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ALFRED WERNER FUND, MASTER'S STUDENT SCHOLARSHIPS

The Alfred Werner Fund of the SCS Foundation was established in 2014 and continues the initiatives and projects of the former foundation 'Stiftung für Stipendien auf dem Gebiete der Chemie', also known as the 'Werner Stiftung'. The SCS Foundation is very proud to provide this program in collaboration with the Swiss chemical and pharmaceutical industry. *https://scs-foundation.ch*

Alfred Werner Master's Student Scholarships

The program invites scholarship applications to carry out Master degree studies in Chemistry or Biochemistry at a Swiss University or Federal Institute of Technology.

The Foundation offers 8 to 10 scholarships of CHF 25'000 each as a one-time contribution to the cost of the Master study program. This opportunity targets students from foreign countries in the top 10% of their undergraduate programs. The goal of the program is to bring in young talent to Swiss Universities or FIT or to keep them after the BSc studies in Switzerland.

Partner Universities / Federal Institutes of Technology

The program is supported by

Winners of the Scholarships 2017–19/20

The committee of the Werner Fund is proud to announce the ten winners of the next term that starts in Fall 2017 and Spring 2018 respectively:

- ***Alena Budinská*** BSc at Institute of Chemical Technology, Prague, Czech Republic. Support for her MSc studies at ETH Zurich
- ***Jessica Caldwell*** BA at Indiana University Purdue, University Columbus, USA. Support for her MSc studies at University of Fribourg
- ***Durbis J. Castillo-Pazos*** BSc at Universidad Autónoma del Estado de Mexico (UAEM), Mexico. Support for his MSc studies at University of Zürich
- ***Ihor Cherniukh*** BSc at Ivan Franko National University of Lviv, Ukraine. Support for his MSc studies at ETH Zurich
- ***Brett M. Garabedian*** BSc at University of California, Berkeley, USA. Support for his MSc studies at University of Basel
- ***Kevin Maik Jablonka*** BSc at Technische Universität, München, Germany. Support for his MSc studies at EPF Lausanne
- ***Asma Mansouri*** BSc at University Houari Boumediene, Alger, Algeria. Support for her MSc studies at University of Geneva
- ***Dragan Miladinov*** BSc at University of Novi Sad, Serbia. Support for his MSc studies at University of Basel
- ***Luka Milosevic*** BSc at University of Belgrade, Serbia. Support for his MSc studies at EPF Lausanne
- ***Kleni Mulliri*** BSc and MSc at University of Tirana, Albania. Support for her MSc studies at University of Bern

Summaries of the Master Thesis from Students of the Scholarship term 2015–17

Photoelectron Spectroscopy of Water Clusters at 26.35 eV

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Keywords: Anisotropy parameter · Electron scattering · Photoelectron spectroscopy · Water

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Studies on liquid water have been extensive throughout many scientific disciplines due to its omnipresence in nature. However, certain questions about water-based systems still remain unanswered. Namely, the molecular picture of electron scattering in liquid water is far from being completely understood. Detailed knowledge about the electron scattering cross-sections (SCS) would be necessary in order to explain the behavior of the secondary electrons (SEs) generated following ionization by high-energy radiation (cosmic-rays, X-rays, fast-moving charged particles). The SEs generally have initial energies below 30 eV and are referred to as the low-energy electrons (LEEs) in the literature. It was shown by Sanche and coworkers that the LEEs play a significant role in DNA damage and ozone depletion.[1–3] Since the efficiency of these processes depends on the energetics of the LEEs, determination of the electron SCS could offer a possibility to improve radiotherapy and understand atmospheric processes.

The high energy scattering can be well described by dielectric models and good agreement with experiments is obtained.[4] However, no accurate SCS of water are available for electrons with energies below 50 eV. Both experiments and theory face problems in the low energy regime where the electron scatters off molecular degrees of freedom (inter- and intramolecular vibrations and electronic). Therefore, a different approach is required. Combining a detailed scattering model with photoelectron studies of water clusters formed in a molecular beam is a promising step towards understanding electron SCS below 50 eV.

