broad range of particles sizes together with some magnetite and iron metal. However, the quality of the data is good enough to establish that zinc ferrite adopts a normal spinel structure under these conditions.


Camilla Nordhei
Swiss-Norwegian Beamlines: A Unique Combination –
Raman spectroscopy Integrated into a Synchrotron Beamline

The Swiss-Norwegian Beamlines (SNBL) at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France are owned and operated by the SNX Foundation. SNX is a consortium of Norwegian (N) and Swiss (CH) universities and funding agencies.

In 2007 SNX Council acquired funds to purchase and incorporate a Raman spectrometer into the EXAFS and XRD powder diffraction beamline. The decision to develop the instrumentation was based on successful tests carried out in 2006 at SNBL by groups from Norway, Switzerland and the UK using a loaned spectrometer. This development puts the SNBL at the forefront in being able to carry out simultaneous experiments using the three complementary techniques. The funds were divided 50:50 between the Norwegian and Swiss Research Council. Responsibility for applying to their respective countries was assigned to David Nicholson (NTNU; Norway) and Jan-Dierk Grunwaldt (ETH; Switzerland).

**Pooling of expertise**
The project involves pooling expertise between different Norwegian groups at the Norwegian University of Science and Technology, the University of Oslo and the Institute for Energy Technology and of course with the partnership’s Swiss universities. There is also input from groups outside the SNBL partnership itself but linked scientifically to the SNBL, for example the Royal Institution, UK and Nottingham Trent University.

The international nature of the SNBL project means that the Norwegian and Swiss sides can pool financial as well as human resources to achieve a very cost effective result so that each country gains access to a unique setup for a modest outlay. These pooled resources greatly strengthen the project through the design of various components of instrumentation required for the different experiments.

**Quality of research**
There is no doubt as to the quality of the research carried out at the SNBL. The beamlines have been independently evaluated several times by the ESRF (according to contract) and found the most productive (in terms of publications) of all the beamlines at the ESRF. In effect, the SNBL may be regarded as a national laboratory for each country. The overall Norwegian share of the proposed investment in the integrated Raman system reflects a significant coordination of activities and resources that will satisfy different requirements and will facilitate effective national exploitation of the equipment.

**The Beamline and Raman spectroscopy**
The SNBL consists of two beamlines and the one we are concerned with here is the unfocused line dedicated to X-ray powder diffraction (XRD) and absorption spectroscopy (XAS). These are the techniques of choice for studying long- and short-range order respectively in the solid state. In contrast, Raman spectroscopy is able to probe the scale between these two extremes. This is what makes the combination interesting to groups in both countries because all three techniques have in common that they are very suitable for in situ studies on a wide range of problems relating to various materials e.g. catalyst materials at relevant working conditions. Indeed, the combination is necessary for some studies. For example, the charge/defect distributions that are important properties in some materials are not detectable by XRD.
techniques but Raman scattering provides this information.

EXAFS setup at SNBL illuminated by laser

The synergy between the synchrotron techniques and Raman spectroscopy is very attractive in advanced studies and a number of combined Raman and XRD or XAS experiments have been performed ex situ. However, more complex scientific problems cannot be satisfied by the ex situ approach. Fortunately, we are now at a stage where current methodology permits more ambitious experiments in which it is possible to fully integrate the techniques and carry out in situ experiments on the same sample under identical conditions.

This integrated approach is only possible at a synchrotron. To the best of our knowledge no current general user facility exists that offers this combination on a routine basis. The SNBL offers its users a truly multipurpose Raman-synchrotron user facility.

David G. Nicholson
Adding hydrogen to the selective catalytic reduction (SCR) hydrocarbons (HC) deNOx process over silver systems leads to enhanced activity. This has been ascribed to the formation of silver nano clusters. Subsequent treatment in NO disperses the metal clusters through oxidation to silver(I). We believe that silver(I) is redispersed to the original protonic sites within the pores. The reversibility of the valence states with the formation of clusters in both systems is significant part of the overall mechanism for reducing NOx (Fig. 1).

The silver environments in the two microporous systems Ag:ZSM-5 and Ag:Y have been studied by in situ X-ray Absorption spectroscopy (XAS) at the Ag K-edge. Samples were heated stepwise in hydrogen while collecting Extended X-ray Absorption Fine Structure (EXAFS), powder diffraction (XRD) and Raman spectroscopy to determine the cluster size as a function of temperature. The EXAFS yields information about the local silver environments such as bond distances and number of neighbours. Silver(I) is reduced by hydrogen to form clusters of metallic silver, but the degree of reduction depends on the parent zeolite. The reduction starts below 100°C for both zeolites and is complete at 350°C. This is seen by the decreased contribution from the Ag-O bond and subsequent formation of an Ag-Ag bond in the Fourier Transform of Ag:Y in Fig. 2.

The coordination numbers of the Ag-Ag neighbouring shell are shown in Fig. 3. Silver metal with its fcc structure has a coordination number of 12 in the bulk form, and coordination numbers of 2-3 are generally expected for nano clusters. It is clear from the EXAFS that nanoclusters are formed in both zeolites at temperatures between 150 and 250°C.

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The results are consistent with powder diffraction (Fig. 4) which for ZSM-5 contains peaks stemming from silver clusters that appear from 350°C. The size of clusters are 60-100 Å (the shift in position is due to the large thermal expansion coefficient of silver). The silver peak is only barely visible for zeolite Y, and only at the highest temperature of 450°C, thus confirming that cluster size is limited by pore geometry. It is also clear that the nanoclusters formed between 150°C and 250°C are too small to be detected by XRD. The parent material is unaffected by the heating and formation of silver clusters. We believe that small clusters are initially formed inside the pores of both zeolite systems, which then sinter upon further heating. For ZSM-5 the larger clusters are allowed to disperse out of the pores, forming larger nanoclusters on the external surface. This is attributed to the zig-zag structure of ZSM-5 formed by interconnecting 10-rings. In zeolite Y the clusters are trapped in the supercages thus limiting the size of the clusters.
This study also included Raman spectroscopy to possibly detect the formation of surface species, or new phases not detectable by XAS or XRD. We encountered several problems with the zeolites materials, the most noticeable is the increased background when heating the samples due to fluorescence from the sample (Fig. 5) The Raman spectra of zeolite Y during dehydration in helium by ramping to 150°C clearly shows the peak attributed to the O-H stretching mode at 3700 cm\(^{-1}\). This arises from water in the system but also protonic sites in the zeolites. The intensity of this peak is clearly reduced during removal of water. The peaks between 1150-1650 cm\(^{-1}\) are ascribed to vibrational and stretching modes of the zeolite lattice.

**Fig. 4** Powder diffractograms displaying the (111) reflection of silver appearing during heating in hydrogen for the two zeolite systems.

**Fig. 5** Raman spectra of dehydration of Ag:Y to 150°C in helium.

**Fig. 5** Raman spectra of dehydration of Ag:Y to 150°C in helium.

References:

*Karina Mathisen*
Decomposition of carbon dioxide over the putative cubic spinel nanophase cobalt, nickel and zinc ferrites

The dynamic alternation between stoichiometry and non-stoichiometry in spinel ferrites \((A\text{II}Fe\text{II}_2O_4)\) is an important feature that can be exploited in gas reactions. These reactions involve lattice oxygen, either through the transfer of oxygen atoms from the ferrite to the gas (oxidation reaction) or through oxygen vacancies being replenished by oxygen from the gas (reduction reaction). The latter process requires the non-stoichiometric form which can be obtained by the use of a reducing agent such as hydrogen. These non-stoichiometric or oxygen-deficient ferrites can be used to decompose water to hydrogen and carbon dioxide to carbon\([1]\). We envisage the reaction of ferrites with mixtures of \(H_2O\) and \(CO_2\) as being especially attractive in this context.

A part of our work\([2]\) on this system is to measure the efficacies of a series of cubic spinel ferrites in abstracting oxygen from carbon dioxide in the absence of water. Oxygen-deficient ferrites are particularly interesting because they exhibit high decomposition efficiencies for both water and carbon dioxide at temperatures as low as 300 °C.

Nanophase (4-6 nm) cobalt, nickel and zinc spinel ferrites were synthesised by coprecipitation and the decomposition of carbon dioxide at 300°C was studied. Oxygen deficiency was obtained by reducing the materials in hydrogen. The divalent metals strongly influence the extent of the reactions; oxygen-deficient nickel ferrite was found to reduce three and nine times more carbon dioxide than the zinc and cobalt analogues, respectively. Carbon monoxide rather than carbon is produced for all of these ferrites.

The reducibility in hydrogen and the degrees of oxygen-deficiencies were studied by X-ray Absorption Spectroscopy at the Swiss-Norwegian Beamline, European Synchrotron Radiation Facility, Grenoble, France. The X-ray Absorption Near Edge Structure reveals that removing oxygen from the spinels leads to the concomitant reduction of iron(III) to iron(II), while the valence state of the divalent metal is unchanged. Of the three ferrites, nickel ferrite exhibits the highest degree of oxygen-deficiency. Extended X-ray Absorption Fine Structure of the nickel ferrite shows that although minor amounts of metallic nickel are expelled through over-reduction, the material is oxygen-deficient in a putative spinel structure.

In the decomposition of carbon dioxide on nanophase oxygen-deficient ferrites, we have shown that their activity and behaviour depend on the divalent A metal. One of the factors governing the reactivities of cobalt, nickel and zinc ferrites is the degree of oxygen-deficiency. This is influenced by the electronic properties of the A metal. Another factor is particle size because within the lower reaches of the nanoregime the degree of non-stoichiometry or oxygen-deficiency is increased relative to the bulk. Significantly, nickel ferrite, which exhibits the largest oxygen-deficiency when reduced in hydrogen, also consumes the largest amount of carbon dioxide. The excellent behaviour of nickel ferrite compared to cobalt and zinc is ascribed to the increased fraction of octahedrally coordinated iron. The degree of oxygen deficiency also affects the reaction mechanism; low oxygen deficiencies appear to favour carbon dioxide reduction to carbon monoxide.

