

**Engineering tri- and tetrapodal ligands derived from 8-hydroxyquinoline for the sensitization of NIR-emitting lanthanide ions.**

Céline Duhot, Steve Comby, Daniel Imbert, Anne-Sophie Chauvin, Frédéric Gummy and Jean-Claude Bünzli

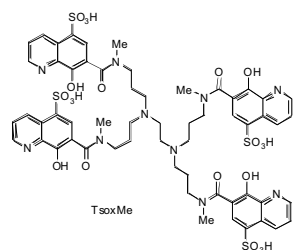
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Interest has recently been focused on the development of luminescent probes emitting in the near-infrared (NIR) range. Despite their relatively weak emissive properties, NIR-emitting lanthanide probes have excited state lifetimes which are long enough to allow the use of time-resolved spectroscopy. We have synthesized several podands containing three or four 8-hydroxyquinoline subunits<sup>[1]</sup> and have compared their ability to efficiently sensitize trivalent lanthanide ions.

Thermodynamically stable and kinetically inert 1:1 water-soluble podates are obtained (*i.e.* pEu = 14.9 with TsoxMe and Eu<sup>III</sup>). No water molecule is detected in the first coordination sphere.

All the ligands sensitize ytterbium(III) and neodymium(III) luminescence and some of them (*i.e.* TsoxMe) erbium(III) luminescence as well.

The best candidate reported so far is the methylated and sulfonated tetrapodal ligand TsoxMe with quantum yields as high as 0.37 % for ytterbium(III) complexes in HBS buffer ( $\tau = 5.79 \mu\text{s}$ ).



[1] Comby, S.; Imbert, D.; Vandevyver, C.; Bünzli, J.-C. G. *Chem. Eur. J.* **2007**, *13*, 936 and ref. therein.

**Luminescent lanthanide helicates as cellular imaging probes**

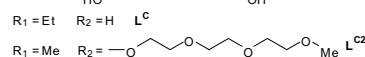
Bo Song, Caroline D. B. Vandevyver, Anne-Sophie Chauvin and Jean-Claude G. Bünzli

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We have been recently developing water-soluble lanthanide bimetallic helicate,  $[\text{Ln}_2(\text{L})_3]$  ( $\text{L} = \text{L}^{\text{C}}$  and  $\text{L}^{\text{C}2}$ , see scheme), as potential cellular imaging probes. These bimetallic edifices are able to permeate the membrane of various cancerous cells and deposit in the cell. Furthermore, no dissociation of the helicates occurs in the cells and no cytotoxicity of the helicates towards the cells is observed up to 500  $\mu\text{M}$ .<sup>[1]</sup> Uptake of the helicate by the cell is assessed both by fluorescence and confocal microscopy. The complexes clearly permeate into cells in a concentration- and time-dependent manner.

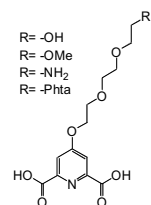
The luminescent stains can be used both for live and fixed cell imaging. An interesting phenomenon is that un-substituted and substituted helicates enter the cells in different ways. The discussion will focus on the ability of the helicate to interact with different cell lines: human keratinocyte (Hacat), human breast adenocarcinoma (MCF-7), human T leukaemia (Jurkat) or hybridoma (5D10), and human cervical adenocarcinoma (HeLa) cells; and on the optimization of the experiment conditions for cell imaging.

[1] C. Vandevyver, A.-S. Chauvin, S. Comby, J.-C. G. Bünzli, *Chem. Commun.* **2007** in press.

**Physicochemical and photophysical study of water soluble lanthanide complexes with ability for binding biological material**

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Sensitive biological analyses require luminescent probes that are water soluble, stable at physiological pH and possess good luminescence properties. Dipicolinic acid (dpa) is known to form stable Ln:L 1:3 complexes with lanthanide ions at physiological pH. However such complexes cannot be coupled directly to biological molecules.

Therefore derivatives with substitution at the 4 position of the pyridine have been designed. A polyoxyethylene arm has been added to this position and the terminal group of the arm functionalized for further grafting with biological material. Four ligands with different terminal functions (alcohol, methoxy, phtalimide and amine groups) have been synthesized and the properties of the Ln:L 1:3 complexes studied.

Thermodynamic studies evidenced good stability of the 1:3 complexes ( $\log\beta_{13} \approx 19-20$  for all Eu<sup>III</sup> complexes). Luminescence measurements revealed a good sensitization of europium and terbium. Complexes of these metals present long lifetimes, up to 1.3 ms for  $[\text{Eu}(\text{L})_3]^{3-}$  and 1 ms for  $[\text{Tb}(\text{L})_3]^{3-}$ , and relatively good quantum yields, up to 12.8 % for the europium complex of  $\text{L}^{\text{OMe}}$ . The next step will be the coupling with activated biomolecules in parallel to the activation of the functional groups.

**New water-soluble luminescent lanthanide bimetallic triple helicates for cellular imaging applications**

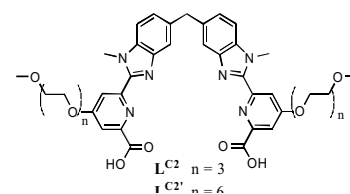
Emmanuel Deiters, Bo Song, Caroline D. B. Vandevyver, Anne-Sophie Chauvin, Jean-Claude G. Bünzli

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Water-soluble luminescent lanthanide (III) chelates are still a subject of current interest mainly due to their potential use as molecular probes *i.e.* in time-resolved fluoroimmuno and DNA hybridization assays.

During the past fifteen years, our laboratory has developed the building of homobimetallic triple-stranded  $[\text{Ln}_2(\text{L})_3]$  helicates. The formation of these complexes by a self-assembly process is based on the so-called induced fit concept. Recently, the ditopic hexadentate ligand  $\text{L}^{\text{C}2}$  has been designed. It carries two polyoxyethylene chains grafted in the para position of the pyridine ring giving rise to an increased solubility of the corresponding helicates in aqueous media. The  $[\text{Eu}_2(\text{L}^{\text{C}2})_3]$  helicate have been successfully tested as imaging probes in human cervical adenocarcinoma cells (HeLa)<sup>[1]</sup>. In order to extend the scope of our investigations, we test here the influence of the chain length of the water solubilizing group. We report on the thermodynamic, photophysical and cell-imaging properties of the triple-stranded helicates obtained with  $\text{L}^{\text{C}2}$ . Comparison is made with the results obtained with  $\text{L}^{\text{C}}$  particularly with respect to the ability of permeating cells.