In this energy regime it can be assumed that the experimentally observed electron properties are determined by two distinct contributions (Fig. 1). The first ('local') contribution is due to the photoionization itself, being defined by the initial state and the properties of the water valence band to which the electron is excited. The quasi-free electron then propagates through the cluster where it experiences elastic and inelastic scattering events ('transport' contribution). The 'local' contributions converge already for small clusters[5] and the 'transport' scattering can be modeled by a random walk algorithm.[6,7] Energetics and angular-dependent properties of photoelectrons obtained from the simulation can then be compared with the experiment.

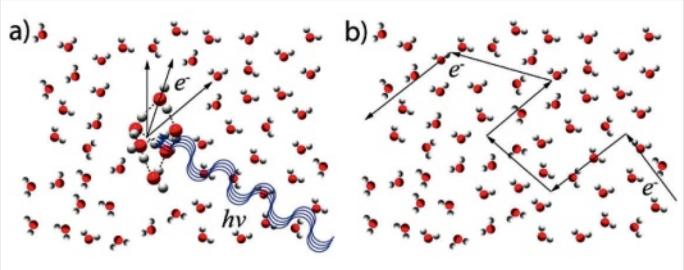

Fig. 1. Electron scattering is assumed to be determined by the 'local' scattering contributions (a) and the 'transport' scattering contributions (b).

In this work, photoelectron spectroscopy of water clusters with a photon energy of 26.35 eV provided by high harmonic generation was performed. Clusters were generated in a molecular beam, ranging from ~100 to ~1000 water molecules. The molecular beam studies offer control over the degree of condensation, leading to a tunable cluster size range that can be examined. Following photoionization, the energy and angular distributions of the photoelectrons were measured by a velocity-map imaging setup. Since each scattering event tends to make angular distribution more isotropic, the anisotropy parameter β can be used as a probe of electron SCS. A decrease in β as a function of the cluster size was measured and compared with the electron scattering simulations. Discrepancies between experiment and simulations, arising at cluster sizes of around 300 molecules, were observed. On the one hand, this could originate from certain experimental biases, such as the insensitivity of the detection to rare extremely large clusters. On the other hand, it might require reassessment of the scattering model, resulting in improved electron SCS for LEEs in liquid water.

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[1] E. Alizadeh, T. M. Orlando, L. Sanche *Annu. Rev. Phys. Chem.* **2015**, *66*, 379.
[2] L. Sanche, *Science* **2009**, *461*, 358.
[3] Q. B. Lu, L. Sanche, *Phys. Rev. Lett.* **2001**, *87*, 0785011.
[4] H. Shinotsuka, B. Da, S. Tanuma, H. Yoshikawa, C. J. Powell, D. R. Penn, *Surf. Interface Anal.* **2017**, *49*, 238.
[5] S. Hartweg, B. L. Yoder, G. A. Garcia, L. Nahon, R. Signorell, *Phys. Rev. Lett.* **2017**, *118*, 1034021.
[6] D. Luckhaus, Y.-i. Yamamoto, T. Suzuki, R. Signorell, *Sci. Adv.* **2017**, *3*, e1603224.
[7] R. Signorell, M. Goldmann, B. L. Yoder, A. Bodi, E. Chasovkikh, L. Lang, D. Luckhaus, *Chem. Phys. Lett.* **2016**, 658, 1.

Towards Directed Evolution of Non-proteogenic Ligands

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Keywords: DNA-encoded library · PNA · Templated ligation

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Specific interactions between different proteins are responsible for a wide range of signalling processes in the cell and therefore, discovering new molecules capable of modulating these interactions is a growing and promising field in drug discovery.[1] Protein–protein interactions (PPI) are the main type of specific interactions in the cells and some of these interactions play a key role in important diseases. However, the traditional drug-like small-molecules are not suitable to target such flat surfaces and therefore discovering new ways to modulate these PPI still remains a challenge.

