NEWSLETTER
PROCESS CHEMISTRY CENTRE

ÅBO AKADEMI
UNIVERSITY

No. 17 | 1/2010

Molecular Process Technology in Two Dimensions

Solid catalysts are one of the most fascinating man-made materials. The discovery of solid metal catalysts was done by accident, as great discoveries almost always are. Controversial experimental observations of great scientists such as Michael Faraday, Johann Döbereiner and Jöns Jacob Berzelius were clarified. Why did not metal powder change, even though it was present when two gases reacted? Because the metal acts as a catalyst, as Berzelius understood and as we agree today.

The understanding of catalysis on the real micro level, actually nano level, is the key for the progress of the science and the new breakthroughs of technology. New observations change the textbooks of schoolchildren: for a long time it was taught that gold is an inert, catalytically inactive metal in catalysis. Gold was claimed to be too aristocratic to take part in any catalytic game of molecules. Today, however, we successfully prepare and use gold-based catalysts at PCC to make renewable chemicals from renewable sources: lactose is oxidized on gold nanoparticles to lactobionic acid, which is a useful chemical in organ transplants. Nanosize gold particles attached to suitable support materials are the secret behind this. Nowadays, there is a gold rush among scientists all over the world; experimentalists make experiments and theoreticians try to explain why gold works. Academy of Finland was wise to grant us, together with the University of Helsinki, a project called Auracat - Aurum at the banks of the Aura river!

At PCC, we cannot remain on the nano level only, because our mission 'Molecular Process Technology' implies that we shall progress towards the real production scale of chemicals and fuels. There the concept of the chemical reactor plays a key role. For a long time, just few different formulations of solid catalysts were available: big catalyst pellets for fixed bed reactors and small (less than 100 micrometer) particles for fluidized beds and slurry reactors. Both technologies suffer from serious drawbacks. The use of large catalyst pellets implies severe diffusion limitations and thus retardation of the chemical reaction rate. On the other hand, dealing with small particles is often cumbersome, since filtration problems appear in slurry reactors and pressure drop increases in reactor beds as the particle size is diminished. This dilemma can be solved by using structured solid catalysts, such as monoliths, solid foams, catalyst fibres and microstructured reactors, on which the active catalyst phase is fixed as a thin layer (10-50 micrometer). The diffusion resistance is suppressed and the pressure drop is low. We have all these structured catalysts available; we prepare them as a collaborative effort of the participating laboratories of PCC. This is a perfect solution for the future.

Professor Tapio Salmi

So, let us prepare gold nanoparticles, fix them on a washcoat layer on a solid, structured support, such as a monolith, foam or microreactor and use the system for the transformation of renewables. This is molecular process technology in two dimensions: chemistry and reactor technology. To the researchers I have only one message, adopted from the logo of Chalmers University of Technology: Avancez!

Tapio Salmi

The author is Academy Professor and works at Process Chemistry Centre

Joint Degree at PCC

With focus on chemicals for environmentally friendly products, **Dr. Sébastien Leveneur** defended his thesis *Catalytic Synthesis and Decomposition of Peroxycarboxylic Acids* on October 23 and took a joint degree in chemistry in co-operation between Åbo Akademi University and INSA de Rouen, France.

Tell me about your research.

My research has focused on the synthesis of peroxycarboxylic acids, which are used as disinfectants and bleaching agents. The use of these compounds in these industries are more eco-friendly than the use of chlorine or chlorine dioxide. However, the process, to synthesize these molecules, still uses sulfuric acid as a catalyst, leading to several drawbacks as corrosion, the need to implement a distillation unit to re-circulate sulfuric acid and a threat to the environment. To avoid these inconveniences, we propose the use of a solid acid catalyst.

How have you become interested in catalytic synthesis of green compounds?

People from my generation are more afraid of chemistry and think that chemistry is responsible for all the casualties like global warming, pollution, production of waste and so on. However, when I started at Åbo Akademi, I saw that it is possible to improve the process of different synthesis. In our laboratory, effort is put on the use of heterogeneous catalysts, which can diminish the amount of waste. It is an interesting challenge to find out how to replace the traditional homogeneous catalyst by a heterogeneous catalyst, to see how to replace some toxic compounds by eco-friendly compounds.

Dr. Sébastien Leveneur

What's the idea about doing a joint degree? What kind of collaboration has it been for you?

The idea to make a joint degree with France is to have a diploma which is recognized by French authorities. If I want to continue in France at a university, it is easier with a French degree.

The other reason is more sentimental in the sense that I keep contact with my laboratory in France. Åbo Akademi University and INSA de Rouen have an agreement for the joint degree, in other words I do not need to pass exams in both countries, only one defense of the thesis is needed, the doctoral thesis can be written in English or French and I can defend my thesis with a jury as in France.

Would you recommend joint degrees for others?