[1] C. Vandevyver, A.-S. Chauvin, S. Comby, J.-C. G. Bünzli, *Chem. Commun.* **2007**, in press.



## Parallel Metal Ion Coordination at Various Sites in Structured RNA

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Mg<sup>2+</sup> acts as a catalytic cofactor in many ribozymes by enhancing the nucleophilicity of the attacking species and/or by stabilizing the transition state and the negatively charged leaving group. Specific Mg<sup>2+</sup> ion binding sites have also been implicated in the stabilization of structural motifs that are essential for folding [1,2]. It is therefore of high importance to be able to thoroughly analyze Mg<sup>2+</sup> ion binding to RNA and calculate the specific affinity constants at each site. Here we describe a detailed picture of the binding mode of Mg<sup>2+</sup> to the branch-point domain of an group II intron ribozyme, of which we have recently solved the NMR structure [3,4]. From the analysis of chemical shift changes in [<sup>1</sup>H<sup>1</sup>H]-NOESY Mg<sup>2+</sup> titration studies we extracted the intrinsic affinity constants for Mg<sup>2+</sup> to 5 binding sites within this 27 nucleotide long RNA hairpin [4]. Up to now, the fact that several binding sites are saturated at the same time, and hence the Mg<sup>2+</sup> concentration actually available at one site is lower than the total amount of Mg<sup>2+</sup> present in solution, has mostly been neglected. Here we introduce a new iterative calculation procedure that tackles this problem [5]. For D6-27 we find an increase in the actual log K<sub>A</sub> for each site by 0.4 to 0.9 log units. These results clearly demonstrate the importance of using the actually available Mg<sup>2+</sup> concentration when calculating affinity constants for a specific binding site in RNA.

- [1] a) Sigel, R. K. O., Pyle, A. M., *Chem. Rev.* **2007**, *107*, 97.  
b) Sigel, R. K. O., Freisinger E., **2007**, doi:10.16 / jccr 2007.03.008.  
[2] Sigel, R. K. O., *Eur. J. Inorg. Chem.* **2005** *12*, 2281.  
[3] Erat, M. C., Zerbe, O., Fox, T., Sigel, R. K. O. *ChemBioChem*, **2007**, *8*, 306.  
[4] Erat, M. C., Sigel, R. K. O., **2007**, submitted.  
[5] Erat, M. C., Finazzo, C., Coles, J., Sigel, R. K. O., **2007**, in preparation.  
Financial support by the Swiss National Science Foundation (SNF-Förderungspersessur to R. K. O. S.) is gratefully acknowledged

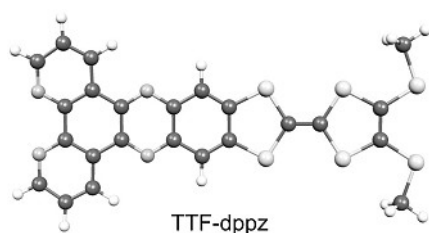
## A Computational Study of Tetrathiafulvalene (TTF) Fused Heterocycles

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Charge transfer transitions can be studied in donor-acceptor (D-A) systems. Tetrathiafulvalene (TTF) is a good donor unit in such D-A systems which are of prime interest on account of their potential applications in molecular electronic devices.

Herein, we will present a computational study of different TTFs fused with heterocycles such as benzene, quinoxaline, phenazine, dipyrido[3,2-a:2',3'-c]phenazine (dppz) [1] and so on. *Ab-initio* calculations are performed and the frontier orbitals examined. We will also show a comparison of the theoretical results with spectroscopic data.



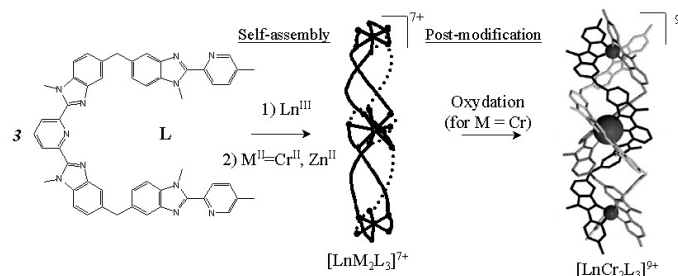
- [1] Ch. Jia, S.-X. Liu, Ch. Tanner, C. Leiggenger, A. Neels, L. Sanguinet, E. Levillain, S. Leutwyler, A. Hauser and S. Decurtins, *Chem. Eur. J.*, **2007**, on-line.

## Encapsulation of NIR lanthanide-emitters into a homobinuclear chromium(III)-containing triple-stranded helicate.

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Stoichiometric mixing of the segmental ligand L with Ln(CF<sub>3</sub>SO<sub>3</sub>)<sub>3</sub> (Ln=Nd, Er, Yb) and M(CF<sub>3</sub>SO<sub>3</sub>)<sub>2</sub> (M=Zn, Cr) under an inert atmosphere produces quantitatively the self-assembled triple-stranded non-covalent podates [LnM<sub>2</sub>L<sub>3</sub>]<sup>7+</sup> [1]. Air oxidation of the low-spin Cr<sup>II</sup> complexes gives selectively the podates [LnCr<sub>2</sub>L<sub>3</sub>]<sup>9+</sup> into which inert Cr<sup>III</sup> has been incorporated. Elemental analysis confirms the formation of the heterotrimetallic complexes with general formulas [LnCr<sub>2</sub>(L)<sub>3</sub>](CF<sub>3</sub>SO<sub>3</sub>)<sub>9</sub>.nS (S=solvents) whose composition is maintained in acetonitrile according to ESI-MS. Photophysical studies evidence the long-lived luminescence of Cr<sup>III</sup>. The Cr<sup>III</sup>→Ln<sup>III</sup> energy transfer increases the lifetime of the Ln-centred luminescence from μs to ms range. This contribution explores the luminescence of these metallic ions in the molecular compounds in order to highlight non-linear properties for Nd<sup>III</sup> and Er<sup>III</sup>.