References:

Camilla Nordhei and David G. Nicholson
Multi-disciplinary chemistry education

In 2007 a multi-disciplinary and multi-lateral NUFU project was awarded to a group consisting of the Chemistry education group at the Department of Chemistry together with the Norwegian Centre for Child Research, the Departments of Geography and Anthropology at NTNU, the University of Zambia and the University of Dilla (Ethiopia). The research project is named “Children, youth and indigenous knowledge in Ethiopia and Zambia” and the main aim is to develop research-based master programs in the South within these fields. In addition to the direct NUFU funding a number of PhD students recruited from the South are associated with the project with financial support from the Norwegian Quota program.

The chemistry education contribution to the project has two main thrusts. One direction of the project is to work within the field of small-scale and low cost chemistry, where we, together with Dilla University, will conduct research on experiments, equipment and the implementation of a practical approach with appropriate technology in schools and undergraduate courses where laboratory facilities are scarce. Although mainly geared to the South, the outcome is also relevant to the Norwegian educational system. The project will not be developing micro-scale equipment which often is too flimsy and difficult to handle and observe. Equipment developed will be smaller than conventional, but will not be allowed to compromise the ability to conduct comprehensive chemistry experiments (in the classroom). Collaboration has been initiated with the North West University of South Africa which is in the forefront within this field.

The second direction is to conduct chemical analysis (e.g. XRF, PIXE, PIGE, XRD, SSIMS) of some pigments of ancient paintings/ illuminated manuscripts in Ethiopian churches and monasteries. This chemical knowledge will be sustained by oral and written sources. The outcome is to benefit conservation and restoration, but an aim is also to rechannel this indigenous knowledge back to the Ethiopian schools, through contextual experiments, as for example the reconstruction of pigments.
**Scientific publications**

### Chemistry Dissemination


**Eggen, Per-Odd; Kvittingen, Lise; Grønneberg, Truls.** Small-scale and low-cost electrodes for "standard" reduction potential measurements. *Journal of Chemical Education* 2007; 84(4)


### Environmental and Analytical Chemistry

**Aaseth, J; Flaten, Trond Peder; Andersen, O.** Hereditary iron and copper deposition: Diagnostics, pathogenesis, and therapeutics. *Scandinavian Journal of Gastroenterology* 2007; 42: 673-681


**Banica, Ana; Culetu, Alina; Banica, Florinel Gabriel.** Electrochemical and EQCM investigation of L-selenomethionine in adsorbed state at gold electrodes. *Journal of electroanalytical chemistry and interfacial electrochemistry* 2007; 599(1): 100-110


Hansen, Bjørn Henrik; Remma, Svein; Garmo, Øyvind Aaberg; Pedersen, Sindre Andre; Olsvik, Pål A.; Andersen, Rolf Arvid. Induction and activity of oxidative stress-related proteins during waterborne Cd/Zn-exposure in brown trout (Salmo trutta). Chemosphere 2007; 67(11): 2241-2249


Mikkelsen, Øyvind; Strasunskiene, Kristina; Skogvold, Silje Marie; Schroeder, Knut Henning; Johnsen, Camilla Constance; Rydningen, Marion; Jonsson, Patrik; Jonsson, Anders. Automatic Voltammetric System for Continuous Trace Metal Monitoring in Various Environmental Samples. Electroanalysis 2007(19-20): 2085-2092

Collecting samples from seawater in the Trondheimsfjord


Steinnes, Eiliv. Some comments on misuse of terms related to chemical analysis. Journal of Radioanalytical and Nuclear Chemistry 2007; 272


Stenehjem, AE; Vahter, M; Nermell, B; Aasen, J; Lierhagen, Syverin; Morland, J; Jacobsen, D. Slow recovery from severe inorganic arsenic poisoning despite treatment with DMSA (2,3-dimercaptosuccinic acid). Clinical Toxicology 2007; 45

Svendsen, Monica Lian; Steinnes, Eiliv; Blom, Hans. Vertical and horizontal distributions of Zn, Cd, Pb, Cu, and Hg in uncultivated soil in the vicinity of a zinc smelter at Odda, Norway. Soil & Sediment Contamination 2007; 16: 585-603

Østebred, Tonje Birgitte; Mikkelsen, Øyvind; Schroeder, Knut Henning; Skogvold, Silje Marie; Strasunskiene, Kristina. Kontinuerlig overvåkning av tungmetaller i grunnvann: Kan varse jordskjelvaktivitet. Kjemi 2007(8): 16-19

Organic Chemistry


Activities


Kildahl-Andersen, Geir; Næss, Stine Nalum; Aslaksen, Petter Broby; Anthonsen, Thorleif; Jensen, Synnøve Liaaen. Studies on the mechanism of the Carr-Price blue colour reaction. Organic and biomolecular chemistry 2007; 5(18): 3027-3033

Lutnaes, Bjart Frode; Krane, Jostein; Smith, BE; Rowland, SJ. Structure elucidation of C-80, C-81 and C-82 isoprenoid tetraacids responsible for naphthenate deposition in crude oil production. Organic and biomolecular chemistry 2007; 5: 1873-1877

Moen, Anders Riise; Ruud, Kjersti; Anthonsen, Thorleif. Chemo-enzymatic synthesis of all isomers of 2-methylbutane-1,2,3,4-tetraol - Important contributors to atmospheric aerosols. European Journal of Organic Chemistry 2007: 1262-1266

Mørkved, Eva Henno. Pyrazine-2,3-Dicarbonitriles substituted with Maleimide Derivatives. Himlå geterocikliceskii soedinenij 2007(9):1409-1414


Mørkved, Eva Henno; Beukes, Jon Are; Mo, Frode. o-Quinonoid Heterocycles: Synthesis and Crystal Structure of 2,3-Dicyano-5,7-bismethylthieno[3,4-b]pyrazine. Molecules 2007; 12: 1623-1631

Næss, Stine Nalum; Sliwka, Hans-Richard; Partali, Vassilia; Mele, Thor Bernt; Naqvi, Kalbe Razi; Jackson, H; Lockwood, S.f.. Hydrophilic carotenoids: surface properties and aggregation of an astaxanthin-lysine conjugate, a rigid, long-chain, highly unsaturated and highly water-soluble tetracationic bolaamphiphile. Chemistry and Physics of Lipids 2007; 148: 63-69

Physical Chemistry and Biochemistry

Alsberg, Bjørn Kåre; Valla, Svein. SSBs prediksjoner om framtidens innvandring. Verdens gang 2007: 41-41

Buttingsrud, Bård; Alsberg, Bjørn Kåre; Astrand, Per-Olof. An investigation of descriptors based on the critical points in the electron density by building quantitative structure-property relationships for

Buttingsrud, Bård; Alsberg, Bjørn Kåre; Åstrand, Per-Olof. Validation of critical points in the electronic density as descriptors by building quantitative structure-property relationships for the atomic polar tensor. *Journal of Computational Chemistry* 2007; 28: 2130-2139

Cakara, Dusko; Chassagne, Claire; Gehin-delval, Cécile; Borkovec, Michal. Protonation of carboxyl latex particles in the presence of a strong cationic polyelectrolyte. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2007; 294: 174-180


Faergestad, Ellen Marie; Rye, Morten Beck; Walczak, Beata; Gidskehaug, Lars; Wold, Jens Petter; Grove, Harald; Jia, X; Hollung, Kristin; Indahl, Ulf; Westad, Frank; et al. Pixel-based analysis of multiple images for the identification of changes: A novel approach applied to unravel proteome patterns of 2-D electrophoresis gel images. *Proteomics* 2007; 7: 3450-3461

Ge, Jialin; Bedeaux, Dick; Simon, Jean-Marc; Kjelstrup, Signe. Integral relations, a simplified method to find interfacial resistivities for heat and mass transfer. *Physica A: Statistical Mechanics and its Applications* 2007; 385: 421-432

Ge, Jialin; Kjelstrup, Signe; Bedeaux, Dick; Simon, Jean-Marc; Rousseau, Bernard. Transfer coefficients for evaporation of a system with a Lennard-Jones long-range spline potential. *Physical Review E* 2007; 75: 061604, 1-10


Hellner Nilsen, Mere te; Nordhe i, Camilla; Ramstad, Astrid Lund; Nicholson, David Graham; Poliakoff, Martyn; Cabañas, Albertina. XAS (XANES and EXAFS) investigations of nanoparticulate ferrites synthesized continuously in near critical and supercritical water. *Journal of Physical Chemistry C* 2007; 111(17): 6252-6262


Students at work


Mathisen, Karina; Nicholson, David Graham; Beale, AM; Sanchez-Sanchez, M; Sankar, G; Bras, W; Nikitenko, S. Comparing CuAPO-5 with Cu:ZSM-5 in the Selective Catalytic Reduction of NOx: An in situ Study. Journal of Physical Chemistry C 2007; 111(7): 3130-3138


Nilsen, Merete Hellner; Antonakou, Eleni; Bouzga, Aud; Lappas, Angelos; Mathisen, Karina; Stöcker, Michael. Investigation of the effect of metal sites in Me-Al-MCM-41 (Me=Fe, Cu or Zn) on the catalytic behavior during the pyrolysis of wooden based biomass. Microporous and Mesoporous Materials 2007; 105: 189-203

Ortiz de Zárate, José; Sengers, J.V.; Bedeaux, Dick; Kjelstrup, Signe. Concentration fluctuations in nonisothermal reaction-diffusion systems. Journal of Chemical Physics 2007; 127


