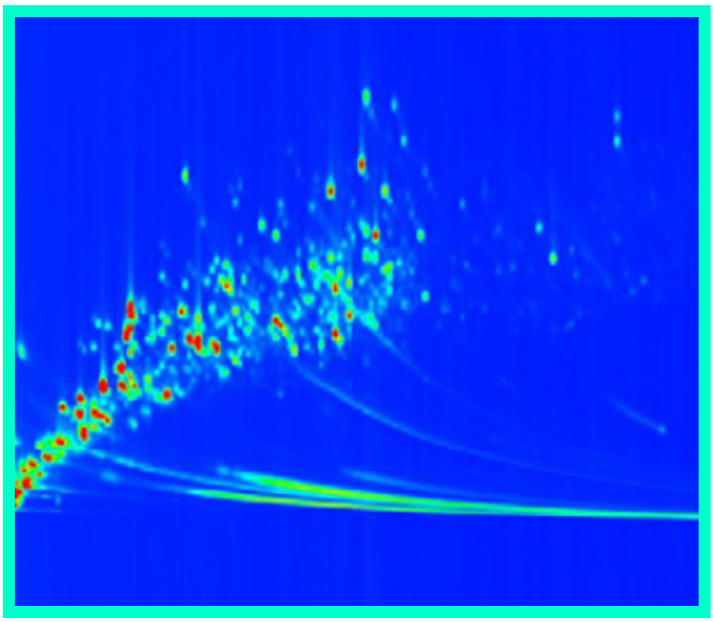
Annual Report 2009



Van 't Hoff Institute for Molecular Sciences

Colophon

Van ’t Hoff Institute for Molecular Sciences
Nieuwe Achtergracht 166
1018 WV Amsterdam
The Netherlands
Phone: +31 20 525 5265
Fax: +31 20 525 5604
www.science.uva.nl/hims

Editing:
R.L.J. Zsom, J.C. van den Heuvel

Cover:
GC×GC-ToF-MS chromatogram of a modified cellulose sample

July 2010

Table of contents

1. General considerations

The year 2009 was a successful year for HIMS. A total of 6,56 M€ external funds was acquired from subsidiaries such as NRSC-C, NWO (including a personnel grant), EU, Senter Novem, CatchBio, etc. The output of HIMS was on a high level in 2009, comparable to 2008. HIMS published 3 papers in absolute top journals (impact factor > 15) and 10 papers in top journals (impact factor 10-15). The total number of refereed publications amounted to 169, reflecting the increased personnel input last year, while 16 PhD dissertations were produced.

The work of the HIMS research groups raised national and international publicity, including publications in various newspapers and on various websites. HIMS research highlights, awards and other measures of esteem with a high societal value we are most proud of are the prestigious Eastern American Society (EAS) award for Excellence in Separation Science received by Prof. Peter Schoenmakers in November 2009.

Prof. Peter Schoenmakers recieves the EAS award 2009

Furthermore, in 2009 Prof. Piet van Leeuwen, emeritus professor of Homogenous Catalysis at the UvA, received a Doctor Honoris Causa degree from the Rovira i Virgili University (URV), University of Tarragona, Spain. Additionally he received an ERC Advanced Grant worth 3.5 M€ for research on nanocatalysts; currently he is working at the Institute of Chemical Research of Catalonia (ICIQ) in Tarragona.

Emeritus Professor Piet van Leeuwen receives the Doctor Honoris Causa degree at the University of Tarragona.

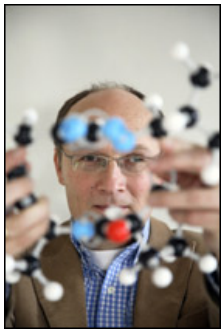
Some other highlights to be mentioned are:

- In December 2009 the first HomKat-InCatT mini-symposium was organized at the Science Park Amsterdam. Esteemed national and international speakers presented recent innovations and developments in the field of homogeneous catalysis.
- In November 2009 Dr. Bas de Bruin presented the lecture *From Hammer to Scalpel: New Bio-Inspired Tools for Sustainable Catalytic Processes* in the framework of the Faculty colloquium series.

- On May 14, 2009, Prof. Peter Timmerman, professor in Protein mimetic chemistry (Bio-molecular Synthesis) gave his inaugural lecture entitled *Therapeutisch vaccin mogelijk toepasbaar bij behandeling kanker*.

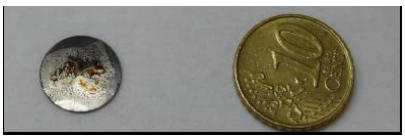
Prof. Peter Timmerman

- Prof. Joost Reek (Catalysis) was highlighted in Angewandte Chemie because he published his 10th article since 2000 in this prestigious journal.
- Prof. Joost Reek (Catalysis) and Prof. Fred Brouwer (Molecular Photonics) and co-workers published a possible breakthrough article in the top journal Proceedings of the National Academy of Sciences (PNAS) on photocatalysis for the production of molecular hydrogen. The work was also highlighted on Kennislink.NL and the UvA website.
- Dr. Jan van Maarseveen (Bio-Molecular Synthesis), presented a lecture during the diner of the University Board, and attended by minister Ter Horst, on the occasion of the opening of the academic year.



Dr. Jan van Maarseveen

- The University of Amsterdam and the VU University started the Amsterdam Graduate School of Science (AGSS) in which they share all beta-master programmes, including all chemistry masters.
- The FDA has accepted Apaziquone (EOquin®), a medicine for bladder cancer synthesized at HIMS many years ago, under its fast track program.
- UvA/HIMS) is the first university in The Netherlands that became a partner of the European centre for EChemTest, a database that can be used to test knowledge and capabilities according to the Eurocurriculum Chemistry. The EChemTest was developed by the European Chemistry Thematic Netwerk Association (ECTNA), of which UvA is a member.
- As from March 2009 the registration and purchasing programme for dangerous substances and gases 'TRACELAB' was fully operative.
- Prof. Gadi Rothenberg cs. published an article on *Chiral imprinting of palladium with cinchona alkaloid* in Nature Chemistry.
- Nicole Fransen, PhD researcher in the group Reek, received a poster prize at the DPI annual meeting 2009.

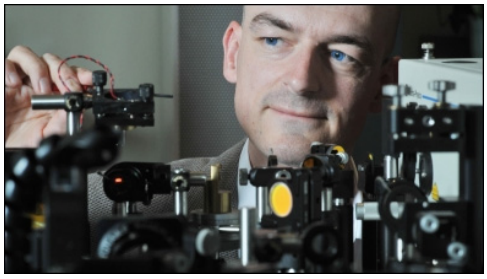


Chiral palladium metal

Since 2006, the year of introduction of the new integral costs allocation model of the university board, the financial position of HIMS has much improved, reflecting the foreseen effect of the reorganization of the chemistry department that took place in the years 2002-2004. HIMS finished the year 2009 with a positive financial result of +0.05 M€[1], as it did in 2008 (+0.9 M€), 2007 (+0.5 M€) and 2006 (+0.3 M€).
Notwithstanding the positive results of the years 2006-2009, however, the financial prospects of HIMS and the faculty are uncertain as a consequence of budget reductions both from the ministry and the university board to be realized in the years 2009-2012. In 2009 HIMS was confronted with a budget reduction of the structural university budgets of 10% (1 M€) for the years 2009-2012. On request of the dean HIMS formulated a plan *Chemie Financieel Duurzaam* in order to realize a cost reduction of equal size. This plan was judged positively by the faculty and comprises cost reductions by early retirements and discontinuation of the röntgen diffraction activities, and increased revenues from the realization of more PhD theses and the Sectorplan Natuurkunde & Scheikunde (SNS).

As a direct consequence of the plan *Chemie Financieel Duurzaam*, several important new scientific staff appointments could be realized in 2009, resulting in an increase in scientific staff members. We strongly hope to continue this positive trend for 2010 by the appointment of a new professor in *Complex Molecular Simulations*. The following appointments of permanent personnel through direct funding (1e geldstroom) were effected in 2009:

- Dr. S. Woutersen was appointed as UHD in the group Profs. Buma and Brouwer
- Dr. G. Vivo Truyens was appointed as UD in the group of Prof. Peter Schoenmakers
- Dr. N.R. Shiju was appointed as UD in the group of Prof. Gadi Rothenberg
- Dr. D. Dubbeldam was appointed as UD in the group of Prof. Peter Bolhuis


Dr. Sander Woutersen

Other important appointments realized in 2009:

- Prof. H. Bakker was re-appointed for 5 years (0.0 Fte) as professor in *Ultrasnelle Spectroscopie van Moleculen in de Gecondenseerde Fase* in the group Buma of the theme Molecular Photonics.
- Prof. J. Oomens was appointed for 5 years (0.2 Fte) as professor in *Action Spectroscopy* in the group Buma of the theme Molecular Photonics.
- Additionally Dr. D. Hetterscheid and Dr. S. Grecea, both NWO-Veni laureates, joined the staff of the institute.


Prof. Jos Oomens

[1] The (unexpected) difference in financial results 2009 and 2008 is still under investigation by the financial department of the faculty.

During the last decade the research activities of the röntgen diffraction group of HIMS have mainly focused on the analysis of polycrystalline materials. Due to budgetary restrictions within the faculty it was decided in 2009 to discontinue the röntgen diffraction activities in 2010 as a part of the cost reduction plan *Chemie Financieel Duurzaam*.