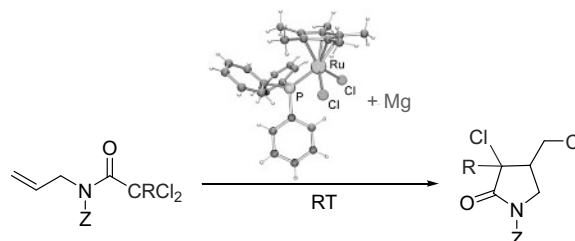
- [1] M. Cantuel, F. Gummy, J.-C. Bünzli, C. Piguet, *Dalton Trans.*, **2006**, 2647.

ATRA and ATRC Reactions Catalyzed by a Mixture of [Cp\*<sub>2</sub>RuCl<sub>2</sub>(PPh<sub>3</sub>)] and Mg

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The main disadvantage of active Ru catalysts for atom transfer radical addition (ATRA) and cyclization (ATRC) reactions has been their low stability. The combination of the air-stable Ru<sup>III</sup> complex [Cp\*<sub>2</sub>RuCl<sub>2</sub>(PPh<sub>3</sub>)] with Mg allows to perform these reactions under mild conditions with high efficiency [1]. Mg as the co-catalyst displays several advantages over the recently reported method with AIBN [2] as it is cheap, non-toxic and easy to handle and separate. It is suggested that Mg acts as a reducing agent that generates and regenerates the catalytically active Ru<sup>II</sup> species.



Intramolecular ATRA reactions are especially interesting from a synthetic point of view. With the new system, cyclizations can be performed under mild conditions with low catalyst loadings and good stereoselectivities. In this context, enantioselective ATRA reactions will be of great interest for the future.

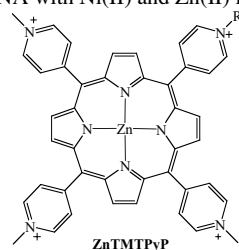
- [1] K. Thommes, B. Içli, R. Scopelliti, K. Severin, *Chem. Eur. J.*, in press  
[2] L. Quebatte, K. Thommes, K. Severin, *J. Am. Chem. Soc.* **2006**, *128*, 7440 - 7441

## Porphyrin Interaction with Short DNA Hairpins

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Cationic zinc porphyrins such as ZnTMTPyP (R = H) have proven to interact exclusively with the Z form of d(GC)<sub>n</sub> rich DNA sequences<sup>[1]</sup>, which can be either induced by dinuclear Zn(II) or Ni(II) complexes or polyamines.<sup>[2,3]</sup> We want to introduce a new series of substituted porphyrin complexes ZnTMTPyP in order to combine sensing and stabilising of the Z-DNA form. These systems were modified to improve binding properties towards alternating purine – pyrimidine (GC) sequences and equipped with alkylating moieties. DNA experiments were performed on short DNA hairpins such as d((CG)<sub>3</sub>TTTT(CG)<sub>3</sub>) which are specifically designed to stabilise the Z form and to easily crystallize. Furthermore, kinetic stopped-flow studies of the induction of Z-DNA with Ni(II) and Zn(II) ions are described.



- [1] M. Balaz, M. De Napoli, A. E. Holmes, A. Mammana, K. Nakanishi, N. Berova, R. Purrello, *Angew. Chem. Int. Ed.* **2005**, *44*, 4006.  
 [2] B. Spingler, Ph. M. Antoni, *Chem. Eur. J.* **2007**, accepted.  
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## Fluorescence Sensors for Lithium Ions

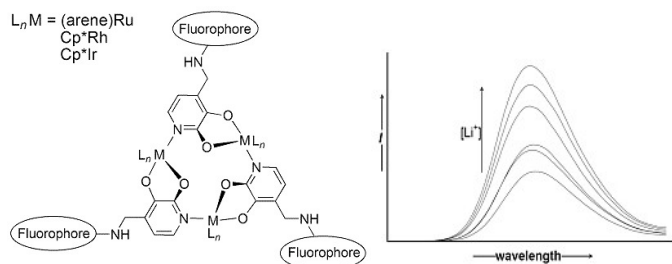
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Lithium carbonate is a widely used drug for patients suffering from bipolar disorder. The unavailability of Li<sup>+</sup> spectroscopic tool represents a severe limitation for investigations in this context.<sup>[1]</sup>

Fluorescent dyes were attached to macrocyclic receptors known to be water-soluble and selective for lithium ions.<sup>[2]</sup> In absence of Li<sup>+</sup>, the fluorescence is quenched due to electron transfer from the late transition metals (Ru<sup>II</sup>, Rh<sup>III</sup>, Ir<sup>III</sup>). When cations are present on the binding sites, the quenching is reduced and the fluorescence intensity increases.

Sensors of this kind may find numerous applications in biomedical investigations involving lithium-based drugs.



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 [2] Z. Grote, R. Scopelliti, K. Severin, *J. Am. Chem. Soc.* **2004**, *126*, 16959-16972.

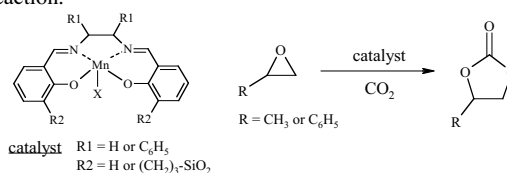
Mn(III)(salen)-catalyzed synthesis of cyclic organic carbonates from epoxides in reactant expanded and supercritical CO<sub>2</sub>

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The synthesis of useful cyclic organic carbonates from epoxides and CO<sub>2</sub> has gained considerable interest in recent years. The search of new and effective catalysts still remains an interesting and auspicious field of research. N,N'-bis(salicylidene)ethylenediamino (salen) complexes of Mn(III) have been reported to catalyze the epoxidation of olefins.

In the present study, we demonstrate that they are also efficient catalysts for the subsequent insertion of CO<sub>2</sub> to afford cyclic carbonates in excellent yield. The reaction rate is similar and even partly exceeding that of analogous Cr(III) complexes used for the same purpose [1]. Dense CO<sub>2</sub> is simultaneously used as solvent, leading to a "solventless" and environmentally benign reaction.