Shen, Quang; Brown, J. W.; Richardson, A. D.; Hagen, Kolbjørn. The molecular structure and conformation of trichloronitromethane as determined by gas-phase electron diffraction and theoretical calculations. Journal of Molecular Structure 2007; 830: 204-207

Simon, Jean-Marc; Inzoli, Isabella; Bedeaux, Dick; Kjelstrup, Signe. Numerical evidence for a thermal driving force during adsorption of butane in silicalite. Molecular Simulation 2007; 33: 839-841


Svelle, Stian; Olsbye, Unni; Joensen, Finn; Bjørgen, Morten. Conversion of methanol to alkenes over medium and large pore acidic zeolites: Steric manipulation of the reaction intermediates governs the ethene/propane product selectivity. Journal of Physical Chemistry C 2007; 49(11): 17981-17984

Old Trondheim, Bakklandet

Xu, Jing; Kjelstrup, Signe; Bedeaux, Dick; Simon, Jean-Marc. The heat of transfer in a chemical reaction at equilibrium. Journal of Non-Equilibrium Thermodynamics 2007; 32(3): 341-349

Xu, Jing; Kjelstrup, Signe; Bedeaux, Dick; Simon, Jean-Marc. Transport properties of 2F = F_2 in a temperature gradient as studied by molecular dynamics simulations. Physical Chemistry, Chemical Physics 2007; 9: 969-981


Honours, Extracurricular activities, Participation in courses, conferences, lectures and study visits

B. Alsberg


T. Andreassen


Co-author on Poster Presentation: Stereoselective Enereactions with N-sulfinyl Sulfimides”.

Bruker Biospin’s pre-ENC Meeting/Workshop, Daytona Beach, Florida, USA, April 20 – 21, 2007.


T. Anthonsen

Member of Editorial Board: Journal of Molecular Catalysis, B Enzymatic Biocatalysis and Biotransformation.

Chairman Management Committee COST Action D25. Applied Biocatalysis, Stereoselective and Environmentally Friendly Reactions Catalyzed by Enzymes. 22 Member Countries.


Co-author on Lecture on: Studies of Charge Delocalized Cations Prepared by Reaction with Deuterated Trityl Cation.


Research Co-operation at Alexandria University, Egypt, Feb. 26 – March 2, 2007.


Opening Remarks and Information about: EU FP7 CALLS in Biocatalysis.


F.G. Banica

Co-author on Poster Presentations: “Seleno-Methionine in Adsorbed State at Electrified Metal Surfaces” and “Electrochemical Reactivity of Homocysteine (Hcy) at a Mercury Electrode in the Presence of Nickel Ion”.

Co-author on Poster Presentations: “Homocysteine Electrochemical Reactions at a Mercury Electrode in the Presence of Nickel or Cobalt Ions” and “Electroanalytical Chemistry of Metal Sulfides at Mercury Electrodes: Thiourea as a Starting Material for Metal Sulfide Preparation”.

D. Bedeaux


Co-author on Lecture on: Heat and Mass Transfer into and through Interfaces.

Visit at ETH, Zürich, Switzerland, May 2 – 11, 2007.
Guest Lecture on: Heat and Mass Transfer into and through Interfaces.

Co-author on Lecture on: Transport Properties of a Reacting Mixture in a Temperature Gradient as Studied by Molecular Dynamics Simulations.

Co-author on Lecture on: Surface Transfer Coefficients in Non-Equilibrium Thermodynamics Studied by Non-Equilibrium Molecular Dynamics Simulations.

Co-author on Lecture on: Non-Isothermal Adsorption of N-Butane on Silicalite by Transient Non-Equilibrium Molecular Dynamics Simulation.


Guest Lecture on: Muscular Contraction and the Calcium Pump.

Skamsund bridge, Inderøy

T. Berg

Co-author on Lecture on: Mercury in the Arctic.

20th Task Force Meeting on the UNECE ICP Vegetation, Dubna, Russia, March 5 – 9, 2007.


Co-author on Lecture on: Kvikksølv i Arktis.

Co-author on Lectures on: “AMDE Activities at Ny-Ålesund, Andøya and Troll” and “COPOL: Contaminants in Polar Regions”.

Lectures on: “Luftforurensninger” and "Effekter av luftforurensninger".
Activities

M. Bjørgen


Co-author on Poster Presentation: Thermally Stable PtY-Based Metal-Organic Framework: Exploring the Accessibility and Electronic Properties of the Metal Centers”.


T. Bruvoll


O. Burheim

Co-author on Lecture on: Through-Plane Thermal Conductivity of Nafion.

P.H. Carlsen

Member of The European COST-D31 Committee.

Establishing of Socrates/Erasmus-NTNU Collaboration Agreements with Institute of Chemical Technology, Prague, Czech Rep., University of Perugia, Italy and University of Vienna, Austria.


P. – O. Eggen

Co-author on Lecture on: Yesterday’s Collections in Today’s Courses.


A. Fiksdahl

Section Leader, Organic Chemistry Group, Department of Chemistry, NTNU.

Established Co-operation with University of Hamburg, Germany, on NFR-Project.

Co-author on Poster Presentations: “Synthesis of new β-Carboline Analouges” and “Oxidative Cyclisation of N-Arylaminopyridines”.

Co-author on Poster Presentation: Synthetic Applications of β-Pyridylmalonates.


T.P. Flaten

Deputy Head of the Department of Chemistry.

Board Member, The Committee for Geomedicine of the Norwegian Academy of Science and Letters.

Editor, Norsk Epidemiologi (Norwegian Journal of Epidemiology).
Activities

Co-author on Poster Presentation: High Resolution ICP-MS Trace Element Analysis of Proteins Obtained from Size Exclusion High Pressure Chromatography of Human Cerebrospinal Fluid.

Co-author on Lectures on: “Iron and Copper Toxicity in Hereditary Diseases” and “Separation of Proteins in Cerebrospinal Fluid by Size Exclusion HPLC and Determination of Trace Elements by HR-ICP-MS”.
Co-author on Poster Presentations: “A Nation-Wide Survey of Trace Elements in Lynx, Wolverines, Wolves and Brown Bears in Norway”, “Effects of Formalin Fixation on Trace Element Concentrations in Biological Tissue”, “Trace Elements in Cerebrospinal Fluid and Blood from Patients with a Rare Progressive Central and Peripheral Demyelinating Disease” and “Trace Elements in Serum from Patients with Parkinson’s Disease – a Prospective Case-Control Study”.

K. Gellein

Co-author on Poster Presentation: High Resolution ICP-MS Trace Element Analysis of Proteins Obtained from Size Exclusion High Pressure Chromatography of Human Cerebrospinal Fluid.

Co-author on Lectures on: “Separation of Proteins in Cerebrospinal Fluid by Size Exclusion HPLC and Determination of Trace Elements by HR-ICP-MS” and "Iron and Copper Toxicity in Hereditary Diseases”.
Co-author on Poster Presentations: “Effects of Formalin Fixation on Trace Element Concentrations in Biological Tissue”, “Trace Elements in Cerebrospinal Fluid and Blood from Patients with a Rare Progressive Central and Peripheral Demyelinating Disease” and “Trace Elements in Serum from Patients with Parkinson's Disease – a Prospective Case-control Study”.

O. – E. Haas


K. Hagen

Activities

Strategy seminar at Jægtvolden, Inderøy

B.H. Hoff

Co-author on Poster Presentations: “Substrate Limitations to the Use of Tetrabutylammonium Hydrogen Difluoride in Nucleophilic Displacements of 2-Bromoacetophenones” and “Chemo-enzymatic Synthesis of Chiral Building Blocks Based on Para-Hydroxpropionophene”.

S. Ingebrigtsen

Co-author on Poster Presentations: “Spectral Analysis of the Light emitted from Streamers in chlorinated Liquids” and “Spectral Analysis of the Light emitted from Streamers in Liquid CCI4”.

I. Inzoli

Co-author on Poster Presentation: Temperature Effects During Adsorption of N-Butane on Silicalite.

Co-author on Poster Presentation: Surface Resistance to Heat and Mass Transfer in a Silicalite Membrane. A Non-Equilibrium Molecular Dynamics Study.

Co-author on Lecture on: Non-Isothermal Adsorption of N-Butane on Silicalite by Transient Non-Equilibrium Molecular Dynamics Simulation.

E.E. Jacobsen

Co-author on Poster Presentations: “Stereoselective Enereactions with N-Sulfinyl Sulfinamides”, “Chemo-enzymatic Methods for Synthesis of Enantiopure Biologically Active Compounds” and “Studies of the Catalytic Centre of Lipase A from Candida Antarctica”.


Lecture on: Important Small Molecules. Enantiopure Building Blocks for Biologically Active Compounds.

S.L. Jensen

Co-author on Lecture on: Studies of Charge Delocalized Cations Prepared by Reaction with Deuterated Trityl Cation.

G. Kildahl-Andersen

Co-author on Lecture on: Studies of Charge Delocalized Cations Prepared by Reaction with Deuterated Trityl Cation.

Co-author on Poster Presentation: A novel Aromatic Compound in Coal Extracts.


S. Kjelstrup

Professor in part time position at TU Delft, Netherlands, Jan. 2 – Feb. 1 and June 1 – July 1, 2007.


Co-author on Lecture on: Heat and Mass Transfer into and through Interfaces.
Activities

Co-author on Lecture on: Through-Plane Thermal Conductivity of Nafion.

Visit at ETH, Zürich, Switzerland, May 2 – 11, 2007.
Guest Lecture on: Heat and Mass Transfer into and through Interfaces.

Co-author on Poster Presentation: Temperature Effects during Adsorption of N-Butane on Silicalite.


Co-author on Lecture on: Transport Properties of a Reacting Mixture in a Temperature Gradient as Studied by Molecular Dynamics Simulations.