Some PPIs are mediated by α-helices and a lot of work has been done mimicking these structures in order to find new molecules that target PPI.[2] However, around half of protein–protein interactions are mediated by peptide loops. The relatively large size of the proteins is required to achieve a unique three-dimensional structure that stabilizes the folded conformation of the loop and, at the end, only a few residues generally participate in the interaction. For this reason, there is an enormous interest in developing loop mimetics as modulators of such PPIs.[3]

The main goal of this master project has been to develop an affordable technology platform to build constrained peptide loops libraries to allow a routine and rapid identification of high quality protein ligands. We have reported the formation of loops through the PNA-templated reaction. This strategy has been implemented to build peptide-loop libraries on a DNA-encoded fashion and further screened against different protein targets (Fig. 1).

Fig. 1. Formation of a loop-library through the PNA-templated reaction.

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[1] J. A. Wells, McClendon, *Nature,* **2007**, *450*, 1001.
[2] H. Yin, A. D. Hamilton, *Angew. Chem. Int. Ed,* **2005**, *44*, 4130.
[3] J. Gavenonis, B.A. Sheneman, T. R. Siegert, M. R. Eshelman, J.A. Kritzer, *Nat. Chem. Biol,* **2014**, *10*, 716.

Polyene Cyclization for the Synthesis of Fragrance Ingredients

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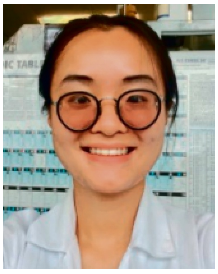

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Master thesis supervisors:
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Prof. Clément Mazet, University of Geneva

Based on previous research of polyene cyclizations both in academia and in the industry, the direct cyclization of polyenes by Lewis or Brønsted acid or photochemically was investigated with polycylic fragrance ingredients or their precursors as target. By-products were separated and elucidated to obtain a mechanistic understanding of the related reactions. Fine-tuning of the interaction between acid catalysts and solvents *via* PCA and DOE improved yields and product selectivities as well as sustainability, *e.g.* atom-efficiency, safety and robustness of the processes.

Future plans

After graduation, Yuting will pursue a PhD at her *Alma Mater* McGill University, focusing on organic synthesis and medicinal chemistry. She will develop her research and communication skills for a successful future career as a research scientist.

Expanding the Scope of Nickel-catalyzed Cross-coupling Reactions

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Nickel-catalyzed cross-couplings have been the subject of a growing interest in contemporary organic chemistry. My work focused on the development of a nickel-catalyzed cross-coupling to access a broad range of valuable olefinic motifs that are difficult to access by conventional methods. Investigations are ongoing and results will be reported in due course.

Future plans

After my Master I will move to United Kingdom to pursue doctoral studies in organic chemistry at the University of Cambridge. I am looking forward to start in order to acquire more knowledge in terms of chemistry and to be daily involved in scientific research.

Enhancing Solar Disinfection of Viruses by the Homogenous and Heterogenous Photo-Fenton Processes in Drinking Water

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Solar-assisted advanced oxidation processes have the advantage of using a free, easily accessible energy source and therefore present an ecological point-of-use alternative to conventional water treatment methods, for remote settlements around the equator. They involve the generation of so-called reactive oxygen species (ROS) which are responsible for the degradation of organic materials. Combined with catalysts available in nature, as iron, and the photo-generated H_2O_2, forming the photo-Fenton process, solar-based treatment has a greater chance of success in developing countries.

The photo-Fenton process has been proved efficient in the degradation of pollutants in water and improvement of microbial quality.[1,2] The classical Fenton process is initiated by the reaction of ferrous ion with H_2O_2 generating ferric ion and oxidative hydroxyl radicals followed by the slower conversion of ferric ion back to ferrous ion.[3]

The aim of this work was to analyze the efficiency of photo-Fenton processes catalyzed by ferrous and ferric ion on the inactivation of viruses using MS2 bacteriophage as a viral model in the context of drinking water, and compare with the homogeneous one (Fig. 1). As a result of the limited solubility of free iron at neutral pH, the efficiency of iron(hydr)oxides as an alternative iron source was assessed to extend the application of the process in natural aquatic systems. Iron oxides undergo reduction in the presence of light producing ferrous ion, the catalyst of the Fenton reaction and hydroxyl radical, the predominant reactive species.[4]

The efficiency of the process is improved by the adsorption of virus particles on the surface of the oxides enhancing the production of reactive species near the virus particle rather than in the bulk solution. The impact of grain size of the iron oxides and presence of natural organic matter which could compete with virus for ROS were also assessed.