For this purpose, we synthesized a series of Mn(salen)X (X = Cl, Br, I) complexes. At first homogeneous catalysts were prepared and the most efficient ones were immobilized on a suitable support. In all cases, the reaction parameters were optimized by means of reactant variation, IR-spectroscopy, phase behaviour studies and kinetic investigations [2].

- [1] M. Ramin, F. Jutz, J.-D. Grunwaldt, A. Baiker, *J. Mol. Catal. A: Chem.* **2005**, *242*, 32  
 [2] F. Jutz, J.-D. Grunwaldt, A. Baiker, *in preparation*

## STM examination of monolayers of dendritic complexes of 2-pyridinecarboxaldehyde-2'-pyridylhydrazone

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Hydrocarbon modified dendritic wedges are able to form stable monolayers on highly ordered pyrolytic graphite.<sup>[1]</sup>

The synthesis of these dendritic wedges is a simple and efficient process that can be easily be done on a large scale.

Of special interest to our group is the attachment of metal binding ligands to these wedges. The ligand 2-pyridinecarboxaldehyde-2'-pyridylhydrazone (paphyH) (Fig. 1) was considered to be a promising candidate. We have coupled first and second generation dendritic wedges with paphyH. We obtained the free ligands of the first and second generations as well as the corresponding iron (II) complexes. The monolayers of these compounds were studied by using scanning tunnelling microscopy (STM).

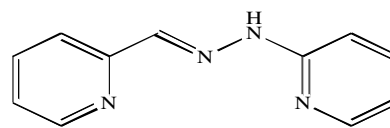


Fig. 1

- [1] Scherer, L. J.; Merz, L.; Constable, E. C.; Housecroft, C. E.; Neuburger, M.; Hermann, B. A. *J. Am. Chem. Soc.* **2005**, *127*, 4033-4041.

**Structural characteristics of Rh in flame-made Rh/Al<sub>2</sub>O<sub>3</sub>**

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Supported noble metals play an important role in catalysis because they display high activity and selectivity in a broad scope of reactions. Their catalytic performance however, is greatly affected by the preparation method, which influences factors such as metal dispersion and oxidation state [1]. The control of the structural properties of the noble metal is especially important in the case of structure sensitive reactions, an example of which is the liquid phase chemo- and enantioselective hydrogenation of ketones [2, 3].

In this contribution, the structure of alumina supported rhodium prepared by flame spray pyrolysis will be discussed. Adsorption of CO by DRIFT on samples reduced at different temperature and temperature programmed reduction experiments reveal that flame-made Rh catalysts contain beside metal particles a large fraction of cationic rhodium species compared to commercial catalysts over a broad range of reduction temperatures (up to 600°C). This behaviour is attributed to the formation of an oxidic Rh phase during flame synthesis that is more stable against reduction than the oxidic phase found in commercial samples.

Catalytic data indicate that the presence of a large fraction of cationic species could be correlated with an increase in selectivity in the hydrogenation of 3,5-di-(trifluoromethyl)-acetophenone [4].

[1] K. Chakarova *et al.*, *J. Mol. Catal. A.: Chem.*, **2007**, 264, 270.[2] E. Toukoniitty *et al.*, *Appl. Catal. A: Gen.*, **2006**, 300, 147.[3] R. Strobel *et al.*, *J. Catal.* **2004**, 222, 307.[4] N. van Vegten *et al.*, submitted for publication.**Magnetic Resonance Imaging contrast agent: grafting of a gadolinium complex on polymer nanoparticles**

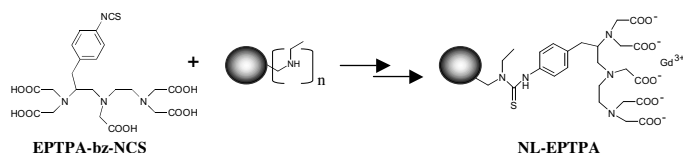
Caroline Cannizzo, Emmanuel Allard, Loïck Moriggi, Angélique Sour, André E. Merbach, Chantal Larpent, Lothar Helm

EPFL-ISIC, 1015 Lausanne, Switzerland

During the last two decades, the use of paramagnetic gadolinium chelates for medical magnetic resonance imaging (MRI) has increased considerably. In order to slow down the correlation time of the complex, and therefore enhance proton relaxivity, it is possible to graft the ligands on macromolecules [1]. It is thus possible to obtain a great number of complexes in a confined space, with a relative rigidity of the system.

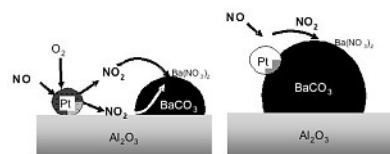
The polymerization of reactive organic monomers in oil-in-water microemulsion affords means to produce stable and translucent suspensions of nanoparticles (D < 50 nm), with narrow size distribution and high degrees of functionalization. The grafting of a new layer at the surface of the particles can be achieved by post-functionalization, directly in the aqueous media.

Here we report the synthesis and NMRD profile of EPTPA-functionalized nanoparticles; the ligand EPTPA-bz-NCS is bound at the surface of aminated nanoparticles via a thiourea linkage. The ligand content was evaluated by elemental analysis, colorimetric titration and magnetic susceptibility of the Gd-loaded particles. These nanoobjects could later on be used for the design of multiple-imaging devices (fluorescence + MRI, etc.).

[1] Laus S., Sour A., Ruloff R., Tóth E., Merbach A.E. *Chem. Eur. J.* **2005**, 11, 3064.**Influence of remote control in Pt/Ba/Al<sub>2</sub>O<sub>3</sub> NO<sub>x</sub> storage-reduction catalysts**Robert Büchel<sup>1,2</sup>, Reto Strobel<sup>1,2</sup>, Sotiris E. Pratsinis<sup>2</sup>, Alfons Baiker<sup>1\*</sup><sup>1</sup>Institute for Chemical and Bioengineering, Wolfgang-Pauli-Strasse 10, 8093 Zurich, Switzerland<sup>2</sup>Particle Technology Laboratory, ETH Zurich, Sonneggstrasse 3, 8092 Zürich, Switzerland

NO<sub>x</sub> storage-reduction (NSR) is applied for exhaust gas treatment of lean fuel engines [1]. The proximity between Pt and BaO in Pt/Ba/Al<sub>2</sub>O<sub>3</sub> NSR catalysts has been found to affect the storage-reduction behavior due to its effect on the spillover of NO<sub>x</sub> species [2]. Here we applied flame synthesis [3] to control the location of the deposition of platinum either on the alumina support or on the Ba storage component.