The year 2009 again turned out to be very successful in terms of external fund raising; a total of 6,56 M€ was acquired from important old and new subsidiaries:

- The National Research School Combination-Catalysis (NRSC-C) was recently re-accredited for the period 2009-2013. In 2008 HIMS received a total of 2.7 M€ for new projects (groups Reek, Elsevier, Hiemstra, Rothenberg and Wever).
- Dr. Hetterscheid, member of the Catalysis theme (group Reek) received a NWO-Veni grant for his research project *Fuel from Water*.
- NWO-ACTS (Advanced Chemical Technologies for Sustainability) awarded the groups of Profs. Rothenberg and Reek 0.41M€ for their projects *Duurzaam proces voor het maken van propeen met een zuurstofspons* and *Uitgekiende metaal complexen voor de activering van Ammoniak: op weg naar de hydroaminering van alkenen met* NH_3.
- The Smart Mix initiative CatchBio, a joint eight-year industry/academia research program in the field of catalytic biomass conversion, has awarded the groups of Prof. Rothenberg (HIMS) and Dr. Van Haveren (WUR) 1.1 M€ to carry out research on the catalytic valorisation of lignin to key phenols and aromatics.
- Prof. Rothenberg, Solarix BV, and Yellow Diesel BV (UvA) have received a 1 M€ subsidy from the Dutch Ministry of Economic Affairs for the development of new biofuels, as part of the EOS KTO program (short term energy research).

After many years of decreasing numbers, the scientific staff numbers in 2009 increased further with 20.2 fte (increase in 2008 compared to 2007: 4.6 fte). The number of externally funded PhD students and Postdocs in 2009 (122.9 fte), by funding originating from the Research Schools NRSC-C, NWO-CW/STW/FOM, and EU, ERC, BSIK/NanoNed, CatchBio and Industry, was also higher than the forgoing years (102.6 fte in 2008, 93.3 fte in 2007). Since the number of 33 vacancies at 01-01-2010 was exceptionally high (including vacancies for various staff positions), a further increase in external research funding (and scientific staff members) is expected in 2010.

At this moment the Van ‘t Hoff Institute for Molecular Sciences is housed in four different buildings located at the Roeterseiland complex, which is far from ideal. Obviously, HIMS is looking forward to the realization of the new buildings that will unite HIMS with the complete Faculty of Science on one location at the Science Park in the Watergraafsmeer. The laboratories for the research groups of Macromolecular and Biosystems Analysis, Computational Chemistry, Molecular Photonics, Bio-catalysis (group Wever) and Röntgen Diffraction are planned in the second phase on two floors of the new building D. For these groups 1566 m^2 lab space will be available. Most offices and sitting rooms and the lecture halls are located in the separate grey building in the middle, all on a very short distance from the lab-space. The research groups for Catalysis and Organic Synthesis (group Hiemstra), including the NMR-facilities, will be housed in a separate three floor building with 2052 m^2 available for the laboratories only. This renovated building is attached on one side to the main building in which the other HIMS research groups will be located, and on the other side to the bachelor student laboratories. The completion of this project is to be expected in September 2010. In this way the curriculum year 2010-2011 can start simultaneously on the same area for the complete Science Faculty.

2. Research themes

2.1. Bio-Molecular Synthesis

Two groups represent this research theme within HIMS, the Synthetic Organic Chemistry group and the Biocatalysis group. Their research is directed at the development of efficient and selective, diversity-oriented synthetic methodology, in particular organocatalytic and biocatalytic procedures, and the target-oriented preparation of molecules of relevance in chemistry, biology and medicine.

Synthetic Organic Chemistry

Four different topics of synthetic research can be distinguished:

Synthetic methodology development. Our work in iminium ion chemistry has resulted in the synthesis of several allenic lactams which were cyclized in the presence of a homogeneous gold catalyst to bicyclic drug-like molecules, among which the natural pyrrolizidine alkaloid heliotridine in enantiopure form.

Target-oriented synthesis. Our research towards the total synthesis of the terpenoid solanoeclepin A should eventually lead to simple active analogues useful in the fight against potato cyst nematodes as parasites in potato production. In 2009 the full carbon skeleton of the eastern section of the natural product was completed in enantiopure form, supported by an X-ray crystal structure determination.

Organocatalysis. Chiral biarylphosphoric acids were used to catalyse Pictet-Spengler reactions to prepare b-carbolines in high ee's. This method was applied in the first total synthesis of the indole alkaloid (-)-arboricine.

Chemical biology. Based on the azide-alkyne cycloaddition, tools for proteomics research were developed. Selective sequestering of azide-labeled peptides from extremely complex mixtures allowed the characterization of these peptides by mass-spectrometry revealing the proteins from which they originated.

Biocatalysis

The group focuses on the use and development of biocatalysts in synthetic organic chemistry as an alternative for existing chemical procedures. A four enzyme one-pot cascade reaction was developed by which is was possible to synthesize a wide variety of non-natural carbohydrates starting from glycerol and a variety of aldehyde, using pyrophosphate as an energy rich phosphorylating agent to drive the reaction to completion. Directed evolution was used to modify the enzymes involved. The antimicrobial and antiviral effect of the vanadium chloroperoxidase and a mutant obtained by directed evolution was also investigated.

Key publications and dissertations

- M.J. Wanner, R.N.A. Boots, B. Eradus, R. de Gelder, J.H. van Maarseveen, H. Hiemstra. Organocatalytic enantioselective total synthesis of (-)-arboricine, Org. Lett. 11, 2579-2581 (2009)
- A.C. Breman, J. Dijkink, J.H. van Maarseveen, S.S. Kinderman, H. Hiemstra. Expedient pyrrolizidine synthesis by propargylsilane addition to N-acyliminium ions followed by gold-catalyzed α-allenyl amides cyclization, J. Org. Chem. 74, 6327-6330 (2009)

1. R.J. Detz. Triazole-based P,N ligands; discovery of an enantioselective propargylic amination reaction, Dissertation UvA, 17.04.2009

2.2. Catalysis

The catalysis theme consists of three research groups, *Organometallic chemistry and catalysis* (Prof. Elsevier), *Homogenous and supramolecular catalysis* (Prof. Reek), and *Heterogeneous catalysis and sustainable chemistry* (Prof. Rothenberg), while there are catalysis activities in the other themes as well. The major objective of the catalysis groups is the development of new catalytic processes, which eventually contribute to the development of sustainable chemical processes. For the next decades it will also be important to develop new catalytic processes using renewals as feedstock. The Elsevier group explores novel organometallic chemistry, and devises new catalytic reactions based on this knowledge. Important reactions include CH activation, selective hydrogenation and C-C bond forming. The Reek group uses ligand design, supramolecular strategies and bio-inspired approaches to arrive at novel catalytic processes. The research spans from fundamental to applied catalysis, the latter in collaboration with industry and via the spin-off companies. The group of Prof. Rothenberg focuses on the discovery and optimization of catalysts for the clean synthesis of bulk and fine chemicals, using computational and experimental methods. Applications include clean energy (bio-diesel production, fuel cells, emission reduction), improved catalytic routes to bulk chemicals (C_1–C_6 chemistry), and waste minimization in fine chemicals manufacturing. In 2009 a new UD started in de group of Rothenberg, while Dr. Hetterscheid received a VENI grant to start research in the area of photo-catalytic processes for green energy applications in the group of Prof. Reek.

Research highlights

- A series of air-stable zero-valent Pd complexes with dissymmetric bidentate N-heterocyclic carbene-amine ligands has been reported by the Elsevier group. These compounds readily enter into catalytic cycles such as (transfer) hydrogenation of unsaturated compounds, thus circum-venting induction periods in catalysis. The amine function in the ligand enabled highly stereoselective transfer hydrogenation catalysis in the absence of the normally required additional base. As such this contributes to ‘zero-waste’ processes.
- The Reek group reported the first bimetallic rhodium catalyst that is both active and very selective in the industrially important asymmetric hydrogenation reaction. In natural enzymes this is accomplished by multi-metallic catalytic groups. The new class of adaptive ligands were shown to give bimetallic species in which the ligand in the anionic form bridges the two metal centers. As these complexes appeared stable during the reaction, their unrivalled selectivity represents a breakthrough in this area.
- The supramolecular ligand approach, in which bidentate ligands are made by self-assembly of functionalized building blocks, has been explored for several years in the Reek group. It now has been demonstrated that interaction between functional groups of the ligand and the substrates can lead to enhanced selectivities. This finding will lead to new tools for catalyst design.
- The Reek group reported a self-assembled supramolecular complex in which porphyrin chromophores are associated to a Fe-S cluster similar to the active site of a natural hydrogenase. Light absorbed by the chromophores enabled to convert protons into molecular hydrogen. Such a light-driven uphill reaction represents an important breakthrough for the technology of artificial solar fuels.
- The first-ever synthesis of a chiral Pd metal was reported by the Rothenberg group. We have succeeded in making and characterising a piece of pure palladium the size of a 10-cent coin, that is chiral. This may even change the definition of chirality, which up to now had no meaning for metals. This groundbreaking discovery was published in Nature Chemistry and featured in several international magazines and newspapers, including Chemistry World, C&EN, Chemistry & Industry and Het Parool.
- In collaboration with the Mirodatos group in Lyon, the Rothenberg group showed that mixed metal oxide catalysts can generate hydrogen gas from methane in conventional power plants. This pragmatic concept was featured in the New Scientist and received worldwide attention.