Co-author on Lecture on: Surface Transfer Coefficients in Non-Equilibrium Thermodynamics Studied by Non-Equilibrium Molecular Dynamics Simulations.

Co-author on Lecture on: Non-Isothermal Adsorption of N-Butane on Silicalite by Transient Non-Equilibrium Molecular Dynamics Simulation.

Research Project at University of Oslo, Norway, April 23 – May 3, 2007.
Lecture on: Small Scale Chemistry.

H. Koch


Workshop on “Highly Accurate Calculations of Molecular Electronic Structure”, University of Karlsruhe, Germany, March 24, 2007.
Lecture on: Method Specific Cholesky Decomposition.

L. Kvittingen


Co-author on Lecture on: Yesterday’s Collections in Today’s Courses.


Research Project at University of Oslo, Norway, April 23 – May 3, 2007.

Activities


S. Lierhagen

Co-author on Poster Presentations: “A Nation-Wide Survey of Trace Elements in Lynx, Wolverines, Wolves and Brown Bears in Norway”, “Trace Elements in Cerebrospinal Fluid and Blood from Patients with a Rare Progressive Central and Peripheral Demyelinating Disease”, “Trace Elements in Serum from Patients with Parkinson’s Disease – a Prospective Case-Control Study” and “Mercury in Urine after Dental Restoration”.

A. Lykkenes

Co-author on Lecture on: Yesterday’s Collections in Today's Courses.

Co-author on Lecture on: Trondheim or Oslo? Territories in Early 20th Century Chemistry Education in Norway.


Meetings at The Niels Bohr Archives and Vitenskapshistorisk Selskab, Copenhagen, Denmark, Nov. 9 – 13, 2007.
Lecture on: Ida Tacke Noddack: Tysk kjemiker på humpete karrierevei.


K. Mathisen


Ø. Mikkelsen

Section Leader, Analytical and Environmental Chemistry Group, Department of Chemistry, NTNU.


Meeting at Lake Biwa Environmental Research Institute, Japan, March 15, 2007. Co-author on Lecture on: Automatic and unattended Monitoring of Pollutants in Aquatic Systems. This focused on heavy Metals in Lakes and Rivers.


Meetings to organize Research Co-operation, University of Science and Technology Lille, France, March, 26 – 30, 2007.

Activities

Co-author on Poster Presentation: Continuous Monitoring of Zinc, Iron and Copper in Raubekken, Løkken verk.


A.R. Moen


D.G. Nicholson

Head of the Department of Chemistry


C. Nordhei


Lecture on: AXANES and EXAFS Study on Nanophase Nickel, Cobalt and Zinc Ferrite.

V. Partali


Research Co-operation at Université de Fribourg, Pérols, Switzerland, Sep. 7 – 16, 2007.

Strategy seminar at Jægtvolden, Inderøy

A.L. Ramstad

Section Leader, Physical Chemistry Group, Department of Chemistry, NTNU.

Lecture on: NanoLab’s Clean Room for Synthesis by Chemical Methods.


C. Sanz-Navarro

Co-author on Lecture on: Molecular Dynamics Simulation of the Binding of Platinum Clusters to Graphite Sheets.

Yale University, New Haven, USA, March 15, 2007.
Co-author on Lecture on: Molecular Dynamics Simulations of Catalytic Activity: Carbon Materials as a Carrier of Platinum Clusters.
Activities

Co-author on Poster Presentations: “Large Time-Scale Protein Dynamics by Strategic Alteration of the Confirmation of Selected Residues” and “Simulations of Transition-Metal Clusters Adsorbed on Carbon Nanofibers by Using ReaxFF”.


Co-author on Lecture on: Molecular Dynamics Simulations of Binding of Metal Catalyst Nanoparticles to Carbon Nanostructures by Using ReaxFF.

Co-author on Lecture on: Molecular Dynamics Simulations of Metal Catalyst Nanoparticles Supported on Carbon Nanostructures by ReaxFF.
Co-author on Poster Presentation: Large Time-Scale Protein Dynamics by Strategic Alteration of the Confirmation of Selected Residues.

13th International Symposium on Relations between Homogeneous and Heterogeneous Catalysis (ISHHC XIII), Berkeley, California, USA, July 16 - 20, 2007.
Co-author on Lecture on: Molecular Dynamics Simulations of Binding of Metal Catalyst Nanoparticles to Carbon Nanostructures by Using ReaxFF.

Co-author on Poster Presentation: Carbon Nanofibers as a Platform in Nanocatalysis Engineering.

R. Schmid


K. Schröder

Research Co-operation at Warsaw University of Technology, Poland, Feb. 1 – 5, 2007.
Lecture on: New Methods for Automatic and Remotely Controlled Monitoring of Heavy Metals in Waters.

Meeting at Lake Biwa Environmental Research Institute, Japan, March 15, 2007.
Lecture on: Automatic and Unattended Monitoring of Pollutants in Aquatic Systems. This Focused on Heavy Metals in Lakes and Rivers.

Lecture on: New Methods for Automatic and Unattended Monitoring of Heavy Metals.

Co-author on Poster Presentation: Continuous Monitoring of Zinc, Iron and Copper in Raubekken, Løkken verk.


S. Skogvold

Co-author on Poster Presentation: Continuous Monitoring of Zinc, Iron and Copper in Raubekken, Løkken verk.

H.S. Smalø

Co-author on Lecture on: “Electronegativity Equalization Models for Non-Metallic System”.

A.O. Steen

Co-author on Lecture on: Mercury in the Arctic.


Co-author on Lecture on: Kvikksølv i Arktis.
Activities

Co-author on Lecture on: AMDE Activities at Ny-Ålesund, Andøya and Troll.

E. Steinnes


20th Task Force Meeting on the UNECE ICP Vegetation, Dubna, Russia, March 5 – 9, 2007.
Co-author on Poster Presentation: Epithermal Neutron Activation Analysis of Moss Biomonitor Used to Estimate Metal Pollution in the Surroundings of Thermal Power Plants in Central Russia.

Lecture on: 30 Years of Atmospheric Deposition Studies in Norway Using Moss Analysis.

Lecture on: Trace Element Speciation in Aquatic Systems: General Principles and Selected Examples.

Lecture on: Soils and Geomedicine.

Lecture on: Soil and Health.

Lecture on: Radioecology.

9th International Conference on the Biogeochemistry of Trace Elements, Beijing, China, July 15 – 19, 2007.
Co-author on Lectures on: “Distribution of 28 Elements in Podzol Profiles Studied by Fractional Extractions and Multivariate Statistics” and “Large-Scale Studies of 137Cs Deposition in Norway from the Chernobyl Accident”.

Lecture on: Deposition of some Inorganic Pollutants in the Vicinity of Norwegian Aluminium Plants.

Lecture on: INAA of Geological Material Using a Combination of Epithermal Activation and Compton Suppression.


Co-author on Poster Presentations: “A Nation-Wide Survey of Trace Elements in Lynx, Wolverines, Wolves and Brown Bears in Norway”, “Trace Elements in Cerebrospinal Fluid and Blood from Patients with a Rare Progressive Central and Peripheral Demyelinating Disease” and “Trace Elements in Serum from Patients with Parkinson’s Disease – a Prospective Case-Control Study”.


Co-author on Lecture on: AMDE Activities at Ny-Ålesund, Andøya and Troll.

Introductory Talk: Distribution and Fate of Metals Supplied to Norway by Long-Range Atmospheric Transport.


View from Trondheim harbour

V. Stockmann


Activities

K. Strasunskiene

Co-author on Poster Presentation: Continuous Monitoring of Zinc, Iron and Copper in Raubekken, Løkken verk.

Research stay at University of Science and Technology of Lille, France, June 24 – July 20, 2007.

F. Tjosås

Co-author on Poster Presentation: Oxidative Cyclisation of N-Aryliminopyridines.

Co-author on Poster Presentation: Synthetic Applications of -Pyridylmalonates.

J. Xu

Co-author on Lecture on: Transport Properties of a Reacting Mixture in a Temperature Gradient as Studied by Molecular Dynamics Simulations.

Co-author on Poster Presentation: Transport Properties of a Reacting Binary Fluid, A Non-Equilibrium Molecular Dynamics Simulations Study.

C.L. Øpstad


Research Stay at Weill Cornell Medical College in Quatar, Doha, Quatar, June 4 – 18, 2007.

J.E. Aaseng

Co-author on Poster Presentation: Aziridines from L-Aspartic Acid – Synthesis and Ring Opening Reactions.

P. – O. Åstrand

Research Co-operation at University of Copenhagen, Denmark, Jan. 2 – 5, 2007.

Lecture on: Electronic Polarization of Nanotube Aggregates as Calculated by a Point-Dipole Interaction Model.
Co-author on Lecture on: Molecular Dynamics Simulation of the Binding of Platinum Clusters to Graphite Sheets.

Research Co-operation at California Institute of Technology, Pasadena, California, USA, March 2 – 6, 2007.
Lecture on: “Molecular Mechanics Models for Linear and Nonlinear Electronic Polarization”.


Lectures on: “Molecular Modelling: Condensed Phases in Strong Fields?” and “Molecular Mechanics Models for Molecular Conductance”

Lecture on: Molecular Dynamics Simulations of Catalytic Activity: Carbon Materials as a Carrier of Platinum Clusters.

Co-author on Poster Presentation: Simulations of Transition-Metal Clusters Adsorbed on Carbon Nanofibers by Using ReaxFF.

Research Co-operation at Université Joseph Fourier, Grenoble, June 3 – 11, 2007.

Co-author on Lecture on: Molecular Dynamics Simulations of Binding of Metal Catalyst Nanoparticles to Carbon Nanostructures by Using ReaxFF.

Research Co-operation at University of Tromsø, Norway, June 13 – 14, 2007.
Co-author on Lecture on: Molecular Dynamics Simulations of Metal Catalyst Nanoparticles Supported on Carbon Nanostructures by ReaxFF.