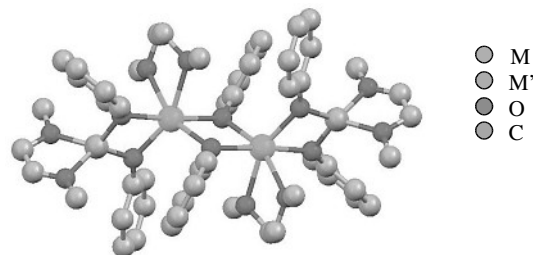
Our studies on the effect of the preferential deposition of platinum on the alumina support or Ba storage component corroborate that the remote control of the different constituents is a crucial factor for high performance of NSR catalysts.

[1] W.S. Epling, L.E. Campbell, A. Yezzerets, N.W. Currier, J.E. Parks, *Catal. Rev.-Sci. & Eng.*, **2004**, 46, 163.[2] N.W. Cant, I.O.Y. Liu, M.J. Patterson, *J. Catal.* **2006**, 243, 309.[3] R. Strobel, L. Madler, M. Piacentini, M. Maciejewski, A. Baiker, S.E. Pratsinis, *Chem.Mater* **2006**, 18, 2532.**Alkoxide and aryloxide clusters of alkali and alkaline earth metal ions**

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The regain in interest of alkali alkoxides and aryloxides resides in the discovery of high-temperature superconducting compounds which has generated a great interest in the formation of oxide materials and other ceramics. However the structures of these compounds are mainly based on the difference of electronegativity between the metal and the oxygen atom (interaction M-O) associated with the bulkiness of the R group.<sup>[1-3]</sup> Some relevant examples as a function of the metal ion and ligand size, as well as neutral O-donor ligands will be presented.

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**The Interaction of Ubiquitin with Anticancer Platinum Complexes by Top-Down Mass Spectrometry**Christian G. Hartinger,<sup>a,b</sup> Wee Han Ang,<sup>a</sup> Angela Casini,<sup>c</sup> Luigi Messori,<sup>c</sup> Yury O. Tsybin,<sup>a</sup> Bernhard K. Keppler,<sup>b</sup> Paul J. Dyson<sup>a</sup><sup>a</sup> Institut des Sciences et Ingénierie Chimiques, Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland<sup>b</sup> Institute of Inorganic Chemistry, University of Vienna, Waehringer Str. 42, A-1090 Vienna, Austria<sup>c</sup> Department of Chemistry, University of Florence, via della Lastruccia 3, Sesto Fiorentino, Florence, Italy

The protein binding of anticancer metallodrugs is regarded as an important part in their mode of action [1]. Characterization of protein binding and release may allow new drugs to be designed which are devoid of protein interactions or capable of binding selectively to protein targets.

MALDI- and nESI-MS were compared for the analysis of ubiquitin (Ub)-Pt anticancer drug interactions and ESI FT-ICR-MS was utilized for high mass accuracy measurements of protein-metal complexes, whereas characterization of the binding sites of Pt complexes on the model protein Ub was performed with diverse tandem mass spectrometric techniques in FT-ICR-MS. Cisplatin, transplatin and oxaliplatin were incubated with Ub (molar ratio 2:1) and the reactions were followed over time. The Pt complexes formed mainly monoadducts with Ub, but of significantly different composition. For cisplatin mainly bifunctional adducts were detected, while with transplatin the most abundant adduct was found to be Ub-[Pt(NH<sub>3</sub>)<sub>2</sub>Cl] and oxaliplatin formed exclusively the bifunctional species Ub-[Pt(chxn)]. Application of high resolution mass spectrometry and different fragmentation modes allowed us to identify binding sites for the Pt complexes. Implications on the mode of action will be discussed.

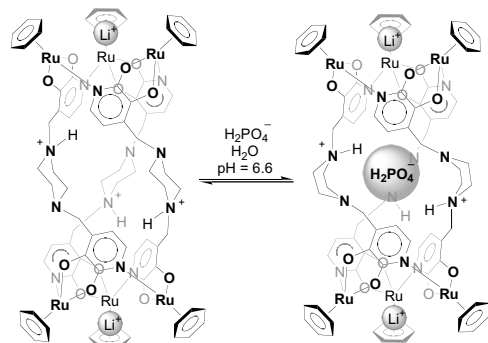
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**A self-assembled receptor for the selective recognition of phosphate in water**

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The self-assembly of organometallic half-sandwich complexes with bridged dihydroxypyridine ligands allowed the synthesis of triple stranded expanded helicates.<sup>[1]</sup> A pH controlled procedure leads to water soluble cationic complexes.



The cationic character of the bridging ligands allowed us to expect interactions with small anions. Indeed, whereas this receptor does not show any affinity for anions such as halides or nitrate, phosphate binding properties have been highlighted, a fact not frequently observed in highly polar solvents.

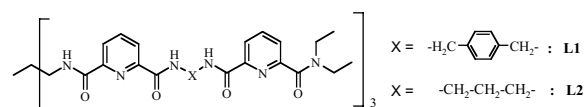
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**New ditopic tripodal ligands for lanthanide complexation**

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Recently, several tripodal [1,2] and tetrapodal ligands [3] have been prepared in order to develop stable binding Ln(III) luminescent devices. Herein we report the synthesis of new ditopic ligands **L1** and **L2**, which have been designed by taking advantage of the chelating effect of 2,6-bis(carbonyl)pyridine subunits. These coordination sites are linked by two different spacers and the final tripodal ligands are obtained by coupling of three ditopic strands with 2-(aminomethyl)-2-methyl-1,3-propanediamine.