Key publications and dissertations

- F.W. Patureau, S. de Boer, M. Kuil, J. Meeuwissen, P.-A, R. Breuil, M.A. Siegler, A. L. Spek, A.J. Sandee, B. de Bruin, J.N.H. Reek, Sulfonamido-Phosphoramidite Ligands in Cooperative Dinuclear Hydrogenation Catalysis. J. Am. Chem. Soc. 2009, 131, 6683-6685
- A.M. Kluwer, R. Kapre, F. Hartl, M. Lutz, A.L. Spek, A.M. Brouwer, P.W.N.M van Leeuwen, J.N.H. Reek Self-assembled Biomimetic [2Fe2S]-Hydrogenase Based Photocatalyst for Molecular Hydrogen Evolution, PNAS, 2009, 26, 10460
- P.-A. Breuil, F. W. Patureau and J. N. H. Reek, LEUPhos: Single hydrogen-bonded supramolecular ligands for highly selective rhodium-catalyzed hydrogenation of methyl 2-hydroxymethylacrylate and its derivatives, Angew. Chem. Int. Ed., 2009, 48, 2162
- L. Durán Pachón, I. Yosef, T.Z. Markus, R. Naaman, D. Avnir and G. Rothenberg, Chiral imprinting of palladium with cinchona alkaloids. Nature Chemistry, 2009, 1, 160-164
- J. Beckers, C. Gaudillere, D. Farrusseng and G. Rothenberg, Marrying gas power and hydrogen energy: A catalytic system for combining methane conversion and hydrogen generation, Green Chem., 2009, 11, 921-925
- D.G.H. Hetterscheid, J.I. van der Vlugt, B. de Bruin, J.N.H. Reek, Water splitting by cooperative catalysis, Angew. Chem. Int. Ed. 2009, 48, 8178-8181
- B. de Bruin, W.I. Dzik, S. Li, B.B. Wayland, Hydrogen-Atom Transfer in Reactions of Organic Radicals with [Co^{II}(por)]. (por=Porphyrinato) and in Subsequent Addition of [Co(H)(por)] to Olefins. Chem. Eur. J, 2009, 15(17), 4312-4320
- G. Berthon-Gelloz, B. de Bruin, B. Tinant, M.I. Marko, Structure and Reactivity of a Unique Y-Shaped Tricoordinate Bis(silyl)platinum(II)-NHC Complex, Angew. Chem. Int. Ed., 2009, 48(17), 3161-3164
- R. Wolf, J.C. Slootweg, A.W. Ehlers, F. Hartl, B. de Bruin, M. Lutz, A.L. Spek, K.A. Lammertsma, Phosphorus Analogue of Bis(h 4-cyclobutadiene)iron(0). Angew. Chem. Int. Ed., 2009, 48(17), 3104-3107
- M.R. Eberhard, B. van Vliet, L. Durán Páchon, G. Rothenberg, G. Eastham, H. Kooijman, A.L. Spek, C.J. Elsevier. A Simple Building-Block Route to (Phosphanyl-carbene)palladium Complexes via Intermolecular Addition of Functionalised Phosphanes to Isocyanides. Eur. J. Inorg. Chem., 2009, 1313-1316

1. A.V. Gaikwad, Nanocatalysts: properties and applications, dissertation UvA, 17.02.2009
2. J. Beckers, Solid oxygen reservoirs for selective hydrogen oxidation, dissertation UvA, 22.09.2009
3. B. Swennenhuis, Self-assembly, characterization and properties of novel polynuclear catalysts, dissertation UvA, 28.05.2009
4. F. Dorro, Phosphacycle containing ligands, dissertation UvA, 30.06.2009
5. J. Meeuwissen, Urea-functionalized phosphorus ligands in transition metal catalysis, dissertation UvA, 2.12.2009
6. F. Patureau, Sulfonamido-phosphorus ligands, and their application in cooperative transition metal catalysis, dissertation UvA, 2.12.2009
7. P.-A. Brieul, Monodentate supramolecular dynamic phosphoramidite ligands based on amino acids in asymmetric hydrogenation reactions, dissertation UvA, 4.12.2009
8. J. Flapper, Nickel and palladium complexes of pyridine-phosphine ligands: synthesis, characterization and ethene oligomerization, dissertation UvA, 05.02.2009

2.3. Computational Chemistry

Developments in computational chemistry focus on simulating more complex systems on increasingly longer time- and length scales. This trend is facilitated both by the continuous increase of computing power, and, more importantly, the application of new theoretical concepts and development of novel efficient computational methods. One of the important aspects is to use a hierarchical approach: linking simulation techniques for different time and length scales. The Computational Chemistry group is one of the few molecular simulation groups in the world that have expertise on all relevant length and time scales. It spans the full range from the molecular quantum level up to the macroscopic scale and its expertise involves both the development of novel methods as well as its application to arrive at fundamental understanding of a wide range of complex phenomena of chemical, physical, and biological nature.
To strengthen our national and international position we have been actively involved in creating the Amsterdam Center of Multiscale Modelling (ACMM) and the Dutch node of Centre Européen de Calcul Atomique et Moléculaire (CECAM). The ACMM combines the expertise of the computational chemistry group at HIMS with that of the theoretical chemistry group of Baerends at the VU, and the computational biophysics group at FOM-AMOLF. Together with the Lorentz Center the ACMM has become a key part of the Dutch CECAM node reflecting the recognition as an internationally renowned centre of computational expertise of all length and time scales relevant for chemistry and related fields in physics and biology.

Research highlights
The group has kept a strong record in modelling complex phenomena in chemical, physical, and biological systems. A selection of the major achievements is given below. The group has been also successful in acquiring 1.2 M€ external funding for research projects via a FOM-Academic Program (Proton mobility in confinement), a FOM-Industrial Partnership Program (Bio-related materials) and the Netherlands Nanoinitiative program.

Nanoporous media. The design and development of many emerging separation and catalytic process technologies require a proper quantitative description of diffusion of mixtures of guest molecules within meso- and microporous structures. With the aid of extensive data sets of molecular dynamic simulations of unary and mixture diffusion in a wide variety of materials such as zeolites, metal-organic frameworks, covalent organic frameworks, carbon nanotubes, and cylindrical silica pores with a diverse range of pore topologies and pore sizes, we derive a molecular-level understanding of the various coefficients that arise in the phenomenological Maxwell-Stefan diffusion formulation. This also demonstrates how a molecular level understanding aids separation and reaction process development. The silicate oligomerization reaction is key to zeolite synthesis. Numerous studies have addressed the physical chemistry of silicate oligomers in the prenucleation stage of siliceous zeolite formation, but the molecular details of the process are still not clear. We have studied silica condensation reaction in aqueous solution with and without the presence of counter ions using ab-initio molecular dynamics simulations. We have found that contact with Li^+ as well as NH_4^+ increases the activation energies of the dimerization step compared to the situation in the absence of counter-ions, and that the presence will increase the relative formation rate of larger oligomers.

Dynamics and structure of (biological) macromolecule. Triblock copolymers consisting of a middle silk-like block flanked by two hydrophilic end blocks that assume a random conformation in aqueous solution at all pH spontaneously assemble into micrometre long fibres at low pH. We revealed the molecular structure of the stacked middle blocks by extensive replica exchange molecular dynamics simulations, and predict the thermodynamically stable conformation of the middle block to be a ß-roll. This ß-roll is not inconsistent with the circular dichroism spectra in water, and directly explains the width of the fibres in water, as deduced from small angle X-ray scattering. These findings explain the conformational properties of net uncharged middle silk-like block in water, and provide a rationale for the solvent-dependency of the molecular conformation of silk-like Gly-Ala repeats in general. They may thus facilitate the design of new self-assembling silk-like materials with novel functionality.

Methods for simulation complex systems. Hydrogen bonds play an important role in stabilizing (meta-)stable states in protein folding. Hence, they can potentially be used as a way to bias these states in molecular simulation methods. We developed a novel hydrogen bond switching (HS) method that involves a Hamiltonian replica exchange molecular dynamics scheme that shuffles and reorders hydrogen bonds in the protein backbone. Extensive validation of the HS method showed that it provides an efficient way to sample the conformational space of a protein, without requiring knowledge of the folded states beforehand.
Together with the group of Visscher (VU) we have developed an accurate adaptive multiscale molecular dynamics method that treats the chemically reactive regions at the quantum mechanical level and inert embedding regions at lower levels of accuracy, while at the same time molecules are allowed to flow across the border between active and inert embedding regions. This scheme affords accurate investigation of chemical reactions in solution.

(Bio)polymers in flow. Microscopic semiflexible filaments suspended in a viscous fluid are widely encountered in biophysical problems. The classic example is the flagella used by microorganisms to generate propulsion. Simulating the dynamics of these filaments numerically is complicated because of the coupling between the motion of the filament and that of the surrounding fluid. We developed an approach where the fluid motion is modelled by using Stokeslets distributed at equal intervals along the model filament. We show that, with an appropriate choice of the hydrodynamic radii, one can recover accurate hydrodynamic behavior of a filament with a finite cross section without requiring an explicit surface. We use the model to compare with analytic theory of filament deformation and rotation in the small deformation limit.