13th International Symposium on Relations Between Homogeneous and Heterogeneous Catalysis (ISHHC XIII), Berkeley, California, USA, July 16 - 20, 2007.
Co-author on Lecture on: Molecular Dynamics Simulations of Binding of Metal Catalyst Nanoparticles to Carbon Nanostructures by Using ReaxFF.

Co-author on Poster Presentation: Carbon Nanofibers as a Platform in Nanocatalysis Engineering.

Co-author on Lectures on: “Calculation of the Frequency-Dependent Polarizability of Hydrocarbons and Fullerenes Using a Charge-Dipole Model”, “A Study of the Structure of Carbon-Supported Metal Clusters by Molecular Dynamics Simulations” and “Electronegativity Equalization Models for Non-Metallic System”.

## Spring examination

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<th>Candidates /Passed</th>
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<td>Reidar Edvald Stølevik, Karl Erik Zachariassen</td>
<td>55/47</td>
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<td>KJ1020</td>
<td>Organic Chemistry (15)</td>
<td>Vassilia Partali</td>
<td>138/98</td>
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<td>KJ2022</td>
<td>Spectroscopic Methods in Organic Chemistry (7,5)</td>
<td>Elisabeth E Jacobsen, Odd Reidar Gautun</td>
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<td>Organic Synthesis, Laboratory (7,5)</td>
<td>Odd Reidar Gautun, Anne Fiksdahl</td>
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<td>Physical Chemistry II (7,5)</td>
<td>Reidar Edvald Stølevik</td>
<td>14/13</td>
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<tr>
<td>KJ2043</td>
<td>Physical Methods in Structural Chemistry (15)</td>
<td>Karina Mathisen, Reidar Edvald Stølevik</td>
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<td>KJ2050</td>
<td>Analytical Chemistry, Basic Course (7,5)</td>
<td>Øyvind Mikkelsen, Florinel Gabriel Banica</td>
<td>13/13</td>
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<td>KJ2053</td>
<td>Chromatography (7,5)</td>
<td>Anne Fiksdahl</td>
<td>23/22</td>
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<td>KJ2070</td>
<td>Environmental Chemistry (15)</td>
<td>Torunn Berg, Trond Peder Flaten</td>
<td>39/34</td>
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<td>KJ3055</td>
<td>Analytical Atomic Spectrometry (7,5)</td>
<td>Florinel Gabriel Banica</td>
<td>4/4</td>
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<td>KJ3065</td>
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<td>Torbjørn Ljones</td>
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<td>Organic Medicinal and Pharmacaceutical Chemistry (7,5)</td>
<td>Derek James Chadwick</td>
<td>27/23</td>
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<td>KJ8106</td>
<td>Advanced Organic Chemistry (7,5)</td>
<td>Per Henning Carlsen</td>
<td>-</td>
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<td>Spectroscopy and Chemometrics (7,5)</td>
<td>Bjørn Kåre Alsberg</td>
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<td>Thermodynamics of Hydrocarbon Mixtures (7,5)</td>
<td>Tore Haug-Warberg</td>
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<td>Statistical Thermodynamics and Computer Simulations (7,5)</td>
<td>Per-Olof Åstrand</td>
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<td>Quantitative Structure-Activity Relationships (7,5)</td>
<td>Bjørn Kåre Alsberg</td>
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<td>Industrial Organic Chemistry, Research Projects (7,5)</td>
<td>Bård Helge Hoff</td>
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<td>TKJ4160</td>
<td>Basic Physical Chemistry and Laboratory (15)</td>
<td>Signe Kjelstrup, Per-Olof Åstrand, Henrik Koch</td>
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<td>Chemical Bond Theory and Spectroscopy (7,5)</td>
<td>Henrik Koch</td>
<td>28/22</td>
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<td>TKJ4175</td>
<td>Chemometrics, Basic Course (7,5)</td>
<td>Bjørn Kåre Alsberg</td>
<td>7/5</td>
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<td>TKJ4190</td>
<td>Physical Chemistry, Project Work (7,5)</td>
<td>Terje Bruvoll</td>
<td>1/1</td>
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<td>TKJ4850</td>
<td>Experts in Team, Interdisciplinary Project (7,5)</td>
<td>Per-Olof Åstrand</td>
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<td>Thorleif Anthonsen Torbjørn Ljones Annette Lykknes</td>
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</tr>
<tr>
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<td>Astrid Lund Ramstad Reidar Edvald Stølevik</td>
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<td>51/49</td>
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<td>KJ2031</td>
<td>Inorganic Chemistry, Advanced Course (7,5)</td>
<td>Karina Mathisen</td>
<td>7/7</td>
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<tr>
<td>KJ2051</td>
<td>Analytical Chemistry, Advanced Course I (7,5)</td>
<td>Øyvind Mikkelsen Florinel Gabriel Banica</td>
<td>6/6</td>
</tr>
<tr>
<td>KJ2090</td>
<td>Chemistry Education - Chemistry Dissemination (7,5)</td>
<td>Per Odd Eggen</td>
<td>3/2</td>
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<tr>
<td>KJ2091</td>
<td>Teacher training/dissemination project in chemistry (7,5)</td>
<td>Lise Kvittingen Per Odd Eggen</td>
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<tr>
<td>KJ3021</td>
<td>Nuclear Magnetic Resonance Spectroscopy (7,5)</td>
<td>Nebojsa Simic Rudolf Schmid</td>
<td>16/14</td>
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<tr>
<td>KJ3058</td>
<td>Analytical Chemical Separation Techniques (7,5)</td>
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<tr>
<td>KJ3071</td>
<td>Applied geochemistry (7,5)</td>
<td>Rolf Tore Ottesen</td>
<td>6/6</td>
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<tr>
<td>RFEL3093</td>
<td>Episodes from the history of science</td>
<td>Annette Lykknes Roland Wittje</td>
<td>3/3</td>
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<tr>
<td>KJ8021</td>
<td>Stereochemistry and Synthesis of Chiral Compounds (7,5)</td>
<td>Thorleif Anthonsen</td>
<td>6/6</td>
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<tr>
<td>KJ8026</td>
<td>Biocatalysis in Organic Chemistry (7,5)</td>
<td>Thorleif Anthonsen</td>
<td>11/11</td>
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<tr>
<td>KJ8052</td>
<td>Analytical Electrochemistry and its Application within Industrial and Environmental Monitoring (7,5)</td>
<td>Øyvind Mikkelsen</td>
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<tr>
<td>KJ8056</td>
<td>Chemical and Sensors and Biosensors (7,5)</td>
<td>Florinel Gabriel Banica</td>
<td>6/6</td>
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<tr>
<td>KJ8070</td>
<td>Advanced Aquatic Chemistry (15)</td>
<td>Trond Peder Flaten</td>
<td>10/10</td>
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<tr>
<td>KJ8104</td>
<td>New Methods in Organic Synthesis (7,5)</td>
<td>Anne Fiksdahl</td>
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<td>KJ8105</td>
<td>Organometallic Compounds in Organic Synthesis (7,5)</td>
<td>Odd Reidar Gautun</td>
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<td>KJ8106</td>
<td>Advanced Organic Chemistry</td>
<td>Per Henning Carlsen</td>
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<td>KJ8206</td>
<td>Advanced Quantum Chemical Methods (7,5)</td>
<td>Mats Linus Henrik Boman</td>
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<td>KJ8207</td>
<td>Advanced Microarray Data Analysis (7,5)</td>
<td>Bjørn Kåre Alsberg</td>
<td>9/8</td>
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<td>TKJ4100</td>
<td>Basic Organic Chemistry and Laboratory (15)</td>
<td>Per Henning Carlsen</td>
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<tr>
<td>TKJ4170</td>
<td>Quantum Chemistry, Advanced Course (7,5)</td>
<td>Mats Linus Henrik Boman</td>
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<tr>
<td>TKJ4180</td>
<td>Physical Organic Chemistry (7,5)</td>
<td>Rudolf Schmid</td>
<td>13/11</td>
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<tr>
<td>TKJ4185</td>
<td>Chemical Instrumentation and Experimental Measurements (7,5)</td>
<td>Terje Bruvoll</td>
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<tr>
<td>TKJ4195</td>
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<td>Bjørn Kåre Alsberg</td>
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<tr>
<td>TKJ4200</td>
<td>Irreversible Thermodynamics (7,5)</td>
<td>Torleif Holt</td>
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<td>TKJ4205</td>
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<td>Per-Olof Åstrand</td>
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<td>TKJ4510</td>
<td>Physical Chemistry, Specialization Project (15)</td>
<td>Terje Bruvoll</td>
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<td>Terje Bruvoll</td>
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<td>TKJ4525</td>
<td>Organic Chemistry, Specialization Course (7,5)</td>
<td>Thorleif Anthonsen</td>
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## Re-sit examination