Both ligands are well preorganised for Ln(III) complexation in two nine-coordinate cavities. Indeed, spectrophotometric and ES-MS titrations of **L1** and **L2** with Ln(III) clearly demonstrate the formation of bimetallic complexes in acetonitrile. In addition, kinetic methods are used to investigate the formation mechanism.

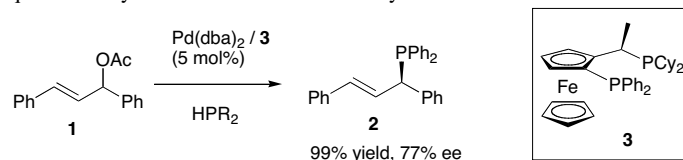
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**Catalytic Asymmetric Allylic Phosphination**

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Pd-catalyzed allylic substitution reactions are known to occur with a variety of carbon, nitrogen, and oxygen nucleophiles. However, to the best of our knowledge, the analogous reaction involving a secondary phosphine has never been reported. Recently, we developed a Ni-catalyzed intermolecular hydrophosphination of activated cyanoalkenes with secondary phosphines [1]. We now found that the same type of nucleophiles may be used for an unprecedented allylic phosphination. Thus, the model substrate 3-acetoxy-1,3-diphenylprop-1-ene (**1**) is converted with diphenylphosphine to the corresponding allylic phosphine (**2**) in the presence of 5 mol-% of a Pd catalyst containing the ferrocenyl ligand *Josiphos* (**3**) [2]. Product **2** is isolated in quantitative yield and the enantioselectivity is 77% ee.



This new C-P bond forming reaction can provide a broad set of chiral phosphines with the opportunity of further a functionalization of the alkene.

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**Homogenous catalytic decomposition of formic acid for hydrogen generation at variable pressure**

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Switzerland

H<sub>2</sub> is a versatile source of energy and an important starting material for many chemical reactions. Conventional hydrogen storage techniques, at high pressure or at low temperature, have weight and safety issues, therefore the development of new strategies to store H<sub>2</sub> is currently an active area of research [1].

We have developed a continuous hydrogen generation process from formic acid by homogenous catalysis in water (eq. 1) [2].



This system allows the *in situ* production of hydrogen gas under mild conditions (25–170°C) and at variable pressure. The catalysis has the advantage of being selective, therefore no CO is generated. The CO<sub>2</sub> formed together with the H<sub>2</sub> can advantageously be used, under different conditions, to reform formic acid (eq. 2).



The catalytic system, which exhibits particularly good robustness, will be discussed in detail, as well as the reaction mechanism.

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**Second Generation Artificial Hydrogenases Based on the Biotin-Avidin Technology: Improving Activity, Stability and Selectivity by Introduction of Enantiopure Amino Acid Spacers**

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Metal-catalyzed enantioselective transformations are among the most efficient means to produce enantiomerically pure compounds. In many respects, enzymes are complementary to homogeneous catalysts.

Incorporation of biotinylated rhodium-diphosphine complexes within (strept)avidin as host protein yields artificial metalloenzymes for the enantioselective hydrogenation of *N*-protected dehydroaminoacids.

Introduction of an (*R*)-proline spacer between the biotin anchor and the diphosphine moiety affords a versatile ligand **Biot-(R)-Pro-1** which displays good (*S*)-selectivities in the presence of either avidin or streptavidin (89 % ee and 91 % ee respectively). The resulting artificial metalloenzymes {Rh(**Biot-(R)-Pro-1**)(COD)}<sup>+</sup> C (strept)avidin display increased stability against organic solvents.<sup>1,2</sup>

Furthermore, experiments using immobilized artificial metalloenzymes will be presented.

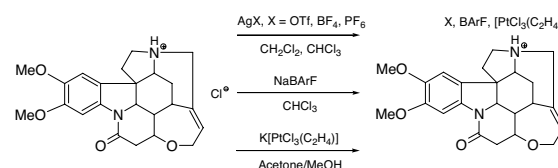
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**Studies on Ionic Interactions in Brucinium Salts using Diffusion and Overhauser NMR Methods**

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Diffusion constants are useful, as they can provide an indication of molecular volume [1] and how the individual charged species translate in solution. This latter point stems, partially, from the ability to use a multinuclear NMR diffusion approach, e.g. <sup>1</sup>H for the cation and <sup>19</sup>F for the anion, combined with <sup>1</sup>H, <sup>19</sup>F HOESY data [2], to follow how the anions and cations interact. Nevertheless, applications of the PGSE method remain sparse and there have been few systematic studies for organic salts in different solvents.



PGSE diffusion, <sup>1</sup>H, <sup>19</sup>F Overhauser and related 2D NMR studies on salts of Brucinium X, where X = OTf, BF<sub>4</sub>, PF<sub>6</sub>, BARf, [PtCl<sub>3</sub>(C<sub>2</sub>H<sub>4</sub>)], are reported. These solution NMR results give an insight into how the anion interacts with the cation as well as the extent of ion pairing and its solvent dependence. Additionally, comparisons to small-sized ammonium salts are made.

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**Metal ions and the splice site recognition complex of a group II intron ribozyme**

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Metal ions are inextricably involved in the process of RNA folding and function.<sup>[1,2,3]</sup> In group II intron ribozymes, which have the ability to undergo self-splicing,<sup>[4]</sup> metal ions (especially Mg<sup>2+</sup>) stabilize tertiary structural elements, but also potassium appears to have a special additional role in binding to high affinity sites.<sup>[5]</sup> These group II introns consist of a conserved set of six domains (D1–D6) which are defined by characteristic secondary structural elements.<sup>[4]</sup> D1, the largest of the six domains, is an independent folding unit and serves as the molecular scaffold for docking of the other domains. For a successful splicing event it is crucial that the exon is correctly recognized by the intron. This is ensured by base-pairing of two regions in D1, the exon binding sites 1 and 2 (EBS1 and EBS2) with the two intron binding sites (IBS1 and IBS2) located at the end of the 5'-exon. As metal ions also reside at the splice site recognition complex EBS1-IBS1<sup>[1,6]</sup> we investigate the structure and metal ion requirements of this complex by NMR and other spectroscopic means. Here, we will discuss the results of our analysis.