Key publications and dissertations

- J. Juraszek and P.G. Bolhuis, Effects of a mutation on the folding mechanism of beta-hairpin, J. Phys. Chem. B 113, 16184 (2009)
- R. Krishna, Describing the diffusion of guest molecules inside porous structures, J. Phys. Chem. C 113, 19756 (2009)
- A.G. Bailey, C.P. Lowe, I. Pagonabarraga, and M.C. Lagomarsino, Accurate simulation dynamics of microscopic filaments using 'caterpillar' Oseen hydrodynamics, Phys. Rev. E 80, 046707 (2009)
- T. T. Trinh, A. P. J. Jansen, R. A. van Santen, J. VandeVondele and E.J. Meijer, Effect of counter ions on the silica oligomerization reaction, Chem. Phys. Chem. 10, 1775 (2009)
- R. E. Bulo, B. Ensing, J. Sikkema, and L. Visscher, Toward a practical method for adaptive QM/MM simulations, J. Chem. Theory Comput. 5, 2212 (2009)
- M. Schor, A.A. Martens, F.A. deWolf, M.A. Cohen Stuart, and P.G. Bolhuis, Prediction of solvent dependent beta-roll formation of a self-assembling silk-like protein domain, Soft Matter 5, 2658 (2009)
- J. Vreede, J. Wolf, M. G. de Leeuw, and P.G. Bolhuis, Reordering hydrogen bonds using Hamiltonian replica exchange enhances sampling of conformational changes in biomolecular systems, J. Phys. Chem. 113, 6484 (2009)

1. J.A. van Meel, A numerical study on the enhancement and suppression of crystal nucleation, dissertation UvA, 20.10.2009
2. N. Geerts, DNA-driven assembly of micron-sized colloid, dissertation UvA, 27.11.2009
3. A.M. Adiciptaningrum, Phase variation of type 1 fimbriae : a single cell investigation, dissertation UvA, 16.01.2009

2.4. Macromolecular and Biosystems Analysis

The Analytical Chemistry group is the research cluster of the Macromolecular and Biosystems Analysis theme within HIMS. Originally, the group focused on methods for the separation and characterization of natural and synthetic macromolecules. During the past years the expertise of the group was already used in a widening application field. Typical focus points, such as the development and application of multi-dimensional separations or the miniaturization of analytical instrumentation towards the micro- and nano-scale, were shown to be of interest in various areas outside the polymer world. Projects were initiated directed on e.g., pharmaceutical, clinical and food analysis. The involvement of the group in teaching for the master program Forensic Sciences led to new contacts with the Dutch Forensic Institute and others active in forensic analysis. Many points of common interest were found with these new contacts, and a variety of opportunities for research cooperation were explored, in the beginning mostly as student projects. However, it appeared to be increasingly important to formalize our collaboration in forensic analysis, and therefore the chair of the theme was redefined in 2009 to *Analytical chemistry and its application in forensic analysis*. At the end of 2009 a first research contract sponsored by the NFI was started on forensic explosives analysis (PhD student H. Brust).

Research highlights

An important event in 2009 was the appointment of Dr. Gabriel Vivó-Truyols as a staff member, who's specialization is in chemometrics and data processing. His expertise will be very welcome in a variety of projects, e.g. processing and interpretation of data from two-dimensional separations. Moreover, his appointment will alleviate the teaching load of the group.

Apart from the forensic project mentioned earlier, two other research projects were started in 2009. One project on Innovations in Gas Chromatography (PhD student D. Peroni) is sponsored directly by industry. The USB Foundation granted a project that will be executed in cooperation with the University of Stellenbosch (South Africa) on Tuberculosis smelling among children (PhD student: vacancy). This project is a spin-off from the research project on pyrolysis-GC-MS presently elaborated in the group by PhD student E. Kaal. Its purpose is to develop methods and instrumentation to detect TB infections among children with greater sensitivity and specificity than existing diagnostic tests, and with minimal impact for the children.

Key publications and dissertations

- Bedani, F; Kok, WT; Janssen, HG, Optimal gradient operation in comprehensive liquid chromatography x liquid chromatography systems with limited orthogonality, Analytica Chimica Acta, 654, 77-84, 2009
- Qureshi, RN; Kok, WT; Schoenmakers, PJ; Fractionation of human serum lipoproteins and simultaneous enzymatic determination of cholesterol and triglycerides, Analytica Chimica Acta, 654, 85-91, 2009
- Eeltink, S; Dolman, S; Swart, R; Ursem, M; Schoenmakers, PJ; Optimizing the peak capacity per unit time in one-dimensional and off-line two-dimensional liquid chromatography for the separation of complex peptide samples, Journal of Chromatography A, 1216, 7368-7374, 2009
- Kaal, E; Kolk, AHJ; Kuijper, S; Janssen, HG; A fast method for the identification of Mycobacterium tuberculosis in sputum and cultures based on thermally assisted hydrolysis and methylation followed by gas chromatography-mass spectrometry, Journal of Chromatography A, 1216, 6319-6325, 2009

1. Peters, R; Characterisation of network polymers, Dissertation UvA, 22.01.2009

2.5. Molecular Photonics

Light-induced chemical conversions play a key role in many technological and biological processes, the most important of all being photosynthesis. Understanding the interaction of light and molecular matter is therefore highly significant. Molecular Photonics aims to advance the fundamental knowledge of the dynamics of excited states in molecules and nano-sized objects, and to contribute with its expertise to applications of the photosciences. The Molecular Photonics group is unique within the Netherlands because it combines the skills of internationally recognized experts in molecular synthesis, spectroscopy and theory. Fields of research are energy and electron transfer, catalytic reactions, and conformational dynamics. This leads to investigations of molecular switches and motors, nanoparticles and photochemical reactions. Topical application areas are found in photochemical energy conversion, polymer science, mechanisms of catalysis, biomedical imaging, and phototherapies. The Molecular Photonics group is a full partner in the LCVU, a European facility (Laser Lab Europe), member of the recently established Amsterdam Institute for Laser Sciences and BioPhotonics, and participates in the Holland Research School of Molecular Chemistry.

Molecular nanotechnology. A wide variety of spectroscopic and theoretical studies has successfully elucidated various fundamental and applied aspects of light-responsive synthetic motor molecules. Using the Free Electron Laser at FOM Rijnhuizen and novel techniques like helium droplet spectroscopy, we have shown how these complex multi-component systems are now within reach of high-resolution UV/IR spectroscopic techniques. The functioning of molecular machines involves the critical balance of intrinsic factors like photochemical reactivity and external factors like friction. Studies of frequently employed switching motives like fumaramide have disclosed the principles behind its reactivity and how to control it, studies of the influence of viscosity have led to a fundamental understanding of the effects of friction. Elementary events that underlie the mechanical motion have until recently not been accessible to detailed studies. We have demonstrated now how each of these events can be observed separately with 2D-IR spectroscopy, thus leading to new insights into the function of molecular machines.

Controlling nonradiative decay. Intersystem crossing in acetylene has fascinated - and frustrated - for decades experimental and theoretical scientists alike. Employing an experimentally challenging approach based on 2D excited-state photoelectron spectroscopy, we have unveiled some its mysteries. We find remarkable interferences between singlet-triplet coupling pathways, conceptually similar to Young's famous double-slit experiment. This observation opens up exciting possibilities for external control schemes over nonradiative decay pathways.

Protein folding. In 2009, we have obtained the first results in our research effort to apply time-resolved vibrational spectroscopy to study protein folding, one of the most important unsolved problems in biophysics. In a cooperation with the UvA groups of Van Maarseveen/Timmerman (peptide synthesis) and Bolhuis (MD simulations), we investigate the fast-folding synthetic mini-protein Trp cage. By combining site-directed isotope-labelling with two-dimensional vibrational spectroscopy, we are now able to probe molecular conformations at the level of specific dihedral bond angles, with picosecond time resolution. Test experiments with the laser setup during its construction phase resulted in the discovery of the relaxation mechanism of vibrational relaxation in hydrogen-bonded liquids.

Nanomedicine. In close cooperation with AMC (van Leeuwen and Aalders) a novel luminescence upconversion nanoplatform for the diagnosis and treatment of cancer has been developed. This nanoplatform, which is based on nanoparticles doped with lanthanide ions, has now passed successfully the exploratory phase and has arrived at the stage of in-vitro imaging and cytotoxicity tests. Apart from the efforts at the UvA, part of the success of the project should undoubtedly be attributed to the unique collaboration with the Changchun Institute of Optics, Fine Mechanics and Physics of the Chinese Academy of Sciences (CIOMP/CAS) where Zhang co-chairs the nanobiology/nanomedicine group (2 professors, 1 associate professor, 1 assistant professor, 12 PhD students and 2 post-docs).

Energy conversion. In collaboration with the Homogeneous Catalysis group a biomimetic catalyst for the photoreduction of hydrogen has been designed, synthesized and characterized. A key feature is the self-assembly of the catalyst, which opens the way to combinatorial optimizations.

Orientational and conformational effects in electron transfer. Probing pathways for charge transfer and the effects of chromophore orientation and molecular conformation on this process has been achieved. A uniform description by the current theory does not hold when a helical foldameric biomimetic bridge is used as a scaffold to organize the chromophores. Molecular orbital calculations rationalize the fast (experimentally observed) photoinduced charge separation, by revealing that the bridging helical foldamer mediates the charge transfer from donor to acceptor via the superexchange mechanism. When probing ground-state conformations with excited-state dynamics of charge separation and recombination in a pyrene-calix[4]arene-perylene bisimide dye system the simultaneous target analysis of the femtosecond data matrices obtained in the visible and NIR regions indicates two ground-state populations (π-stacked and extended) and spectral and kinetic distinction of a compact and an extended charge-transfer state upon visible excitation.