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<tr>
<th>Course no.</th>
<th>Course title (credits)</th>
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<tr>
<td>RFEL1001</td>
<td>Natural Science and World Views (7,5)</td>
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<td>KJ1000</td>
<td>General Chemistry (15)</td>
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<td>KJ1020</td>
<td>Organic Chemistry (15)</td>
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<td>Inorganic Chemistry (15)</td>
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<td>KJ1040</td>
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<td>KJ2053</td>
<td>Chromatography (7,5)</td>
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<td>KJ2070</td>
<td>Environmental Chemistry (15)</td>
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<td>KJ3021</td>
<td>Nuclear Magnetic Resonance Spectroscopy (7,5)</td>
<td>1/1</td>
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<tr>
<td>KJ3058</td>
<td>Analytical Chemical Separation Techniques (7,5)</td>
<td>1/1</td>
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<tr>
<td>KJ8056</td>
<td>Chemical and Sensors and Biosensors (7,5)</td>
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<tr>
<td>KJ8070</td>
<td>Advanced Aquatic Chemistry (15)</td>
<td>1/1</td>
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<tr>
<td>KJ8100</td>
<td>Organic Medicinal and Pharmaceautical Chemistry (7,5)</td>
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<td>KJ8202</td>
<td>Thermodynamics of Hydrocarbon Mixtures (7,5)</td>
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<td>Advanced Microarray Data Analysis (7,5)</td>
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<td>KJ8208</td>
<td>Advanced Irreversible Thermodynamics (6)</td>
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<td>TKJ4125</td>
<td>Natural Products Chemistry (7,5)</td>
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<td>TKJ4160</td>
<td>Basic Physical Chemistry and Laboratory (15)</td>
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<td>TKJ4166</td>
<td>Chemical Bond Theory and Spectroscopy (7,5)</td>
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<td>TKJ4175</td>
<td>Chemometrics, Basic Course (7,5)</td>
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<td>TKJ4180</td>
<td>Physical Organic Chemistry (7,5)</td>
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</tbody>
</table>

Willow herb (Epilobium angustifolium)
Graduate Students

Siv.ing. students

3. year (MTKJ)
Lyngvi, Eirik
Mekki, Miriam
Seglem, Karen Nessler
Slungård, Sigrid Volden
Takla, Marit
Vågenes, Birgitte Bårli
Willassen, Veronica

4. year (MTKJ)
Krakeli, Tor Arne
Kvalvåg, Sondre Schnell
Landsem, Eva
Mui, Vivian Wing Laam
Ringholm, Magnus
Strand, Lilian Helene Sola
Sørensen, Benedicte Riise
Serum, Christopher
Voldsun, Mari
Wilhelmsen, Øivind
Åstrand, Ove Alexander

5. year (MTKJ)
Høgmoen, Hanne
Lervik, Anders
Melnes, Silje

Master students

Chemistry (MKJ)
Alsvik, Inger Lise
Berge, May Britt
Berge, Øystein Rønning
Bøyesen, Katrine Lie
Delic, Asmira
Grave, Anlaug Haukvik
Helland, Tone Grangård
Hermann, Solveig
Holt, Yngvil
Hystad, Madeleine
Jonassen, Hilding
Kjøglum, Kristin Tyldum
Lie, Alexander
Lorentzen, Marianne
Lystvet, Sina Maria
Martinsen, Morten
Martinsen, Thomas
Mølegård, Ståle
Neerland, Elisabeth
Næss, Mari Kirkebøen
Siegesmund, Øyvind Turbjørn
Skår, Jenne Skeeide
Sørensen, Kari Bjerke
Tjemsland, Johanne Marie
Valvik, Beate
Aaen, Ingrid

Environmental toxicology and chemistry (MFORU)
Holsen, Aase Marie Hersleth
Ottemo, Vivian Grønhaug

Natural resource mangagement (MNATR)
Eliassen, Ragnhild Oline
Salomonsen, Silje Naper

Master of Science Education (MLREAL)
Bjørk, Tina Beate
Brimi, Aslak Opsahl
Elgen, Marianne
Frøland, Stine Lindset
Hanssen, Mari Roen
Hole, Marianne Prestvik
Valved, Hilde
PhD in Chemistry

Buttingsrud, Bård
An improved method for comparing the 3D electronic structure of molecules in rational drug design.
Trial lecture
Searching for new drugs using combinational chemistry
Supervisor
Professor Bjørn Kåre Alsberg
Evaluation committee
Reader Dr. Paul Popelier, Manchester Interdisciplinary Biocentre (MIB), University of Manchester
Research Associate Dr Amanda Clare, Department of Computer Science, University of Wales
Professor Reidar E. Stølevik, Institutt for kjemi, NTNU

Gidskehaug, Lars
Development of chemometric methods for variable selection on microarray data.
Trial lecture
Variable selection in high-throughput data problems
Supervisor
Professor Bjørn Kåre Alsberg
Evaluation committee
Assistant Professor PhD Johan Westerhuis, Universiteit van Amsterdam
Swammerdam, Institute for Life Sciences Biosystems Data Analysis, Amsterdam, The Netherlands
Postdoc PhD Solve Sæbø, Institutt for kjemi, bioteknologi og matvitenskap, Universitet for miljø og biovitenskap, Ås
Professor Henrik Koch, Institutt for kjemi, NTNU

Kildahl-Andersen, Geir
Polyenyl cations and radical cations - synthesis, spectroscopic properties and reactions.
Trial lecture
Chemical Aspects of Photodynamic Cancer Therapy
Supervisor
Professor Thorleif Anthonsen, Institutt for kjemi, NTNU
Evaluation committee
Professor Dr. Johan Lugtenburg, Gorlaeus Laboratories, University of Leiden, RA Leiden, The Netherlands
Professor Arne Jørgen Aasen, Farmasøytisk institutt, Universitetet i Oslo
Førsteamanuensis Dr. Eva H. Mørkved, Institutt for kjemi, NTNU

Meland, Anne-Kristine
Impedance Diagrams of the Electrodes in the Polymer Electrolyte Membrane Fuel Cell.
Trial lecture
Electrochemical reduction of carbon dioxide. Fundamentals and applications
Supervisor
Professor Signe Kjelstrup
Evaluation committee
Professor dr.tekn. Göran Lindbergh, Kjemiteknikk, Kungliga Tekniska högskolan, Stockholm
Seniorforsker dr. Børre Tore Børresen, Statoil forskningscenter ASA, Rotvoll
Professor dr.ing. Svein Sunde, Institutt for materialteknologi, NTNU, Trondheim

Moen, Anders Riise
Enzymatic asymmetrization and kinetic resolution. Synthesis of drug precursors, natural products and carbohydrates.
Trial lecture
Asymmetrisk organokatalyse og aldolreaksjonen; betydning for homokiralitet i naturen?
Supervisor
Professor Thorleif Anthonsen
Evaluation committee
Dr. Poul B. Rosenius Poulsen, New Business Discovery Novozymes, Denmark
Professor Arne Jørgen Aasen, Farmasøytisk institutt, Universitetet i Oslo
Professor Torbjørn Ljones, Institutt for kjemi, NTNU

Rye, Morten Beck
Image segmentation and multivariate analysis in two-dimensional gel electrophoresis.
Trial lecture
An overview of the Ogston model and its applications in protein gel electrophoresis
Supervisor
Professor Bjørn Alsberg
Evaluation committee
Associate Professor PhD Ib Søndergaard, Danmarks Tekniske Universitet, BioCentrum-DTU, Kgs. Lyngby, Denmark
Professor PhD Tormod Næs, Matforsk AS, Ås
Professor PhD Per-Olof Åstrand, Institutt for kjemi, NTNU
Post Graduate Students

Tjosås, Freddy  
Nitropyridines and pyridyl malonate derivatives in heterocyclic chemistry.  
Trial lecture  
Gullkatalyserte reaksjoner i organisk syntese  
Supervisor  
Professor Anne Fiksdahl  
Evaluation committee  
Professor Kristina Luthman, Institutionen för kemi, Läkemedelskemi, Göteborgs universitet, Sverige  
Førsteamanuensis Tore Hansen, Kjemisk institutt, Universitetet i Oslo  
Førsteamanuensis Odd Reidar Gautun, Institutt for kjemi, NTNU

Cand.scient in Chemistry 2007

Azizyan, Mahnaz  
Studier av human mitokondriell uracil-DNA glucosylase UNG1.  
Supervisors:  
Professor Geir Slupphaug  
Professor Thorleif Anthonsen  
Examiner:  
Dr. Ingrid Eftedal.

Bergene, Nina Iren  
Rensing og karakterisering av AlgL fra Pseudomonas fluorescens, og forsøk på etablering av et in vitro-system for alginatsyntese  
Supervisors:  
Research officer Helga Ertesvåg  
Professor Svein Valla  
Professor Thorleif Anthonsen  
Examiner:  
Associate Professor Kåre Haugan

Storstad, Trond Magne  
Tungmetaller i viltvoksende norske matsopper  
Supervisors:  
Professor Steinnes, Eiliv  
Adviser Bjørn Ove Berthelsen  
Examiner:  
Supervisor Per Varskog

Daffodils outside the department
MSc in Chemistry/Siv.ing. 2007

Siv.ing. Ane Arstad
Synthesis of new tripodal chelators for complexation of actinides and latinides
Supervisor: Associate Professor Bård Hoff and Research Scientist Bror Johan Wik
Examiner: Associate Professor Trond Vidar Hansen

Siv.ing. Kristine Løland Eriksen
Synthesis of beta-carbolin analogues
Supervisor: Professor Anne Fiksdahl
Examiner: Professor Jan Skramstad

Siv.ing. Ingvild Eide-Haugmo
Preparation and characterization of polyermatrixes for use in composite fuel
Supervisor: Associate Professor Rudolf Schmid and Research Scientist Erik Unneberg
Examiner: Associate Professor Per Ola Renning

Siv.ing. Ivar Brøndbo Kjerstad
Cyclisation reactions for the making of 6-azaindoles and oxazolopyridines
Supervisor: Professor Anne Fiksdahl
Examiner: Associate Professor Kåre B Jørgensen

Siv.ing. Maria Førde Møll
Synthesis and analysis of alfa-fluorophenylethanones and alfa-fluorophenylethanols
Supervisor: Associate Professor Bård Helge Hoff
Examiner: Dr.scient. Viggo Waagen

Siv.ing. Alexander Nicolaisen
Synthesis of polyheterocyclic compounds from pyridylnalinate
Supervisor: Professor Anne Fiksdahl
Examiner: Professor Jan Skramstad

Siv.ing. Gard Reian
Asymmetric catalytic aziridination of alkenes for the purpose of manufacturing substituted 2-aminotetralines
Supervisor: Associate Professor Odd Reidar Gautun
Examiner: Associate Professor Trond Vidar Hansen

