



October 2015

FMS topical seminar on Catalytic Chemistry in Living Cells: Towards man-made catalysts that work in living cells

FMS topical seminars are half day symposia where experts on exciting topics relevant to the FMS Research Center (gravitation program) are invited to get together in an informal setting to present new developments in current research and discuss future perspectives.

On September 17th, the FMS topical seminar on catalytic chemistry in living cells was held in Groningen, organized by Gerard Roelfes and Anja Palmans (TUE). During this meeting a number of distinguished speakers presented various aspects important to the overall goal of achieving non-natural catalysis in living cells, with the ultimate goal of complementing bio-synthesis with new chemistry. A general introduction to the field was given by Gerard Roelfes and then lectures were presented by Thomas Ward (Basel) on artificial enzymes, Eric Meggers (Marburg) on transition metal catalysis in living cells. Oscar Kuipers (Groningen) on synthetic biology approaches to new antibiotics, Lorenzo Albertazzi (Barcelona) on compartmentalization approaches involving single chain polymer nanoparticles.

The symposium was attended by about 45 participants from Groningen, Nijmegen and Eindhoven, who participated actively in the discussion during and after the symposium.

Highlights by Prof. dr. Jan B.F.N. Engberts

- Chemists at the Technical University of Darmstadt, Germany, developed a simplified synthetic route to multifunctional chiral molecules using the sequential catalytic assembly of achiral building blocks. They prepared several aldose carbohydrates and derivatives from formaldehyde, glycolaldehyde and other aldehydes via biocatalytic tandem reactions using engineered variants of D-fructose-6-phosphate aldolase (FSA). The method can be achieved with optimal energetic and atomic economy, and makes clear that the use of engineered enzymes like FSA can be highly valuable in the construction of complex molecules. *Szekrenyi, A., Garrabou, X., Parella, T., Joglar, J., Bujons, J., Clapés, P., Nature Chem., 2015, 7, 724-729.*
- An interesting mechanism has been suggested for the reduction of an arene by samarium diiodide-water. It was found at Lehigh University, USA, that the reaction occurs through an initial proton-coupled electron-transfer. Upon coordination of water to Sm(II) in THF, a significant weakening of the O-H bond takes place. Thermochemical data indicate a decrease in the bond dissociation energy of the O-H bond of 73 kcal/mol! This is the largest one seen so far for low-valent reductants containing bound water. *Chciuk, T.V., Flowersil, R.A., J.Am.Chem.Soc. 2015, DOI 10.1021/jacs.5b07518.*
- An open question so far was whether anions and cations could interact with one and the same aromatic surface. This has now been investigated at the University of Geneva, and such interactions are referred to as ion-pair- π interactions. The origin of spectral tuning by these types of interactions was unraveled with energy-minimized excited-state structures. The differences between parallel and antiparallel ion pair- π interactions was studied by time-resolved fluorescence measurements. By employing a number of other approaches, an overall quite complete picture of these interesting interactions has been obtained. *Fujisawa, K., Humbert-Droz, M., Letrun, T., Vauthey, E., Wesolowski, T.A., Sakai, N., Matile, S., J.Am.Chem.Soc. 2015, 137, 11047-11056.*