Key publications and dissertations

- Shaw, D.J.; Panman M.R.; Woutersen, S., Evidence for cooperative vibrational relaxation of the NH-, OH-, and OD-stretching modes in hydrogen-bonded liquids using infrared pump-probe spectroscopy. Phys. Rev. Lett. 2009, 103, 227401
- Liu, X.M.; Zhao J.W.; Sun, Y.J.; Song, K.; Yu, Y.; Du, C.A.; Kong, X.G.; Zhang, H., Ionothermal synthesis of hexagonal-phase $NaYF_4$:Yb^{3+},Er^{3+}/Tm^{3+} upconversion nanophosphors. Chem. Comm. 2009, 43, 6628-6630
- Bodis, P.; Panman, M.R.; Bakker, B.H.; Mateo-Alonso, A.; Prato, M.; Buma, W.J.; Brouwer, A.M.; Kay, E.R.; Leigh, D.A.; Woutersen, S., Two-dimensional vibrational spectroscopy of rotaxane-based molecular machines. Acc. Chem. Res. 2009, 42, 1462-1469
- Kluwer, A.M.; Kapre, R.; Hartl, F.; Lutz, M.; Spek, A.L.; Brouwer, A.M.; van Leeuwen, P.W.N.M.; Reek, J.N.H., Self-assembled biomimetic [2Fe2S]-hydrogenase-based photocatalyst for molecular hydrogen evolution. Proc. Natl. Acad. Sci. 2009, 106, 10460-10465
- Wolffs, M.; Delsuc, N.; Veldman, D.; Van Anh, N.; Williams, R.M.; Meskers, S.C.J.; Janssen, R.A.J.; Huc, I.; Schenning, A.P.H.J., Helical aromatic oligoamide foldamers as organizational scaffolds for photoinduced charge transfer. J. Am. Chem. Soc. 2009, 131, 4819-4821
- Rijs, A.M.; Compagnon, I.; Oomens, J.; Hannam, J.S.; Leigh, D.A., Buma, W.J., Stiff and sticky at the right places: binding interactions in isolated mechanically interlocked molecules probed by mid-infrared spectroscopy. J. Am. Chem. Soc. 2009, 131, 2428-2429
- de Groot, M.; Field, R.W.; Buma, W.J., Intersystem crossing in acetylene: interference effects reveal a double doorway mechanism. Proc. Natl. Acad. Sci. 2009, 106, 2510-2514

1. Zoon, P.D., Fluorescent probe molecules with individual detection capability, Dissertation UvA, 17.06.2009

3. Strategy, activities and results

As is described in the FNWI-CvB convenant 2009-2010, implementation of the *Sectorplan Natuurkunde en Scheikunde* (SNS/sciences sector plan) is of major importance to HIMS. Our research activities[2] in synthesis, catalysis, analysis, spectroscopy/photonics and multiscale modelling are part of the joint investment plan of the Amsterdam universities UvA/VU, which will prospectively further strengthen the level of the Institute and the Amsterdam area as a whole on the short term.
New initiatives of HIMS to be mentioned are the ongoing explorations towards more intense forms of cooperation with other academic and non-academic partners, such as the Medical Faculty/Academisch Medisch Centrum (AMC) of the UvA, the VU University (in the framework of the SNS), the FOM institutes AMOLF & Rijnhuizen, and important new country-wide initiatives such as CatchBio and Comprehensive Analytical Science and Technology (TI-COAST).
A few important new nation wide developments with HIMS participation are the FES programmes *Towards Biosolar Cells* and *Towards a Sustainable Open Innovation Ecosystem.* The latter programme includes the Netherlands Nano Initiative (NNI). HIMS is also partner in the new programme quantitative multidimensional imaging for individualized treatment (QUANTIVISION); and part of the countrywide initiative NWO-Theme *New Instruments for Healthcare* (NIG)

Appointments of special (endowed and part-time) professors are also important for HIMS to further strengthen the level of the Institute. This HIMS policy is illustrated by the appointment in 2009 of Prof. J. Oomens as endowed professor from FOM/Rijnhuizen through the Stichting Fysica for a period of 5 years. New appointments will follow in the coming years.
It is increasingly difficult to attract and keep top talent. We hope that the new tenure track policy of the faculty (including the MacGillavry fellowships) will help to overcome this threat.

An important development for HIMS in 2009 was the selection of *Systems Biology* and *e-Science* as faculty spearheads, and HIMS will explore possible participation in the coming years. Additionally discussions were started to promote UvA sustainability efforts. Sustainability is a major profile of HIMS, with activities in all HIMS themes.

Valorisation of know-how is of increasing importance, as evidenced by the new HIMS spin-off company InCatT established at 01-08-2009 under the umbrella of the UvA Holding. In order to protect our intellectual property, HIMS follows an active patenting policy, on most occasions directly with our industrial partners. The institute has applied for several patents, while some new projects are promising. In the future out-licensed patents could be important for HIMS as source of income.

The Faculty of Sciences recently started a new MSc programme in Forensic Sciences, an exclusive collaboration with the Netherlands Forensic Institute (NFI), and in Art (Conservation & Restoration) Sciences, a collaboration with the Faculty of Humanities. To create and sustain a master-level course, we believe it is essential to combine research with education. HIMS is in an excellent position to conduct research projects in forensic science and art science because of our knowledge in analysis, spectroscopy and characterization. Research activities are gaining momentum in the Analytical Chemistry / Forensic Science group (Schoenmakers), where one PhD student is fully funded by the NFI, and two PhD students are conducting their research externally. It is anticipated that additional projects will be started soon for both Forensic - and Art sciences, with various partners and partially based on new NWO (launched in 2010) and EU programmes.

Strategies for each research theme are briefly outlined below, related to the *Sectorplan Natuurkunde Scheikunde* (SNS), the collaboration with the VU and other partners, and in line with the advice of the Scientific Advisory Committee.

[2] We have obtained financial support in the framework of the SNS for the appointments of two new chairs (biocatalysis and supramolecular separations) and two tenure track staff positions, one of which should be a woman. The HIMS part of the investment plan assigned is altogether 0.58 M€/year for 5 years (total investment 2.9 mln €).

Bio-molecular Synthesis (BMS)
Synthesis research remains an important discipline for various medical and industrial applications. Considering the investment obtained from the SNS, the joining of forces with synthesis activities at the VU University Amsterdam, the presence of the AMC, and the strong interactions with the Catalysis groups, the Biomolecular Synthesis theme will be well equipped for the next decade.

Catalysis (CAT)
The Catalysis theme has been strengthened in recent years in line with the focus and mass policy followed in the Netherlands, and is well equipped to realise their full potential in the coming years. With the expected appointment of a new chair holder in bio-catalysis in 2011 (see also the SNS plan), the UvA has a unique position in the Netherlands because all catalysis disciplines are actively pursued. In the near future we will take advantage of this situation to start new activities, e.g. in green energy with Molecular Photonics, and by establishing a Synthesis and Catalysis Centre of Expertise together with the VU to attract more high potentials.

Computational Chemistry (COMP)
In 2007 computational chemists from both Amsterdam universities and computational physicists from AMOLF established the Amsterdam Center for Multiscale Modelling (ACMM); since 2009 they are part of a CECAM node. With the expected appointment of a new professor of Molecular Simulation the theme will be able to extend collaborative efforts within HIMS and with Systems Biology and Physics, i.e. with SILS, NISB, and WZI. It is anticipated that ACMM will become a strong and viable partner in the e-Science Research Center, and play an (inter)nationally leading role in the field of molecular and multiscale simulation.

Macromolecular & bio-systems analysis (MBA)
The research programme of this theme has been stimulated by new education programmes (forensic science, art science) and by the strong nationwide cooperation in the field of analytical chemistry through the TI-COAST initiative. TI-COAST and the good collaboration with strong groups at the VU University (Gooijer and Irth) in the framework of the SNS create an ideal opportunity to establish a national Center of Expertise in Amsterdam.

Molecular Photonics (MOLP)
The theme defined a new research programme which identifies a limited number of priorities based on existing strengths and promising collaborations. Health and Energy were chosen as important application areas and the theme started new strategic alliances within HIMS and with related groups from the VU (also in the framework of TI-COAST), the FOM institutes AMOLF and Rijnhuizen, photonics-oriented groups in hospitals (e.g. the Biomedical Engineering and Physics department of the AMC), and WZI. Together with the Catalysis theme of HIMS we can hopefully strengthen our activities in the area of photo-catalysis for green energy application, a research area that is of high societal importance.

The formal research collaboration with the VU is the most important partnership of HIMS within the Amsterdam area. In 2009 the profiling of the present five research themes of HIMS (including biochemistry/systems biology from SILS/UvA) has been discussed extensively with colleagues from the VU, resulting in a revision and combination of the chemistry programmes of both universities. In the framework of the countrywide focus and mass policy, key research themes have been defined with a strong focus either at UvA or VU. The research themes that are fully aligned with the research themes presented in the SNS are:

- *Synthesis & Catalysis (mainly UvA/HIMS expertise)*
- *Analytical Chemistry & Spectroscopy (existing synergy with VU groups)*
- *Theoretical Chemistry (ACMM/existing synergy with VU groups)*
- *Medicinal, Bio-Organic & Synthetic Chemistry (VU expertise)*
- *Chemical Biology (NISB/mainly UvA/SILS expertise)*

Together with our VU colleagues it is our ambition to establish Centers of Expertise for all key research themes. Furhermore, the Science Faculty of the VU, the FOM/NWO institutes, the academic medical centres AMC and VUmc, institutions such as the NKI, and the Science Faculty of the UvA aim to establish *Amsterdam: City of Science*, with an important role for chemistry (HIMS).

Summarizing, HIMS is performing scientific and applied research of importance for a sustainable society, energy supply, health, forensic applications, and is active in valorisation of know-how. HIMS participates in important national and international research programmes, such as NRSCC, CATCHBIO, TI-COAST, together with researchers from the AMC, VU, FOM institutes and the chemical industry. In addition, HIMS is active in several EU programmes. HIMS will expand their teaching efforts and start research activities in forensic- and art sciences. Finally, HIMS will increase the number of PhD diplomas and the efficiency of the doctoral research path, in line with the 100+ programme of the faculty. An overview of the HIMS activities, objectives and results for the period 2010-2012, as defined in the FNWI-UvA convenant are given in the following table.