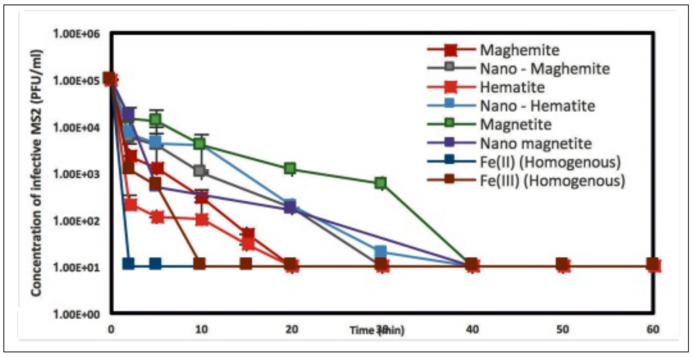

Fig. 1. Inactivation of MS2 virus by homogenous and heterogenous photo-Fenton (Solar irradiance 900W/m^2.Concentration of iron, iron oxides, H_2O_2 = 1mg/L)

Conclusions

- Homogenous and heterogenous photo-Fenton processes carried out with low concentrations of reagents achieved rapid and complete inactivation of MS2 virus
- Photolysis of Fe-organo complexes improved the homogenous photo-Fenton process in the presence of NOM while the efficiency of the process was reduced with oxides due to competition between NOM and virus particles for sorption sites.
- Heterogenous photo-Fenton was more efficient with ~5 µm oxides than with nano-oxides due to a higher amount of oxidative action per area.

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[1] S. Giannakis, M. I. Polo López, D. Spuhler, J. A. Sánchez Pérez, P. Fernández Ibáñez, C. Pulgarin, *Appl. Catal. B: Environ.* **2016**, *199*, 199.

[2] S. Giannakis, M. I. Polo López, D. Spuhler, J. A. Sánchez Pérez, P. Fernández Ibáñez, C. Pulgarin, *Appl. Catal. B: Environ.* **2016**, *198*, 431.

[3] J. J. Pignatello, E. Oliveros, A. MacKay, *Crit. Rev. Environ. Sci. Technol.* **2016**, *36*, 1.

[4] C. Ruales-Lonfat, J. F. Barona, A. Sienkiewicz, M. Bensimon, J. Vélez-Colmenares, N. Benítez, C. Pulgarin, *Appl. Catal. B: Environ.* **2015**, *166*, 497.

Validation of an Experimental Protocol for Crystal Size and Shape Control

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Keywords: Crystal size and shape control · Design of Experiments · Industrial crystallization

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Serving as both a separation and a purification stage at the same time, crystallization is a widely employed unit operation in the chemical industry. Among the main properties of interest, crystal size and shape greatly affects processability and the performance of the final product.

Despite its widespread application in many processes, crystallization is nevertheless an intrinsically difficult process to control, due to the high number of physical phenomena that undergo in solution and affect crystals formation and growth.

A process comprising repeated cycles of crystallization (cooling), milling and dissolution (heating) stages had been developed previously in order to control crystal size and shape distribution.