Financial support by the Boehringer Ingelheim Fonds (fellowship to D.K.) and the Swiss National Science Foundation (*SNF-Förderungsprofessur* to R.K.O.S.) is gratefully acknowledged.

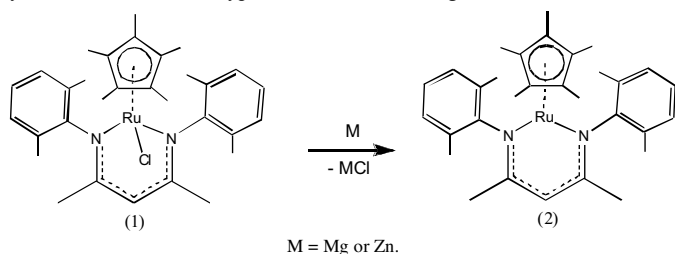
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### Catalysis and Reactivity Studies of Cyclopentadienyl Ruthenium (II)- and (III)- $\beta$ -Diketiminato Complexes

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Recently, the  $\beta$ -Diketiminato class of ligands demonstrate significant advantages for the stabilization of coordinatively unsaturated main-group and transition metal complexes. We report on the synthesis, characterization and chemical reactivity of a series of  $\eta^5$ -C<sub>5</sub>Me<sub>5</sub>-substituted Ru- $\beta$ -diketiminato (1). Starting with this air-stable, paramagnetic Ru(III) species, metathesis reactions provide coordinatively unsaturated Ru(II) species. However, chloride abstraction with reducing agents affords a reactive complex with the metal center in the +2 oxidation state (2). In particular, this species reacts in an unusual manner towards O<sub>2</sub>, resulting in ligand insertion rather than oxygenation of the Ru center. Protonation of 2 at the  $\alpha$ -carbon site of the diketiminato ligand, yields a highly unstable coordinatively unsaturated complex. Several types of Ru(III)-chloride species (1) were also evaluated for their ability to perform atom transfer radical addition of halogenated hydrocarbons to various types of alkene-containing substrates.



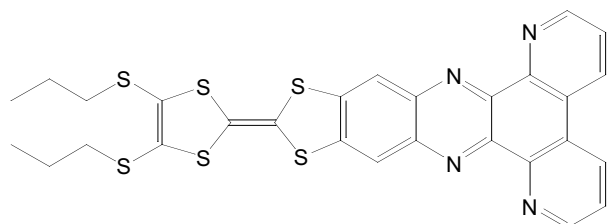
### A Redox Active Bridge: Tetrathiafulvalene-dipyrido-phenazine

Elvira Beitler, Christine Goze, Shi-Xia Liu\*, Natalie Dupont, Andreas Hauser, Silvio Decurtins

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Not in vain are Ruthenium(II) complexes the focus of many scientific investigations, as they exhibit multifarious photophysical properties that strongly depend on the nature of the ligands. One recent example is the incorporation of one or more tetrathiafulvalene (TTF) units into Ru(II) chromophores [1]. TTF is known for its  $\pi$ -donor capacity and induces long-lived charge separated states in aforementioned complexes.

In the work at hand, a TTF unit was fused with dipyrido(2,3-a'-3',2'-c)phenazine, which is capable of coordinating two distinct metal ions. The resulting dinuclear complexes are expected to show a range of charge-transfer options upon photoexcitation, oxidation or reduction.



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### Palladium complexes of N-heterocyclic carbenes. An NMR study on molecular dynamics

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A series of carbene compounds of the type [Pd(C<sub>3</sub>H<sub>5</sub>)X(IPr)] have been prepared, where IPr = N, N'-bis(2,6-diisopropylphenyl)imidazol-2-ylidene and X = Br<sup>-</sup>, I<sup>-</sup>, N<sub>3</sub><sup>-</sup>, trifluoromethanesulfonate, acetate and 4-picoline, starting from the commercially available material [Pd(C<sub>3</sub>H<sub>5</sub>)Cl(IPr)]. <sup>1</sup>H, <sup>13</sup>C NMR and exchange spectroscopic techniques have been used to investigate these allyl complexes.

The NMR experiments show exchange of the 2,6-di-*i*-propylphenyl moieties of the carbene and a *syn/anti* exchange of the allylic protons *cis* to the carbene. This indicates restricted rotation of the carbene ligand around the Pd-C bond and a process of  $\eta^3$ - $\eta^1$  rearrangement of the allyl moiety. These two processes have, for each complex, a similar kinetic constant, while the range of rates obtained by changing the X ligand varies from fast (OTf<sup>-</sup> and OAc<sup>-</sup>) to slow (4-picoline) exchange, in the NMR time scale, suggesting that the rotational barrier is mainly of steric nature<sup>2</sup>.

The <sup>13</sup>C NMR chemical shifts of the allyl group show, as expected, a larger imbalance between *cis* and *trans* position with respect to the carbene when going to weaker X donors.

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### The nature of Ru species in Ru-exchanged hydroxyapatite catalysts for aerobic alcohol oxidation

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Ru-exchanged hydroxyapatites (RuHAp, HAp = Ca<sub>10</sub>(PO<sub>4</sub>)<sub>6</sub>(OH)<sub>2</sub>) are highly effective and selective catalysts for the aerobic oxidation of alcohols to carbonyls using molecular oxygen [1, 2]. The activity of the catalyst can be improved by fine tuning the structure of the catalyst, including the location and accessibility of the Ru active sites.

The Ru species present on a 2.6 wt% RuHAp catalyst prepared with a short contact time of the Ru salt solution with HAp (10 min) have been characterized using CO as probe molecule for cationic species [3]. The material has been studied as-prepared and treated with O<sub>2</sub>, H<sub>2</sub> and at increasing temperature prior to CO adsorption in order to gain insight in the nature of the complex infrared spectra. A set of six bands can be found on as-prepared RuHAp in the 2150-1950 cm<sup>-1</sup> spectral range. The desorption behaviour of these bands and their different ratios in the oxidized sample and in that treated at increasing temperature prior to CO adsorption reveal that the bands can be divided in two groups. The first group belongs to isolated Ru<sup>3+</sup> ions (adsorbed, ion-exchanged at the outer surface of HAp, or in Ru-phosphate formed by dissolution-redeposition from HAp) and the second to (RuO<sub>x</sub>)Ru<sup>2+</sup> cations located on a labile RuO<sub>x</sub> (x < 2) phase. This last species is similar to the one that is supposed to be involved in alcohol oxidation over supported Ru.