	Activities	***Objectives and results***
2010	a. recruitment from outside and guest PhD students b. improve the efficiency of the doctoral research path through better control and guidance c. develop policies for appointing of 1-6 endowed (part-time) professors d. discussions with education- and teaching directors, from within and outside the faculty, about a greater HIMS share HIMS in teaching tasks e. agree with the colleagues of the VU for the three HIMS key-areas on the creation of Centers of Expertise (according ACMM) f. new research initiatives with the VU, including in the new field of renewable energy (including Physics UvA and VU) g. New research initiatives in the field of forensic- and - art sciences with various partners, based on such new NWO (early 2010) and EU programs	Ad a. 1-3 additional PhD Ad b. develop and formulate policies Ad c. preparation and appointment of 1-2 new (preferably endowed) part-time professors Ad d. agree on the share in the 2010-2011 curricula Ad e. agree and formulate together with the VU colleagues for CoE *Synthesis & Catalysis* and CoE *Analysis and Spectroscopy* Ad f. prepare and submit new research initiatives together with VU colleagues Ad g. prepare and submit projects in NWO- and EU programs together with various relevant partners and in consultation with the faculty coordinator FS (Kimmo Himberg)
2011	a. see 2010 b. see 2010 c. see 2010 d. increase contribution to develop /update / implement teaching modules. e. see 2010 f. see 2010 g. see 2010	Ad a. see 2010 Ad b. efficiency 5% better. Ad c. appointment of 1-2 new (preferably endowed) part-time professors Ad d. 5% increase in the share of HIMS in various courses together Ad e. opening CoE *Synthesis & Catalysis* and opening CoE *Analysis and Spectroscopy* Ad f. 1-2 new joint research projects. Ad g. 1-2 new joint research projects.
2012	a-g. Evaluation of activities and achievement of objectives and results and realize possible extensions	Ad a. 2-5 additional PhD students in 2010-2012 Ad b. 10% efficiency improvement in plan period 2010-2012 Ad c. 3-6 (preferably endowed) part-time professors appointed in 2010-2012 Ad d. 5-10% increase of the HIMS share in various special courses in the plan period Ad e. new projects submitted with the VU colleagues in the context of the CoE Ad f. 2-4 new joint research projects. Ad g. 2-4 new joint research projects.

4. Dissemination of knowledge, valorisation, promotional activities

Bio-Molecular Synthesis
Hiemstra is editor of the European Journal of Organic Chemistry and has edited volume 48 of Science of Synthesis (Thieme Verlag, Stuttgart, 2009). He gave a lecture at the kickoff meeting of the 3rd grant period of the Catalysis research school NRSCC in Utrecht, Nov 2009.
Van Maarseveen was one of the organizers of the HRSMC summer school 'Synthesis towards bioactive compounds' in Maastricht, July 2009. He was elected best teacher of the year by the Life Sciences students.
The continuing research on the vanadium chloroperoxidase resulted in a patent application (R. Wever, Antifouling coating containing enzymes, European patent application 9160004.9). The group leader visited Danisco, Aarhus, Denmark and the University of Aarhus to initiate co-operation on this subject. Cooperation on the use of the enzyme to prevent biofilm formation in the oral cavity was set up with prof. Crielaard (ACTA). Furthermore, the group leader lectured at the NIOK Master Course in Biocatalysis in Delft and the B-Basic Master Class 'Directed Evolution and Protein engineering for Biocatalysis' in Groningen to highlight some of the research activities of the group.

Catalysis
Yellow Diesel BV received a boost with the success of scaling up the biodiesel process to liter scale, and producing biodiesel that conforms to the European norm EN14214. The company is now negotiating the construction of a pilot plant. InCatT BV, Innovative Catalyst Technologies, is a spin-off company that started in august 2009 based on IP generated by the Reek group in the area of supramolecular transition metal catalysis. It provides screening services for industrial relevant catalytic processes using supramolecular ligand approaches and evolutionary screening. The official start of InCatT was celebrated with the InCatT symposium, a joined effort of the Reek group combined with the defense of 3 related PhD theses during that week.

- Chiraal Metaal. A. Dijkgraaf, C2W, 16.05.2009
- Gold might become tasty. A. Turley, Chemistry & Industry, 10.05.2009
- Imparting chirality to metals. M. Jacoby, C&EN, 2009, 87, 10
- Existing gas power plants could pump out hydrogen. C. Barras, New Scientist, 12.05.2009
- Chiral metals shape up for catalysis. H. Birch, Chemistry World, 20.04.2009
- Rijden op liters oud frituur en slachtvet. J. Zandhuis, Het Parool, 14.02.2009
- Blokken: knutselen met katalyse: De Pers, 25-11-2009

Computational Chemistry
The group has a strong record in the field of training, valorisation, and promotional activities related to molecular simulation. Via the AtoSim program it runs a one-year MSc program in the field of molecular simulation together with the Ecole Normale Superieur Lyon and the University La Sapienza Rome. AtoSim targets top students from all over the world, and will provide an important source of well-trained PhD students. The 2008/2009 class consisted of 12 students. ATOSIM is supported via the EU Erasmus Mundus program.
The 2009 edition of MolSim in January continued the strong tradition of providing a 2-week intensive and targeted PhD training course in molecular simulation. The school attracted about 70 participants from all over the world. The school was financially supported (45 k€) by CECAM and the ESF program SimBioMa.
Through the FOM-IPP program there are several connections to the industry (dairy industry, Unilever, DSM, etc.) mediated by institutions such as DPI, TIFN, and NIZO.

Macromolecular and Biosystems Analysis
The group is strongly supported by the Dutch Polymer Institute (DPI) and the Dutch nanotechnology initiative (NanoNed). In addition, the group receives massive support from several companies. AstraZeneca, Atlas GL (GL Science), Dow Chemical, NLisis, Syngenta, and Waters provide invaluable support and high-level scientific input for specific PhD projects, while AkzoNobel, DSM,

Leco, Océ Technologies, Philips, Polymer Laboratories (Varian), Shell, Shimadzu, Unilever, and Wyatt Technology help to make other projects possible.
TI-COAST (Comprehensive Analytical Science and Technology) is an initiative to cluster existing and new techniques in the analytical and spectroscopic fields with the main target to achieve break-throughs using informatics and nanotechnology. The TI-COAST business plan was completed August 2009, and there is a high probability that implementation will start in 2010. The HIMS professors Schoenmakers and Janssen are both appointed as board members of TI-COAST.
It is obvious that the research performed in the group and the results obtained are of significant relevance for industry and society.

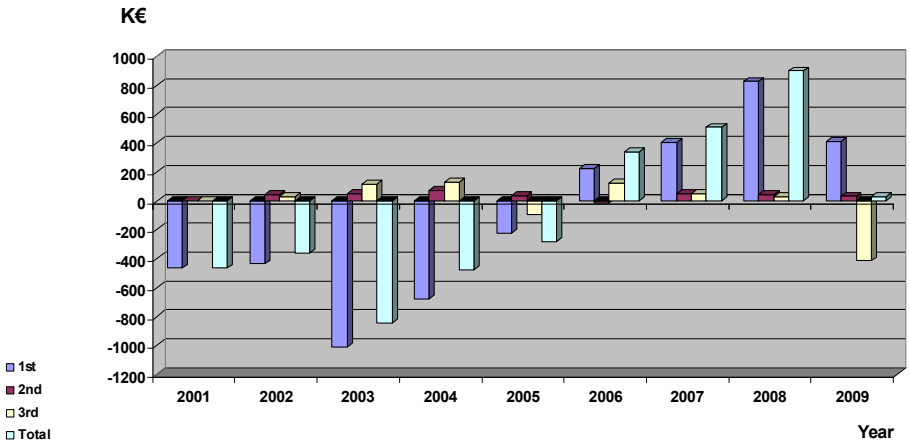
Molecular Photonics
A large part of the key publications has attracted the attention of the popular press, leading to articles and commentaries in popular journals and on the web. Promotional activities included contributions to popular scientific journals (Nederlands Tijdschrift voor Natuurkunde) and lectures like *Atomen en moleculen: van Democritus tot moleculaire machines*, a bèta-lecture by Dr. Woutersen at CREA.

5. Management and finances

Since 2006, the year of introduction of the new (integral costs) allocation model of the university board, the financial position of HIMS has much improved, reflecting the foreseen effect of the reorganization of the chemistry department that took place in the years 2002-2004, as illustrated by the graph below. However, the integral result (all funding sources) obtained in 2009 (-12 k€) is appreciably lower than obtained in 2008 (+899 k€), related to a 5% lower internal budget. This reduction forced the institute not to fulfil vacancies in the 1st moneystream, therefore 726 k€ less was spent on salary costs. Again, HIMS was successful in obtaining external funds: the 2nd and 3d moneystream increased with 613 k€, while the contributions to running projects were raised with 445 k€. The other costs increased with 603 k€ because of higher prices for basic facilities. The negative result in the 3rd funding source (-414 k€) is related with several error entries in the bookkeeping. The negative 3rd result will be booked in 2010 to the 1st moneystream where it belongs.

A general overview of HIMS resources and results in the current decade is presented in the diagram below.

HIMS result 2001 – 2009 (all funding sources; k€)



Funding source 1st: University (direct) funding and NRSC-Catalysis
2nd: NWO, FOM and STW
3rd: EU, BSIK and Industrial

More specifically, actual numbers of 2009 and 2008 are given in the subsequent tables, as well as the difference with the previous year.