Siv.ing. Solrun Johanne Vevelstad
Synthetic studies towards piperazinomycin
Supervisor: Associate Professor Odd Reidar Gautun
Examiner: Associate Professor Kåre B Jørgensen

Juan Francisco Insua Peres
(Sokrates student)
Synthesis of polyheterocyclic compounds from pyridylmalonate
Supervisor: Professor Anne Fiksdahl
Examiner: Professor Emeritus Jan Magnus Bakke
MSc in Chemistry 2007

Angelsen, Ragnhild Beate Strand
Undersøkning av det aktive senteret til lipase A frå Candida antarctica.
Supervisor: Professor Thorleif Anthonsen
Examiner: Associate Professor Eirik Sundby

Drange, Kristine
Specieringsstudier av aktuelle spormetaller, i vann og sedimenter i brakkvannsone - utvikling av analysemetodikk
Supervisors: Professor Øyvind Mikkelsen
Professor Knut Henning Schrøder
Senior Research Fellow Kalman Nagy
Examiner:

Frigstad, Marte Marie Hansen
Kjemo-enzynamtisk syntese av iminosykilitol, potensiell hemmer av glykosidaser og glykosyltransferaser
Supervisor: Professor Thorleif Anthonsen
Examiner: Professor Arne Jørgen Aasen

Halkjelsvik, Anveig Bjordal
Industriell påverknad av elvesletter langs Driva
Supervisors: Professor Eiliv Steinnes
Adjunct Professor Rolf Tore Ottesen
Supervisor Per Varskog
Examiner:

Midtaune, Håkon
Kjemoenzynmatisk syntese av enantiomert rene byggesteiner basert på para-hydroksypropiofenon
Supervisor: Professor Thorleif Anthonsen
Examiner: Associate Professor Trond Vidar Hansen

Nordløkken, Marit
Artsforskjeller i konsentrasjon av 56 elementer i naturlig vegetasjon i Sør-Rogaland
Supervisor: Professor Eiliv Steinnes
Adviser Bjørn Ove Berthelsen
Examiner:

Tronstad, Ingvild
Bestemmelse av tungmetaller i elvevann ved bruk av ICP-MS og DGT analyser. Sammenligning mot nyutviklet metode for automatisk tungmetall analyse for bruk i felt
Supervisor: Professor Øyvind Mikkelsen
Professor Knut Henning Schrøder
Senior Research Fellow Kalman Nagy
Examiner:

MSc in Education, Chemistry

MSc Tonje Birgitte Østebrød
Utvikling av metode for forutsigelse av jordskjelvakтивitet ved hjelp av automatisk overvåking av tungmetallkonsentrasjonen i grunnvann
Supervisor: Professor Øyvind Mikkelsen
Professor Emeritus Knut Schrøder
Senior Research Scientist Kalman Nagy
Examiner:
The following PhD-projects are in progress:

<table>
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<tr>
<th>Student</th>
<th>Title</th>
<th>Thesis advisor</th>
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<tbody>
<tr>
<td>Andreassen, Trygve</td>
<td>Assymetriske ene-reaksjoner med aza-analoger til svoveldioksid.</td>
<td>Odd Reidar Gautun</td>
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<td>Boman, Mats Henrik Linus</td>
<td>Analytical coupled-cluster calculation of gauge invariant optical properties.</td>
<td>Henrik Koch</td>
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<td>Burheim, Odne Stokke</td>
<td>Elektronisk utfelling av jern. (Electrowinning of iron from chloride melts)</td>
<td>Signe Kjelstrup</td>
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<td>Eggen, Per-Odd</td>
<td>Current chemistry – learning and teaching electrochemistry by experiments.</td>
<td>Lise Kvittingen</td>
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<td>Esmurziev, Aslan</td>
<td>Synthesis of new fluorinated uronic acids and total synthesis of new uridine diphosphate fluoro-uronic acids. (Syntese av fluorerte uronsyrer og talsyntes av nye uridine difosfat fluoro-uronsyrer.)</td>
<td>Bård Helge Hoff</td>
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<td>Flatberg, Arnar</td>
<td>Simulation of microarray experiments and protsomic 2D gel electrophoresis.</td>
<td>Bjørn K. Alsberg</td>
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<tr>
<td>Fuglseth, Erik</td>
<td>New chiral and fluorinated aromatic compounds. (Nye kirale og fluorere aromatiske forbindelser.)</td>
<td>Bård Helge Hoff</td>
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<td>Gebremariam, Kidane Fanta</td>
<td>Analytical Methods for Art objects Investigation</td>
<td>Lise Kvittingen</td>
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<td>Gellein, Kristin</td>
<td>Trace elements and health – in vitro, experimental animal and human population studies.</td>
<td>Trond Peder Flaten</td>
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<td>Glavatsky, Kirill Sergeevich</td>
<td>Multi-component evaporation as described Using the Nonequilibrium van der Waals square gradient model.</td>
<td>Dick Bedeaux</td>
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<td>Gonzalez, Susana Villa</td>
<td>Synthesis of optically active surfactants and the study of their properties.</td>
<td>Per H. Carlsen</td>
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<td>Haas, Ole-Erich</td>
<td>Transport on a nanoscale; at surfaces and contact lines in PEM fuel cells.</td>
<td>Astrid Lund Ramstad</td>
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<tr>
<td>Hestad, Øystein Leif</td>
<td>Elektroniske prosesser i frosne dialektriske væsker under høg elektrisk feltpåkjenning.</td>
<td>Per-Olof Åstrand</td>
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<td>Ingebrigtsen, Stian</td>
<td>Elektroniske prosesser i flytende dielektrika under høye elektriske felt-påkjenninger. (Electronic process in liquid dielectrics under high electric field stress.)</td>
<td>Per-Olof Åstrand</td>
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<tr>
<td>Inzoli, Isabella Maria</td>
<td>Molecular modelling of coupled transport of heat and mass.</td>
<td>Signe Kjelstrup</td>
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### Post Graduate Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Supervisor</th>
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<tr>
<td>Jartun, Morten</td>
<td>Urban risk – Dispersion mechanisms and possible health effects of PCB in the urban environment.</td>
<td>Eiliv Steinnes</td>
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<tr>
<td>Kumelj, Tjasa</td>
<td>Free energy calculations of ligand-protein interactions.</td>
<td>Per-Olof Åstrand</td>
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<tr>
<td>Løkken, Torbjørn Vegard</td>
<td>Analyser av vannduggpunkt og hydrokarbonduggpunkt i naturgass. (Determination of water dewpoint and hydrocarbon dewpoint in natural gas.)</td>
<td>Rudolf Schmid</td>
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<tr>
<td>Nordhei, Camilla</td>
<td>Structural Studies of Functional Oxides and their Catalytic Behaviour – XAS and XRD Studies of Nanophase Spinels.</td>
<td>Astrid Lund Ramstad</td>
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<tr>
<td>Ryeng, Einar</td>
<td>Analyse av mikromatriisedata med induktiv logikk-programmering.</td>
<td>Bjørn K. Alsberg</td>
</tr>
<tr>
<td>Sandru, Eugenia-Mariana</td>
<td>Synthese av høy umettete bioorganiske forbindelser. (Synthesis of highly unsaturated bioorganic compounds.)</td>
<td>Vassilia Partali</td>
</tr>
<tr>
<td>Skogvold, Silje Marie</td>
<td>Overvoltage in Voltammetry; Fundamental Processes, related to Analytical Sensor Development for Online and Remote Trace Analyses.</td>
<td>Øyvind Mikkelsen</td>
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<tr>
<td>Smalø, Hans Sverre</td>
<td>Molecular models of electronic processen in liquids.</td>
<td>Per-Olof Åstrand</td>
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<tr>
<td>Steen, Anne Orderdalen</td>
<td>Atmosfærisk spesiering av kvikksølv i polare områder.</td>
<td>Torunn Berg</td>
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<tr>
<td>Stockmann, Vegar</td>
<td>Synthetic Applications of Nitropyridine Derivates.</td>
<td>Anne Fiksdahl</td>
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<tr>
<td>Strasunskiene, Kristina</td>
<td>Automatically measuring systems for heavy Metals and trace Metals in waste water from sewage discharge and incineration plants. Early warming systems.</td>
<td>Øyvind Mikkelsen</td>
</tr>
<tr>
<td>Svendsen, Monica Lian</td>
<td>Systemanalyse av metallforurensning i det terrestriske miljø i Odda-området.</td>
<td>Eiliv Steinnes</td>
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<tr>
<td>Xu, Jing</td>
<td>A Nonequilibrium Molecular Dynamics Simulation Study of Chemical Reactors.</td>
<td>Signe Kjelstrup</td>
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<tr>
<td>Yu, Qiang</td>
<td>Synthesis of Nucleic Base containing oligomers and polymers.</td>
<td>Per H. Carlsen</td>
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<tr>
<td>Øpstad, Christer Lorentz</td>
<td>Synthesis and properties of hydrophilic highly unsaturated amphiphiles for gene transfer.</td>
<td>Vassilia Partali</td>
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<tr>
<td>Aarhaug, Thor Anders</td>
<td>Ny membran for polymer brenselsceller.</td>
<td>Signe Kjelstrup</td>
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<tr>
<td>Aaseng, Jon Erik</td>
<td>Asymmetric synthesis of substituted 2-aminotetralins. (Asymmetrisk syntese av substituerte 2-aminotetraliner.)</td>
<td>Odd Reidar Gautun</td>
</tr>
</tbody>
</table>
## Student Exchange from NTNU, Department of Chemistry 2007