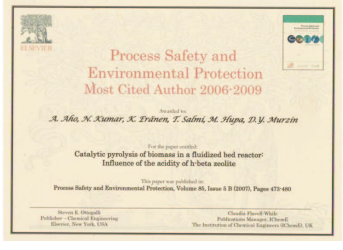
Difficult question, I do believe that collaboration works if both Professors know each other quite well, if the project is clearly defined: which laboratory will be responsible for what part of the project, if this experimental part will be done in France and for how long time, both laboratories should be a complement of each other and the famous disturbing question Who will be paing the salary?. Before starting a joint degree, one should really care about such issues, otherwise it could be difficult.

Why did you choose Åbo Akademi?

At Åbo Akademi, the system is less bureaucratic and more flexible and open. For instance, we can take the lectures when we want during the PhD study, we do not need to fill several papers to go for a conference and you can use English everywhere. Nordic countries are quite exotic and that was a good reason to come to Finland.

Most Cited Author Award to Dr. Atte Aho

A recently published research paper by Atte Aho, Narendra Kumar, Kari Eränen, Tapio Salmi, Mikko Hupa, and Dmitry Yu. Murzin at PCC was awarded by the publisher Elsevier. Atte Aho's publication with the title *"Catalytic Pyrolysis of Biomass in a Fluidized Bed Reactor: Influence of the Acidity of H-Beta Zeolite*" is the most cited paper 2006-2009 in *Journal Process Safety and Environmental Protection*. The paper was published in Volume 85, Issue 5 B (2007), Pages 473-480.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A. Aho, N. Kumar, K. Eränen, T. Salmi, M. Hupa, D.Y. Murzin
Catalytic pyrolysis of biomass in a fluidized bed reactor: Influence of the acidity of h-beta zeolite
Process Safety and Environmental Protection, Volume 85, Issue 5 B (2007), Pages 473-480

Chinese Government Award to Di Zhang

Di Zhang was awarded a $ 5,000 personal scholarship by the Chinese government. The title of the prize was 2008 Chinese Government Award for Outstanding Self-Financed Students Abroad. This award is annually issued by the China Scholarship Council for self-financed students all over the world. In the year 2008, there were 300 awardees, of which four in Finland. The certificate of the award was assigned to **Di Zhang** by the Chinese Ambassador in Finland on April 10, 2009.

PCC Annual Seminar 2009

The Åbo Akademi Process Chemistry Centre Annual Meeting was held in Arken on August 20, 2009. PCC research activities were overviewed by the group leaders and the recent PhD theses by **Atte Aho**, **Sébastien Leveneur**, **Markus Engblom**, and **Pierdomenico Biasi** were presented. Moreover 12 lightning poster presentations were shown by PhD students. The dinner in the evening took place at Ruissalo Spa Hotel after a cruise onboard M/S Lily. In 2008, 9 doctoral theses, 5 licentiate theses, and 19 master of science theses were published. The number of articles in refereed international scientific journals and series were 101.

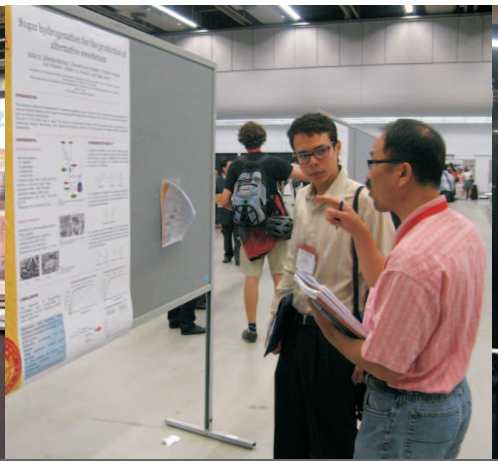
Runar Bäckström Prize to PCC

Prof. Johan Bobacka and **Prof. Ari Ivaska** at the PCC achieved a scholarship from the foundation *Runar Bäckströms Stiftelse* on May 13, 2009 for their invention of a method for precipitation of noble metals from solutions. The recovery of noble metals from aqueous solutions is of industrial importance. This new invention is a simple and environmentally friendly method for the separation of noble metals such as gold, palladium, and platinum from a water solution. The method has been tested on a solution containing 50 ppm of gold and the result showed that 99.9% of the gold was separated. The foundation is promoting inventions of industrial importance and the sum was 15,000 €.

From Montréal to Nådendal - A Scientific Conference is Coming to Finland

The 8th World Congress of Chemical Engineering, held at the Palais des Congés in Montreal, August 2009, collected more than two thousand participants taking part in scientific presentations, poster sessions, as well as the social program. It was delightful to notice that all Finnish universities with research in process chemistry were represented. Researchers from the PCC gave ten oral presentations and several poster presentations. Sustainable development and technology was the main theme of the event. The plenary lectures involved chemical education, energy resources, storage of carbon dioxide, and computational fluid dynamics calculations.