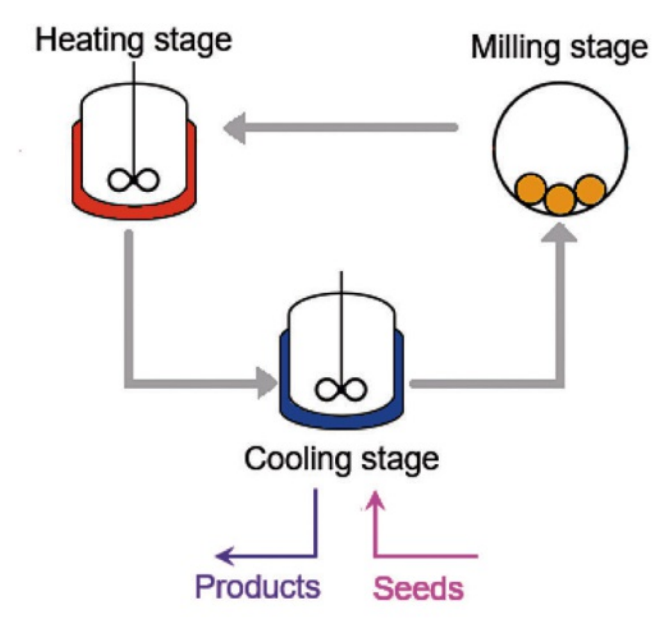

Fig. 1. Schematic representation of the process.

The purpose of the thesis was to apply a Factorial Design of Experiments (FDoE) to the aforementioned process to evaluate the effect of specific process variables on crystal size and shape distributions of uncharacterized compound showing different crystal morphologies. Three compounds were analyzed, the first one being γ-mannitol and the other two being APIs produced by F. Hoffman-La Roche AG in Basel, who sponsored the project and where the experiments using these compounds were carried out.

The FDoE was demonstrated to be an effective method to gain valuable insights in a timely fashion on the behavior of the compounds analyzed. Attainable regions on the crystal size and shape space were identified and explored with a minimum amount of experiments, which is a priority in an industrial environment. The effect of the process on different crystal morphologies, namely needle and platelet structures, was evaluated and improvements in the particles shape and processability were also noticed and analyzed.

Future Plans

After graduation, I decided to look for a job in industry in the field of process design and control, with possibly a focus on solid product design.

Novel Approaches on Hemiporphyrazines: Synthesis, Characterization and NMR studies

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Keywords: Hemiporphyrazines · Photodynamic Therapy · Heterocycles

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Hemiporphyrazines (Hps) are tetradentate, either C_{2v} or D_{2h} symmetric and non-aromatic macrocyclic compounds. The free base hemiporphyarzine (HpH_2) and two metallo hemiporphyrazine (MHp) were first synthesized by Elvidge and Linstead.[1] Since then, hemiporphyrazines continue to be a class of compounds that fascinates the researchers.[2]

The simple hemiporphyrazine structure (Fig. 1) contains two co-facial isoindole and two co-facial 2,6-diaminopyridine units that are linked through four aza bridges as benzo-fused porphyrazine (tetraazaporphine). Hemiporphyrazines are also called analogues of phthalocyanine (Pc), in which two opposing (*trans*) isoindoline units are replaced by 2,6-diamino substituted pyridine rings.

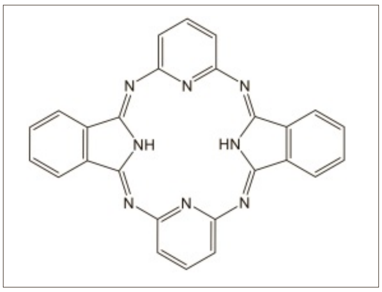

Fig. 1. Structure of hemiporphyrazine.

In our research, we concentrated on the synthesis and characterizations of known and novel hemiporphyrazines such as diazahemiporphyrazines, purinohemiporphyrazines and redox-switchable hemiporphyrazines. We were interested whether hemiporphyrazines could act as photosensitizer instead of porphyrins that we studied earlier.[3] The hemiporphyrazines were expected to have better photophysical properties for the application of photodynamic therapy than the porphyrins we have previously studied.

Diazahemiporphyrazines

The first diazahemiporphyrazine molecule was reported by Geiger and Schmidt in 1992.[4] However, their experimental characterization was incomplete by today's standards. In our research, we employed novel synthetic approaches, optimized the yield, purification and characterization. 1D- and 2D-NMR studies allowed to assign all proton and carbon signals of both isomers. We also synthesized one other novel diazahemiporphyrazine (Fig. 2).