<table>
<thead>
<tr>
<th>Name</th>
<th>Specialization</th>
<th>Level</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hystad, Madeleine</td>
<td>BkJ-Struct.chem.</td>
<td>BSc, 3th yr</td>
<td>University of British Colombia, Canada</td>
</tr>
<tr>
<td>Høyvik, Ida-Marie</td>
<td>BkJ-Struct.chem.</td>
<td>BSc, 3th yr</td>
<td>University of California, Berkeley, USA</td>
</tr>
<tr>
<td>Åstrand, Ole Alexander</td>
<td>MTKJ-Fys.chem.</td>
<td>MSc, 4th yr</td>
<td>University of California, Berkeley, USA</td>
</tr>
<tr>
<td>Høgmoen, Hanne</td>
<td>MTKJ-Org.chem.</td>
<td>MSc, 5th yr</td>
<td>University of California, Berkeley, USA</td>
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</tbody>
</table>

## Student exchange to NTNU, Department of Chemistry 2007

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Ausin, Maider Reguera</td>
<td>University of the Basque Country, Spain</td>
</tr>
<tr>
<td>Barras, Mathieu</td>
<td>Université de Technologie de Troyes, France</td>
</tr>
<tr>
<td>Böhme, Alexandra</td>
<td>Martin-Luther-University Halle-Wittenberg, Germany</td>
</tr>
<tr>
<td>Ciftja, Arlinda</td>
<td>University of Tirana, Albania</td>
</tr>
<tr>
<td>Corcostegeui, Cecilia</td>
<td>University of the Basque Country, Spain</td>
</tr>
<tr>
<td>Einarsdóttir, Dórdóthea</td>
<td>University of Iceland, Iceland</td>
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<tr>
<td>Exner, Alexander</td>
<td>Universität Hamburg, Germany</td>
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<tr>
<td>Hauge, Drew Allen</td>
<td>University of Minnesota, USA</td>
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<tr>
<td>Holler, Jes Gitz</td>
<td>Danish University of Pharmaceutical Science, Denmark</td>
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<tr>
<td>Lesven, Ludovic</td>
<td>University of Lille, France</td>
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<tr>
<td>Louriño Cabana, Beatriz</td>
<td>Universidad de la Coruña, Spain</td>
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<tr>
<td>De Meester, Raf Homer Ghislena</td>
<td>Ghent University, Belgium</td>
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<td>Rennebaum, Sandra</td>
<td>RWTH Aachen University of Technology, Germany</td>
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<tr>
<td>Rueda Verano, Maria Jesus</td>
<td>University of Cadiz, Spain</td>
</tr>
<tr>
<td>Schwidom, Dirk</td>
<td>Universität Hamburg, Germany</td>
</tr>
</tbody>
</table>
Staff

Academic Staff

Organic Chemistry

Group Leader
Professor, Dr.ing.
Anne Fiksdahl

Adjunct Professor, Ph.D.
(Oxford). Derek Chadwick

Professor, Dr.rer.nat.
(Fribourg). Vassilia Partali

Professor, Dr.ing.
Thorleif Anthonsen

Associate Professor, Dr.ing.
Odd Reidar Gautun

Associate Professor, Dr.rer.nat.
(Zürich). Rudolf Schmid

Professor, Ph.D. (Buffalo).
Per Carlsen

Associate Professor, Dr.scient
Bård Helge Hoff

Associate Professor
Nebojsa Simic
Physical Chemistry

Group Leader
Associate Professor, Dr.scient.
Astrid Lund Ramstad

Professor, Dr.philos.
Kolbjørn Hagen

Professor, Dr.philos.
Reidar Stølevik

Professor, Dr.scient.
Bjørn Alsberg

Professor, Dr.techn.
Signe Kjelstrup

Professor, Ph.D. (Lund)
Per-Olof Åstrand

Adjunct Professor, Dr.philos.
(Utrecht). Dick Bedeaux

Professor, Ph.D. (Århus).
Henrik Koch

Associate Professor
Morten Bjørgen

Assistant Professor
Terje Bruvoll

Professor, Ph.D.
Torbjørn Ljones
Environmental and Analytical Chemistry

Group Leader
Dr. Scient
Øyvind Mikkelsen

Professor, Dr. scient.
Lise Kvittingen

Professor, Dr. philos.
Knut Schrøder

Associate Professor, Dr. ing.
Florinel G. Banica

Ph.D.
Karina Mathisen

Professor, Dr. philos.
Eiliv Steinnes

Professor, Dr. scient.
Torunn Berg

Professor, Ph.D. (London)
David Nicholson

Associate Professor, Dr. scient,
Annette Lykknes

Associate Professor, Dr. ing.
Trond Peder Flaten

Adjunct Professor
Rolf Tore Ottesen
Administrative staff

Head of administration
Anne Langseth

Senior consultant
Lillian Hanssen

First secretary
Aase Sæther

Consultant
Inger Marie Frøseth

Consultant
Ingrid Kristine Tømmerdal

Technical staff

Senior Technician
Stein Almo

Chief Technician
Julie Jackson

Technician
Nina Klausen
Staff

Chief Technician
Syverin Lierhagen

Chief Technician
Tron Rolfsen

Technician
Kari Tanem

Technician
Gunnar Svare

Technician
Kjersti Ljones

Technician
Roger Aarvik

Temporary Lecturers

Hårklau, Halvard
Jacobsen, Elisabeth E.

Scientific Assistants

Alsvik, Inger Lise
Andreassen, Trygve
Angelsen, Ragnhild Strand
Bjerk, Tina Beate
Bolstad, Kjersti H.
Breivik, Åshild S.
Eiasson, Ragnhild
Egede-Nissen, Cecilie
Fuglseth, Erik
Grave, Anlauq H.
Haas, Ole-Erich
Hansen, Mari Roen
Holt, Yngvil
Lystvet, Sina
Neerland, Elisabeth
Siegsmund, Øyvind
Steen, Anne O.
Storstad, Trond Magne
Valved, Hilde
Østad, Christer L.
Øvergård, Tommy
Aaseng, Jan Erik
### Demonstrators (Master Students)

<table>
<thead>
<tr>
<th>Demonstrator</th>
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<tbody>
<tr>
<td>Angelsen, Ragnhild Strand</td>
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<tr>
<td>Bjørk, Tina Beate</td>
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<td>Braaten, Hans Fredrik</td>
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<td>Elgen, Marianne</td>
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<td>Eliassen, Ragnhild</td>
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<td>Esmurziev, Aslan</td>
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<td>Finnstun, Elin</td>
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<td>Fraford, Anders Malm</td>
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<td>Frigstad, Marte M. Hansen</td>
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<td>Frøland, Stine Lindset</td>
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<td>Gebremariam, Kidane Fanta</td>
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<td>Helgerud, Trygve</td>
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<td>Hermann, Solveig</td>
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<td>Johansen, Hege D.</td>
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<td>Jonassen, Hilding</td>
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<td>Karstensen, Kristin</td>
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<td>Kvitvang, Hans Fr.</td>
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<td>Landseml, EvaLervik, Anders</td>
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<td>Lie, Aleksander</td>
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<td>Lieungh, Ida</td>
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<td>Lorentzen, Marianne</td>
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<td>Lyngvi, Eirik</td>
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<td>Martinsen, Morten</td>
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<td>Martinez, Marcus C.</td>
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<td>Melnes, Silje</td>
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<td>Midtaue, Håkon</td>
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<td>Ringholm, Magnus</td>
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<td>Skåm, Jenny Skeeide</td>
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<td>Smørvik, Marte S.</td>
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<td>Strand, Lilian H.E.</td>
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<td>Sørorgård, Hanne</td>
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<td>Wiik, Siv Åshild</td>
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<td>Wilhelmsen, Øivind</td>
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<td>Øverby, Anders</td>
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### Guest professors/researchers/lecturers

<table>
<thead>
<tr>
<th>Guest Professor/Researcher/Lecturer</th>
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<tbody>
<tr>
<td>James Burger</td>
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<tr>
<td>Alexander Mayer</td>
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<tr>
<td>Gabriel Billon</td>
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<tr>
<td>Olga Safanova</td>
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<tr>
<td>Donald L. Macalady</td>
</tr>
<tr>
<td>Director of the Novartis Foundation, London, UK and Adjunct</td>
</tr>
<tr>
<td>Professor at Department of Chemistry, NTNU, Derek Chadwick</td>
</tr>
<tr>
<td>“Challenges for the Pharmaceutical Industry”</td>
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<tr>
<td>Research Scientist Christian Collin-Hansen, Statoil, Trondheim</td>
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<tr>
<td>“The big Questions about Global Warming – and how Chemists might provide the Answer”</td>
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<tr>
<td>Professor Jürgen Heck, Universität Hamburg, Germany</td>
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<td>Socrates Lecture I: Organometallic Catalysis:</td>
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<tr>
<td>“Transformations of Coordinated Cyclooctatetraene”</td>
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<td>Professor Jürgen Heck, Universität Hamburg, Germany</td>
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<tr>
<td>Socrates Lecture II: Organometallic Catalysis:</td>
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<td>“Structure Property Relationships in Dipolar Organometallic Compounds”</td>
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<tr>
<td>Director of Research Anne-Marie Caminade, CNRS Toulouse, France</td>
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<tr>
<td>“Phosphorous Dendrimers – Synthesis, Reactivity, Properties”</td>
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<tr>
<td>Research Scientist Jenny Beckman, University of Uppsala, Sweden</td>
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<tr>
<td>“Biologihistorie 1 – Ording og utvikling”</td>
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<tr>
<td>“Biologihistorie 2 – Molekyler og miljø”</td>
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<tr>
<td>Dr. Slawomira Skrzypek, University of Lodz, Poland</td>
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<tr>
<td>“Compounds included Guanidine Group as Catalysts for Hydrogen Reduction at a Mercury Electrode: Application in Analysis of Pharmaceuticals in Biological Samples”</td>
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*Dates listed are the period of their visit.*
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.

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