The congress incorporated several minor special events of high quality, such as gas-liquid-solid reactors, multifunctional reactors, and catalysis in multi-phase systems. The scientific committee of the symposiums CAMURE (Catalysis in Mulitphase Reactors) and ISMR (International Symposium on Multifunctional Reactors) assembled and decided that the CAMURE&ISMR conference in future will be held as separate events. Next time the researchers in multi-phase and multi-functional reactors meet in Finland at Nådendal Spa Hotel on May 22-25, 2011. The main organizer is Academy Professor **Tapio Salmi** and the scientific committee consists of specialists from all over the world. Approximately 200 participants is expected and especially the organization of the social program will be a challenge. In Montréal we enjoyed the wonderful artists of Cirque de Soleil, However, Åbo is the European Cultural Capital in the year 2011.



GUEST LECTURERS

Prof. Robert J. Davis, Department of Chemical Engineering, University of Virginia, Charlottesville, Virginia, USA: "*Catalytic Conversion of Bio-renewable Molecules to Fuels and Chemicals*" on March 6, 2009. Host: **Prof. Dmitry Yu. Murzin**.

Prof. Marek Trojanowicz, Department of Chemistry, University of Warsaw, Pasteura, Warswa, Poland.

Prof. Ernö Lindner, Department of Biomedical Engineering, The University of Memphis, USA: "*Evaluating the Performance Characteristics of a New Device or Method: Method Comparison Studies and Their Pitfalls*" on November 18, 2009. Host: **Prof. Ari Ivaska**.

Dr. David Kubička, VÚAnCH, Department of Refinery and Petrochemical Research, Litvínov, Czech Republic: "*Deoxygenation of Triglycerides – A Promising Route for Production of Renewable Fuels and Chemicals*" on December 4, 2009.

DOCTORAL DEFENSES

José Rafael Hernández Carucci: "*Experimental and Modeling Aspects of Nitrogen Oxides Reduction in Mini- and Microreactors*" on September 24, 2009. Opponent: **Prof. Milos Marek**, Institute of Chemical Technology, Prague, Czech Republic.

Atte Aho: "*Catalytic Pyrolysis of Biomass in a Fluidized Bed Reactor*" on September 25, 2009. Opponent: **Prof. Iacovos Vasalos**, Aristotle University of Thessaloniki, Greece.

Pasi Virtanen: "*Supported Ionic Liquid Catalysts (SILCA) for Preparation of Fine Chemicals*" on October 22, 2009. Opponent: **Dr. Mihkel Koel**, Tallin University of Technology, Estonia.

Sébastien Leveneur: "*Catalytic Synthesis and Decomposition of Peroxycarboxylic Acids*" on October 23, 2009. Opponent: **Prof. Jean-Claude Charpentier**, Laboratoire des Sciences du Génie Chimique, CNRS/ENSIC/INPL, Nancy, France.

Kjell-Erik Saarela: "*Elemental Analysis of Wood Materials by External Millibeam Thick Target PIXE*" on November 13, 2009. Opponent: **Prof. Willy Maenhaut**, Universiteit Gent, Belgium.

Zekra Mousavi: "*Ion Sensing Based on the Conducting Polumer Poly(3,4-ethylenedioxy-thiophene)*" on November 20, 2009. Opponent: **Prof. Ernö Lindner**, The University of Memphis, USA.

Eva Sarkadi-Pribóczki: "*Novel 11C Radioisotope Method for Studying Transformations over H- and Metal Modified Zeolites and MCM-41*" on December 4, 2009. Opponent: **Dr. David Kubička**, VÚAnCH, Department of Refinery and

PCC SCIENTIFIC AND INDUSTRIAL ADVISORY BOARDS

PCC FACTS AND MISSION

A Centre of Excellence in research appointed by the Academy of Finland for the periods 2000-2005 and 2006-2011. The Åbo Akademi Process Chemistry Centre (ÅA-PCC) studies physico-chemical processes at the molecular level in environments of industrial importance, in order to meet the needs of tomorrow's processes and product development. Our particular focus on the understanding of complex process chemistry we call *Molecular Process Technology*.

The Centre consists of four research groups at the Department of Chemical Engineering, Åbo Akademi University:
·Combustion & Materials Chemistry (Prof. Mikko Hupa),
·Kinetics & Catalysts (Prof. Tapio Salmi),
·Process Analytical Chemistry (Prof. Ari Ivaska) and
·Wood and Paper Chemistry (Prof. Bjarne Holmbom).
In the year 2009, about 130 people (including 20 senior researchers) took part in the PCC activities with a total funding of approximately 6 million euros.

PROCESS CHEMISTRY CENTRE

PCC EXECUTIVE BOARD
Prof. Bjarne Holmbom | email: bjarne.holmbom@abo.fi
Prof. Mikko Hupa | email: mikko.hupa@abo.fi
Prof. Ari Ivaska | email: ari.ivaska@abo.fi
Prof. Tapio Salmi | email: tapio.salmi@abo.fi

COORDINATING ASSISTANT
Maria Ljung | email: pcc@abo.fi
Biskopsgatan 8, 20500 Turku / Åbo, Finland

EDITOR IN CHIEF
Prof. Mikko Hupa | email: mikko.hupa@abo.fi

EDITOR
Dr. Andreas Bernas | email: andreas.bernas@abo.fi