HIMS resources and results 2009 (€)

2009	**1st**	**2nd**	**3d**	**total**
Total benefits/budget	**7.095.595**	**3.749.627**	**3.698.846**	**14.544.065**
Direct/UvA 1st	9.694.946			9.694.946
External funding 1st	79.527	1.813.036	2.278.041	4.170.604
Internal funding	6.936.539			6.936.539
Contribution running projects	-2.678.878	1.936.591	1.420.805	678.518
Total costs	**6.727.288**	**3.716.198**	**4.112.881**	**14.556.366**
Personnel costs	3.990.357	1.661.098	1.295.736	6.947.191
Other costs	2.736.931	2.055.100	2.817.145	7.609.176
Result 2009	**368.307**	**33.429**	**-414.035**	**-12.301**

HIMS resources and results 2008 (€)

2008	**1st**	**2nd**	**3d**	**total**
Total benefits/budget	**9.118.106**	**2.782.097**	**3.095.654**	**14.995.857**
Direct/UvA 1st	11.159.063			11.159.063
External funding 1st	125.528	1.329.843	2.147.789	3.603.160
Internal funding	13.200.020			13.200.020
Contribution running projects	-2.166.485	1.452.254	947.865	233.634
Total costs	**8.290.906**	**2.741.917**	**3.066.358**	**14.099.180**
Personnel costs	4.716.705	1.216.832	1.159.408	7.092.945
Other costs	3.574.201	1.525.085	1.906.950	7.006.236
Result 2008	**827.200**	**40.180**	**29.296**	**896.677**

Differences HIMS resources and results 2009-2008 (€)

Differences 2009-2008	**1st**	**2nd**	**3d**	**total**
Total benefits/budget	**-2.022.511**	**967.530**	**603.192**	**-451.792**
Direct/UvA 1st	-1.464.117			-1.464.117
External funding 1st	-46.001	483.193	130.252	567.444
Internal funding	-6.263.481			-6.263.481
Contribution running projects	-512.393	484.337	472.940	444.884
Total costs	**-1.563.618**	**974.281**	**1.046.523**	**457.186**
Personnel costs	-726.348	444.266	136.328	-145.754
Other costs	-837.270	530.015	910.195	602.940
Result	**-458.893**	**-6.751**	**-443.331**	**-908.978**

6. External evaluation

The Scientific Advisory Committee (SAC) of HIMS performed a mid-term review of the research quality in 2008. A short summary of the recommendations of the committee is as follows:

- Bio-molecular synthesis: consider the possibility to strengthen the group by early replacement for Wever.
- Catalysis: has been strengthened over the past years and should now develop from the existing position to realise their full potential.
- Computational Chemistry: a high priority should be to strengthen the group to the level as it was before the departure of Smit and Frenkel; the committee strongly endorses the replacement of Smit.
- Macromolecular & Bio-systems Analysis: there exists a good base on which to build, e.g. within the COAST initiative; an additional appointment is justified considering the teaching load (incl. forensic science) and PhD supervision.
- Molecular Photonics: a research programme should be formulated which identifies a (limited) number of priorities based on existing strengths and promising collaborations.

The outcome of the official midterm review report 2008 of the SAC was very positive, substantiating the earlier conclusions from their 2006 report.

On the occasion of the mid-term review in 2008, the Center for Science and Technology Studies (CWTS) conducted a bibliometric analysis over the period 2001-2007. In 2002 a comparable analysis was performed by the VSNU over the period 1991-2000. On the occasion of the 2010 assessment of research quality (to take place in September 2010), the CWTS conducted a bibliometric analysis over the period 1999-2008. The results of the three bibliometric surveys for the HIMS themes and groups are shown in the table below.

Latest VSNU scores of the HIMS research themes and groups

HIMS themes & Other activities	**Research group**	**CPP/FCSm[1] 1991-2000**	**CPP/FCSm[2] 2001-2007**	**CPP/FCSm[3] 1999-2008**	
				group	**theme**
Bio-Molecular Synthesis	Hiemstra	1.81	1.79	2.01	1.86
	Wever	1.19	1.39	0.99	
Catalysis	Reek / Van Leeuwen	2.70	2.32	2.07	1.87
	Elsevier	2.08	1.37	1.37	
	Rothenberg	-	-	1.51	
Computational Chemistry	Krishna	3.00	1.31	1.82	2.14
	Bolhuis/Smit	2.61	1.94	2.34	
Macromolecular and Biosystems Analysis	Schoenmakers	1.64	1.29	1.26	1.26
Molecular Photonics	Buma	0.96	1.17	1.89	1.81
	Brouwer	-		1.50	
Röntgen Diffraction	Peschar / Schenk	0.64	0.79	0.80	1.02
Polymer & Process Systems	Iedema	0.53	0.99	0.98	
Reactor Dynamics	Van den Heuvel	-	-	1.50	
Total HIMS		**1.51**	**1.58**	**1.81**	

CPP/FCSm: Impact of an institute/group's articles, compared to the world citation average in the (sub)fields in which the institute/group is active.
[1)] Source: Chemistry, Past Performance and Future Perspective, Association of Universities in The Netherlands (VSNU), 2002
[2)] Source: Bibliometric analysis performed by the Center for Science and Technology Studies, 2008
[3)] Source: Bibliometric analysis performed by the Center for Science and Technology Studies, 2010

The ratio of the average number of citations per publication (corrected for self-citations) CCP and the world mean field citation score FCSm is an important indicator of a publication's impact compared to the international average. For HIMS as a whole, CPP/FCSm values were 1.51 and 1.58 over the periods 1991-2000 and 2001-2007, respectively, which is well above the international standard of 1.0. Furthermore, all five HIMS themes have individual scores well above 1.0 (see table above). It should be noted that the registration in the present 2010 CWTS analysis (future perspective; publications of staff members per theme present at January 01, 2008) is quite different from the registration in the older analyses (past performance; publications of all staff members per theme present in that period).

In the period 1999-2008 HIMS published 1602 papers used in the present CWTS analysis. These publications had an average of 37.5 references per paper and were cited in total 30,767 times, incl. self-citations (on average 19.2 citations per paper, identical to the average of all Dutch universities). References to papers published before 1980 and to non-published papers were not used in the analysis.

Compared to the journal and field average impact levels, HIMS performs very well. With CPP/JCSm and CPP/FCSm values of 1.21 and 1.81 respectively, the HIMS researchers score higher than the average of all Dutch chemistry researchers combined (see table below).
The output is stable over the years, while the impact shows a fluctuating pattern, with high impact scores at both the initial and final blocks of the trend analysis. Since this is due to high impact papers in the early years and some high impact publications in 2007 and 2008, it shows that the younger staff has reached the high quality level of their predecessors and re-established the international position of the individual research groups.

An important observation of the present CWTS analysis is that in all seven fields representing >5% of the output, HIMS groups achieve high impact scores. In three of these seven fields impact levels amount to twice the worldwide average (see table above). It was noted that the present Biocatalysis group of HIMS has a lower impact; their output represents only a small portion of HIMS.

Another observation of the CWTS analysis is that for the UvA the single institute output (41%, CPP/FCSm 1.87) covers the largest share of the output, although the difference with international output (36%, CPP/FCSm 1.80) is small. The remaining output (23%, CPP/FCSm 1.74) is national output. For HIMS very high impact scores were reached in the period 1999-2008 . In the coming years the senior staff of HIMS will be increasingly involved in international programs and projects (e.g. REVCAT/CAT, Erasmus Mundus/COMP, with the Chinese Academy of Science/MOLP). In relation with such programmes we expect that the HIMS international output will increase accordingly in the coming years.

Finally, an increase of the visibility is evidenced by the CWTS analysis for UvA/HIMS: the institute is more visible as might be expected from the output volume. In conclusion, the overall results of the 2010 bibliometric analysis are more than satisfactory for HIMS.

VSNU scores of HIMS compared with the average scores of all Dutch universities [3]

Report	Period	CPP/JCSm	CPP/FCSm	JCSm/FCSm
HIMS 2002 [1)]	**1991-2001**	**1.13**	**1.51**	**1.33**
HIMS 2008 [2)]	**2001-2007**	**1.08**	**1.58**	**1.43**
HIMS 2010 [3)]	**1999-2008**	**1.21**	**1.81**	**1.47**
All universities 2010 [3)]	**1999-2008**	**1.20**	**1.67**	**1.39**

CPP/FCSm: Impact of an institute/group's articles, compared to the world citation average in the (sub)fields in which the institute/group is active.
CPP/JCSm: Impact of an institute/group's articles, compared to the average citation rate of the institute/group's journals.
JCSm/FCSm: Impact of the journals in which an institute/group has published, compared to the world citation average in the fields covered by these journals.
[1)] Source: Chemistry, Past Performance and Future Perspective, Association of Universities in The Netherlands (VSNU), 2002
[2)] Source: Bibliometric analysis performed by the Center for Science and Technology Studies, 2008
[3)] Source: Bibliometric analysis performed by the Center for Science and Technology Studies, 2010

7. Facts and figures

7.1. Personnel

7.1.1. Research input

In the following table the research input of the HIMS staff members is presented as full time equivalents (fte).

Research staff 2009 of the HIMS themes, per employment type (fte)[a] **source: METIS**

	BMS	CAT	COMP	MBA	MOLP	Others	Total
Tenured staff	2,0	2,8	2,0	1,0	2,5	1,6	**11,9**
Non-tenured staff	1,6	14,1	4,3	5,8	4,2	2,0	**32,0**
PhD candidates	5,9	19.0	9,7	12,3	15,4	4,4	**66,7**
Total research staff	**9,5**	**35,9**	**16,0**	**19,1**	**22,1**	**8,1**	**110,6**
Technicians [b]	4,9	9,0	1,0	2,3	3,9	2,3	**23,4**
Visiting fellows [c]	0,2	0,2	0,0	0,2	0,1	0,0	**0,7**
Supporting staff						7,7	**7,7**
Total staff	**14,6**	**45,1**	**17,0**	**21,6**	**26,0**	**18,1**	**142,4**

[a] Note that the table shows the net time available for research. The numbers are based on an input of 0.5 fte (full-time equivalent) per fte tenured staff and visiting fellows[c], 0.9 fte per fte non-tenured staff (visiting researchers, postdocs) and 0.75 fte per fte PhD student and 1.0 fte for technicians, supporting staff; not all appointments are full-time.
[b] Various technicians contribute to teaching, however their research input is represented as 1.0 fte. For technicians per research theme see the B-chapters.
[c] Endowed and visiting professors.