Redox-switchable Hemiporphyrazines

Hemiporphyrazine molecules generally have a limited absorbance in the visible range, since they mainly absorb the light below 450 nm. Several groups have elegantly used redox processes in their synthesis of similar azacalixphyrins.[5] In our research, we have synthesized novel hemiporpyhrazines which have a strong absorbance around 780 nm even though not being aromatic (Fig. 3).

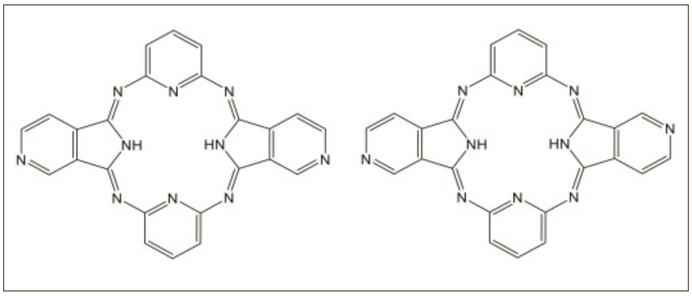

Fig. 2. *cis*- and *trans*-Diazahemiporphyrazine

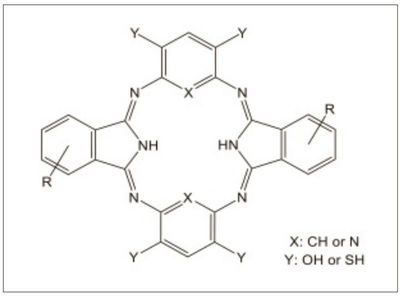

Fig. 3. Structure of novel, synthesized hemiporphyrazines

Acknowledgements

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[1] J. A. Elvidge, R. P. Linstead, *J. Chem. Soc.* **1952**, 5008.
[2] a) D. Attanasio, I. Collamati, E. Cervone, *Inorg. Chem.* **1983**, *22*, 3281; b) C. W. Dirk, T. J. Marks, *Inorg. Chem.* **1984**, *23*, 4325; c) K. Sakata, Y.-I. Hayashi, K. Gondo, M. Hashimoto, *Inorg. Chim. Acta* **1989**, *156*, 1; d) M. Ruf, W. S. Durfee, C. G. Pierpont, *Chem. Commun.* **2004**, 1022; e) R. Wu, A. Çetin, W. S. Durfee, C. J. Ziegler, *Angew. Chem. Int. Ed.* **2006**, *45*, 5670; f) S. M. Huber, M. S. Seyfried, A. Linden, N. W. Luedtke, *Inorg. Chem.* **2012**, *51*, 7032; g) S. M. Huber, G. Mata, A. Linden, N. W. Luedtke, *Chem. Commun.* **2013**, *49*, 4280; h) E. Kleinpeter, A. Koch, S. Schulz, P. Wacker, *Tetrahedron* **2014**, *70*, 9230; i) A. Muranaka, S. Ohira, N. Toriumi, M. Hirayama, F. Kyotani, Y. Mori, D. Hashizume, M. Uchiyama, *J. Phys. Chem. A* **2014**, *118*, 4415.
[3] a) A. Naik, R. Rubbiani, G. Gasser, B. Spingler, *Angew. Chem. Int. Ed.* **2014**, *53*, 6938; b) P. M. Antoni, A. Naik, I. Albert, R. Rubbiani, S. Gupta, P. Ruiz-Sanchez, P. Munikorn, J. M. Mateos, V. Luginbuehl, P. Thamyongkit, U. Ziegler, G. Gasser, G. Jeschke, B. Spingler, *Chem. Eur. J.* **2015**, *21*, 1179.
[4] D. K. Geiger, R. G. Schmidt, *Inorg. Chim. Acta* **1992**, *197*, 203.
[5] a) A. Muranaka, S. Ohira, D. Hashizume, H. Koshino, F. Kyotani, M. Hirayama, M. Uchiyama, *J. Am. Chem. Soc.* **2012**, *134*, 190; b) Z. Chen, R. Haddoub, J. Mahé, G. Marchand, D. Jacquemin, J. A. Edzang, G. Canard, D. Ferry, O. Grauby, A. Ranguis, O. Siri, *Chem. Eur. J.* **2016**, *22*, 17820.