- In a brief paper from Rutgers University, Newark, USA, the highly stereoselective Pd(o)-catalyzed ketone synthesis via cross-coupling between boronic acids and geometrically activated amides is described. The reaction occurs through selective activation of the N-C(O) bond. The versatile ketones were produced in quite high yields and the process shows excellent functional group tolerance. A reasonable mechanism has been proposed involving destabilization of the amide ground state. The generation of acyl-metal intermediates directly from the amides sets the stage for an array of transition metal catalyzed transformations of amide bonds. *Meng, G., Szostak, M., Org.Lett.* 2015, DOI 10.1021/acs.orglett.5b02209.
- Many attempts have recently been made to simultaneously improve the performance and long-term stability of perovskite solar cells. A successful approach has recently been reported by chemists from the Ecole Polytechnique in Lausanne, Switzerland, and the University of Wuhan, China. The procedure involves crystal crosslinking with alkylphosphonic acid ω -ammonium chlorides. Structural studies indicate that the additives act as a crosslink between neighbouring grains in the perovskite structure through strong hydrogen bonding of the $-\text{PO}(\text{OH})_2$ and $-\text{NH}_3^+$ terminal groups to the perovskite surface. The material's photovoltaic performance could be enhanced from 8.8 to 16.7% and the resistance to moisture was also improved. *Li, X., Dar, M.I., Yi, C., Luo, J., Tschumi, M., Zakeeruddin, S.M., Nazeeruddin, M.K., Han, H., Grätzel, M., Nature Chem.*, 2015, DOI 10.1038/nchem.2324.
- After cellulose, lignin is the most frequently occurring organic material on earth. From the viewpoint of green chemistry, it is therefore a great challenge to employ this material for the production of useful organic materials, particularly well-defined aromatic chemicals. Katalin Barta and her coworkers, and in cooperation with Hans de Vries and chemists from the University of St. Andrews, UKh, made an important contribution in this area. Suppressing undesired pathways, they prepared diverse aromatic compounds, not previously targeted systematically from lignin. It was found that a catalytic amount of triflic acid can effectively cleave the β -O-4 linkage, that is most abundant in lignin. The novel strategy might well be generally applicable for the production of useful aromatic materials from lignin. *Deuss, P.J., Scott, M., Tran, F., Westwood, de Vries, J.G., Barta, K., J.Am.Chem.Soc.*, 2015, 137, 7456-7467.
- In a cooperative project of three Chinese universities, an unprecedented sandwich complex has been synthesized. Sandwich complexes consist usually of one metal center bound by two arene ligands, as, for example, in ferrocene. But now, for the first time, an all-metal aromatic sandwich complex $[\text{Sb}_3\text{Au}_3\text{Sb}_3]_3^-$ was prepared, which was isolated as the $\text{K}([\text{2.2.2}]\text{crypt})^+$ salt and identified by single-crystal X-ray diffraction. Its electronic properties were studied by quantum mechanics, with particular emphasis on the intramolecular electron transfer processes in the complex. *Pan, F.-X., Li, L.-J., Wang, Y.-J., Guo, J.-C., Zhai, H.-J., Xu, L., Sun, Z.-M., J.Am.Chem.Soc.*, 2015, 137, 10954-10957.
- In a study, performed at The Ohio State University, USA, it was shown that nanotubes, formed by self-assembly of a (L)-proline-(L)-lysine dipeptide, provide hydrophobic microenvironments that are able to catalyze the aldol reaction in water. These nanotubes function at low loading levels and good to excellent conversions were observed. When the nanotubes are dissociated into soluble monomers, the catalytic activity was minimal. The catalyst can be readily recovered by ultracentrifugation. The conversion rate decreased slightly over five cycles, but, remarkably, the selectivity improved from 85.3 to 93.5 % ee. Apparently, the packing within the nanotubes changes over time. *Lee, K.S., Parquette, J.R., Chem.Comm.*, 2015, DOI 10.1039/C5CC06142C.
- Manoharan, from Harvard University, published in Science a high-quality review of colloidal matter, emphasizing packing, geometry and entropy. It is argued that colloids should be seen as a form of matter in their own right. Both experimental and theoretical studies offer a controlled approach towards understanding and harnessing self-assembly, a fundamental topic in materials science, condensed-matter physics, and biophysics. Entropy is highly important for colloidal dispersions and affects not only the structure of these systems, but also the dynamics of how colloids are formed. Much further work has still to be done, and should come from systematic and iterative collaborations of synthetic chemists, from scientists who measure their structure and dynamics and from those who construct models explaining the sometimes highly complex phenomena that are observed. *Manoharan, V.N., Science* 2015, DOI 10.1126/science.1253751.
- It is, of course, well-known that, although $[4\pi+2\pi]$ cycloadditions occur readily, the $[2\pi+2\pi]$ cycloadditions to give cyclobutanes, require photochemical conditions, a fact that can be explained by orbital symmetry constraints. At Princeton University, iron-based catalysts have now been developed by Chirik and coworkers, that catalyze $[2\pi+2\pi]$ cycloadditions of unactivated alkenes and cross cycloadditions of alkenes and dienes

that enable region- and stereoselective routes to cyclobutanes. This is an important contribution to synthetic organic chemistry as discussed in a brief review by Smith and Baran. Hoyt, J.M., Schmidt, V.A., Tondreau, A.M., Chirik, P.J., *Science* 2015, 349,960-963. Smith, M.W., Baran, P.S., *Science* 2015, 349, 925-926.

Jan Engberts

Stratingh Lectures



Prof. Thomas E. Nielsen

University of Copenhagen ,
Director of Protein and Peptide Chemistry, Novo Nordisk

Title: New Opportunities for Solid-Phase Synthesis: Functional Materials, Molecular Libraries and Biomedical Screening

Day: Tuesday, October 13th, 2015

Room: 5111.0080

Time: 16:00

New appointments



Yuchen Wei

As of 1/9/2015

PhD—Group Feringa



Alwin M. Hartman

As of 16/9/2015

PhD—Group Hirsch



Ranajit Mondol

As of 1/9/2015

PhD—Group Browne



G. Henrike Heideman

As of 1/9/2015

PhD—Group Feringa



Shermin S. Goh

As of 1/9/2015

Visiting scientist
Group Feringa



Kathryn E. Splan

As of 1/9/2015

Visiting scientist
Group Roelfes



Marzia Nuzzolo

As of 1/9/2015

Research analyst



Anna K.H. Hirsch

As of 1/9/2015

Associate professor

Werkbespreking: Thursday morning 8.30 hrs, room 5111.0080

8th October— **Jeffrey Buter** (PhD Minnaard): "Asymmetric Total Synthesis of Mastigophorene A and Tuberculosinyl Adenosines"

15th October—**Symposium De Chemische Binding**: "Act responsibly, think sustainable"

22nd October— **Beatriz Calvo Gonzalez** (PhD Minnaard): "Title to be announced"

29th October— **Alexander Wolters** (Msc Feringa): "Combining different carbon-carbon bond forming reactions in one pot"

5th November— **Dowine de Bruijn** (PhD Roelfes): "Bioorthogonal metal catalysis"

If you have items for the next issue of this Newsletter, please send an e mail to the Stratingh Institute office: Stratingh@rug.nl