Research themes: BMS = Bio-Molecular Synthesis; CAT = Catalysis; COMP = Computational Chemistry; MBA = Macromolecular and Bio-systems Analysis; MOLP = Molecular Photonics; Others includes: CF = Complex Fluids (discontinued 2008); RD = Röntgen Diffraction (to be discontinued 2010), and other discontinued activities

7.1.2. Scientific staff

Bio-Molecular Synthesis
2 research groups

Prof. dr. H. Hiemstra (rg[3]-1.1)
Synthetische Organische Chemie

Prof. dr. R. Wever (rg-1.2)
Biokatalysatoren en Bio-Anorganische Chemie

Prof. dr. H.E. Schoemaker/DSM (rg-1.1)
Industriële Fijnchemie
(bijzonder hoogleraar Stichting Betaplus)

Prof. Dr. P. Timmerman (rg-1.1)
Protein-mimetic Chemistry
(Bijzonder hoogleraar Genootschap ter bevordering van Natuur-, Genees- en Heelkunde)

Dr. J.H. van Maarseveen (rg-1.1), uhd
Dr. S. Ingemann Jørgensen (rg-1.1), ud
Dr. S. Kinderman (rg-1.1), Veni lauriate, pd

[3] rg = research group

Catalysis
3 research groups

Prof. dr. J.N.H. Reek, Vici Laureate (rg-2.1)
Supra-Moleculaire Katalyse

Prof. dr. P.C.J. Kamer (rg-2.1)
Homogene Katalyse

Prof. dr. C.J. Elsevier (rg-2.2)
Coördinatie- en Organometaalchemie

Prof. Dr. G. Rothenberg, Vidi Laureate (rg-2.3)
Heterogene Katalyse en Duurzame Chemie

Dr. B. de Bruin, uhd, Vidi and ERC Laureate (rg-2.1)
Dr. J.I. Van der Vlugt (rg-2.1), ud, Veni Laureate
Dr. E. Eiser (rg-2.2), ud (0.1 Fte)
Vacancy (rg-2.2), ud
Dr. N.R. Shiju (rg-2.3), ud
Dr. D.G.H. Hetterscheid (rg-2.1), Veni lauriate, pd
Dr. S. Grecea (rg-2.3), Veni lauriate, pd

Computational Chemistry
2 research groups

Vacancy (rg-3.1)
Complexe Moleculaire Simulaties

Prof. dr. R. Krishna (rg-3.2)
Chemische Reaktorkunde

Prof. dr. A. Fasolino/KUN (rg-3.1)
Computationele Fysica van de Gecondenseerde Materie

Prof. dr. P.G. Bolhuis (rg-3.3, Vici, Vidi and FOM Springplank Laureate
Simulaties van bio-moleculaire systemen

Dr. E.J. Meijer (rg-3.1), KNAW fellow, uhd
Dr. C.P. Lowe (rg-3.3), KNAW fellow, uhd
Dr. D. Dubbeldam (rg-3.3), ud
Dr. B. Ensing (rg-3.1), Vidi Laureate, pd
Dr. J. Vreede (rg-3.3), Veni Laureate, pd

Macromolecular and Biosystems Analysis / Forensic Analytical Chemistry
1 research group [4]

Prof. dr. ir. P.J. Schoenmakers (rg-4)
Analytical Chemistry including its applications in Forensic Science

Prof. dr. ir. J.G.M. Janssen/Unilever
Analytische Scheidingen van Biomacromoleculen
(bijzonder hoogleraar Stichting Betaplus)

Prof. dr. S. van der Wal /DSM
Bioterials Analysis
(bijzonder hoogleraar Stichting Betaplus)

Dr. W.Th. Kok, uhd
Dr. G. Vivó Truyols, ud

Molecular Photonics
1 research group

Prof. dr. W.J. Buma (rg-5)
Molecuulspectroscopie

Prof. Dr. A.M. Brouwer (rg-5), uhd
Molecuulspectroscopie (bijzonder hoogleraar John van Geunsfonds)

Prof. dr. H.J. Bakker/FOM-Amolf
Ultrasnelle Spectroscopie van Moleculen in de Gecondenseerde Fase

Prof. dr. J. Oomens/FOM-Rijnhuizen
Action Spectroscopy

Dr. H. Zhang, ud
Dr. R.M. Williams, ud
Dr. S. Woutersen, uhd, Vidi and ERC Laureate

Other activities

Art and Forensic sciences/Polymer and Process Systems
Prof. Dr. P. Iedema
Fysische Technologie

Scanning Tunneling Microscopy (STM)
Dr. J.C. van den Heuvel, uhd

Röntgen Diffraction department
Dr. R. Peschar, ud

[4] Collaboration with De Koster and Smilde from SILS

7.2. Research

Research input of the HIMS themes.

Research staff 2009 of HIMS and the HIMS themes, per funding type (fte)[a] **source: METIS**

	BMS	CAT	COMP	MBA	MOLP	Others	Total	%
Direct funding[1]	8,5	18,0	4,7	3,8	7,7	3,8	**54,1**	***38***
Research grants[2]	3,5	5,9	6,1	0,8	8,2	0,0	**24,4**	***17***
Contract research[3]	0,0	7,9	2,3	4,6	3,1	0,0	**17,9**	***13***
Other[4]	2,6	13,3	3,9	12,5	7,1	6,6	**45,9**	***32***
Total	**14,6**	**45,1**	**17,0**	**21,6**	**26,0**	**10,4**	**142,3**	***100***

[1]Direct funding (eerstegeldstroom; university/direct funding, NRSC-C/Top Research School Catalysis)
[2]Research grants (tweedegeldstroom; NWO-CW, FOM, STW, KNAW, DFG)
[3]Contract research (derdegeldstroom; EU, ERC, DPI, Senter, FES/NanoNed, Industrial)
[4]Other (vierdegeldstroom; guest PhD students & guest researchers employed elsewhere, PhD students with finished contracts/not yet graduated, etc.)
[a] Note that the table shows the net time available for research (source METIS). The numbers are based on an input of 0.5 fte (full-time equivalent) per fte tenured staff and visiting fellows, 0.9 fte per fte non-tenured staff (visiting researchers, postdocs) and 0.75 fte per fte PhD student and 1.0 fte for technicians; not all appointments are full-time.

Research themes: BMS = Bio-Molecular Synthesis; CAT = Catalysis; COMP = Computational Chemistry; MBA = Macromolecular and Bio-systems Analysis; MOLP = Molecular Photonics; Other includes: CF = Complex Fluids (discontinued 2008); RD = Röntgen Diffraction (to be discontinued 2010), and other discontinued activities

Externally financed projects acquired in 2009 (mln €) and HIMS themes per funding type[1]

	BMS	CAT	COMP	MBA	MOLP	Others	Total
1st - NRSC-C [2]	0,60	2,10	0,00	0,00	0,00	0,00	**2,70**
1st - Others [3]	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**
2nd [4]	0,00	0,89	0,93	0,00	0,23	0,00	**2.06**
3rd [5]	0,02	1,10	0,04	0,20	0,00	0,44	**1.80**
Total	**0,62**	**4,09**	**0,97**	**0,20**	**0,23**	**0,44**	**6,56[6]**

[1] Matching contributions UvA/FNWI and own contributions HIMS (in kind and cash/from reserves) included
[2] NRSC-C (TOP Research School Catalysis); [3] COF, CvB (Funds from University Board); [4] NWO-CW, FOM, STW, KNAW, DFG
[5] EU, ERC, DPI, Senter, NanoNed, Industry;
[6] Budgets were obtained for 14 PhD's and 16 postdocs in 2009

Research output 2009 of the HIMS themes

Research output 2009 of HIMS and the HIMS themes, per type of publication **source: METIS**

	BMS	CAT	COMP	MBA	MOLP	Others	Joint[1]	Total
Refereed articles	13	51	35	14	59	1	-4	**169**
Non-refereed articles	0	0	0	0	2	0	0	**2**
Books	0	0	0	0	0	0	0	**0**
Book chapters	2	0	1	1	0	0	0	**4**
PhD-theses	1	9	3	1	2	0	0	**16**
Patents	0	1	0	0	0	0	0	**1**
Professional publications	1	1	0	0	1	1	-3	**1**
Total	**17**	**62**	**39**	**16**	**64**	**2**	**-7**	**193**

[1] Number of joint results obtained from collaborations between different research themes

	BMS	CAT	COMP	MBA	MOLP	Others	Joint[1]	Total
>15	0	1	1	1	0	0	0	**3**
10-15	1	6	1	0	2	0	0	**10**
5-10	4	11	1	0	18	0	-2	**32**
<5	8	33	32	13	39	1	-2	**124**
Total	**13**	**51**	**35**	**14**	**59**	**1**	**-4**	**169**

7.3. Finance 2009

The table below shows the HIMS financial result 2009, excluding the teaching activities of the HIMS staff (1170 k€).

HIMS result 2009 (k€)

	1e structural	1e others	1e total	2e	3e	Total
HIMS						
Budget (base)	8997	698	9695	1813	2278	13786
Other income		79	79			80
Matching contract research	-2494	-185	-2679	1936	1421	722
Budget total	**6503**	**592**	**7095**	**3749**	**3699**	**14543**
percentage	***45,0***	***3,9***	***48,9***	***25,7***	***25,4***	***100***
Personal costs	-3710	-280	-3990	-1661	-1296	-6947
Other costs	-655	-49	-704	-333	-1035	-2072
Overhead on activities	681	51	732	-1720	-1647	-2635
Various costs	-32	-3	-35	-2	-2	-39
Other (secundary) costs	-2538	-191	-2729		-133	-2862
Costs total	**-6254**	**-472**	**-6726**	**-3716**	**-4113**	**-14555**
percentage	***52,3***	***3,9***	***56,3***	***23,4***	***18,3***	***98***
Result	**249**	**120**	**369**	**33**	**-414**	**-12**

Including the correction of 44 k€ on the running projects contribution to be received afterwards, the HIMS result 2009 will amount to + 32 k€.