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## Antimicrobial-Coated Surfaces

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Implant-associated infections are serious complications of medical device insertions. The biofilm coated surface is resistant to pharmacological agents as well as host defences [1].



Artificial hip stems

Silver is the most powerful antimicrobial and antibacterial inorganic agent used safely in medicine for many years [2]. The combination of silver compounds and antibiotics may provide additive activity against most microorganisms. We focus on producing self-protective surfaces that aim at the prevention of bacterial colonization and eradicate implant associated infections [3].

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Investigation of metal/thiolate clusters in wheat E<sub>c</sub>-I plant metallothioneins by mass spectrometry

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Metallothioneins (MTs), a group of metal-binding proteins which has typically low molecular mass (6~7 kDa), during the last four decades both medicine and biology have focused on them because of their multifunctional physiological behaviour in transport, storage and detoxification of metals. [1]

MTs are able to coordinate heavy metal ions with d<sup>10</sup> electron configuration. Despite their wide distribution among the animal and plant kingdoms, MTs show an extremely heterogeneous composition. They are currently classified in 15 families following the taxonomical criteria. Placed in the 15<sup>th</sup> family, plant metallothioneins contain two cysteine-rich domains and a spacer region devoid of this amino acid. Plant MTs are further classified in four sub-families according to the distribution of the cysteine residues and the length of the spacer region. [2]

The first discovered plant MT is the *Triticum aestivum* E<sub>c</sub>-I, also known as wheat early cysteine labelled protein. E<sub>c</sub>-I has 17 cysteine residues and is able to bind up to 6 Cd<sup>2+</sup> or Zn<sup>2+</sup>. [3]

To better understand the mechanisms of metal binding and get insights into the function of this representative of the subfamily E<sub>c</sub> of plant MTs, we have used mass spectrometry to characterize this protein and its metal clusters. Results from our investigations will be presented and discussed.

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Cd<sup>2+</sup> and Sc.a15γ: Providing an Insight into the Metal Ion Binding Properties of a Group II Intron Ribozyme Domain

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Group II introns are RNA sequences that are capable to perform self-splicing: These non-coding sequences are removed autocatalytically from the pre-mRNA during processing, thus acting as ribozymes.<sup>[1]</sup> This process is highly dependent of mono- and divalent metal ions,<sup>[2]</sup> in nature mainly K<sup>+</sup> and Mg<sup>2+</sup>. It is known that especially the divalent metal ions are located at distinct binding sites to stabilise local structural motives.<sup>[2,3]</sup> Various divalent metal ions like Mn<sup>2+</sup>, Co<sup>2+</sup>, and Cd<sup>2+</sup> are known to mimic Mg<sup>2+</sup> in ribozyme reactions<sup>[4]</sup> and can thus be used to replace Mg<sup>2+</sup> in biochemical studies. Cd<sup>2+</sup> is of interest also due to the toxicity and carcinogenic potential that might result from an interference with biological processes involving Mg<sup>2+</sup>, Ca<sup>2+</sup>, or Zn<sup>2+</sup>. Based on its solution structure,<sup>[5]</sup> we now used different NMR techniques to study the Cd<sup>2+</sup> binding properties of the catalytically relevant domain 5 (D5) of the group II intron Sc.a15γ from *S. cerevisiae*. We found five distinct Cd<sup>2+</sup> binding sites within D5 and quantified the stability of the complexes formed. A comparison with the ones obtained for Mg<sup>2+</sup> allows us to point out the similarities and differences between the two metal ions and consequently to assess the potential of Cd<sup>2+</sup> as a mimic for Mg<sup>2+</sup>.

Financial support by the Swiss National Science Foundation (SNF-Förderungsprofessur to R. K. O. S.) is gratefully acknowledged.

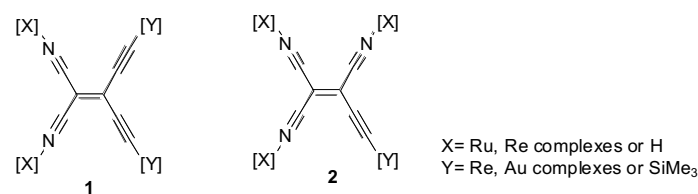
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## Synthesis and characterization of cyanoethynylethylene bridged complexes

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Cyanoethynylethylenes (CEEs) are useful building blocks for the construction of organometallic complexes because of their multi-binding sites [1]. Organic donor substituted cyanoethynylethylene molecules show highly efficient optical nonlinearities and strong electron-field-induced charge-transfer character [2][3]. Therefore, we describe the synthesis and characterization of several ruthenium and rhenium complexes with cyanoethynylethylene as a bridging ligand (scheme 1). Their electrochemical and photophysical properties are also studied.



Scheme 1

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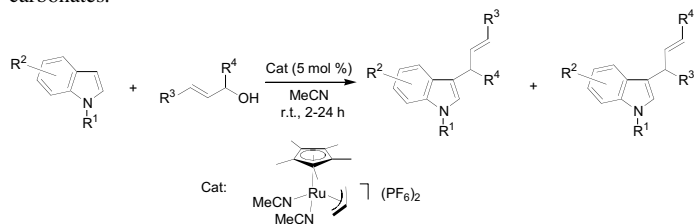


### Efficient ruthenium(IV)-catalyzed allylation of indoles with allyl alcohols

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Dicationic ruthenium(IV) allyl complexes are efficient catalysts in the Friedel-Crafts allylation of phenols and related compounds.<sup>1,2</sup> We have found that related ruthenium(IV) complexes catalyze the reaction of indoles with allyl alcohols to form 3-allylindoles under mild conditions in high yield and selectivity. This process offers several advantages over the appropriate palladium-catalyzed transformation.<sup>3</sup> Specifically a) there is no need for the addition of BEt<sub>3</sub>, b) relatively short reaction times at room temperature, and c) the possibility of allylation of 1-substituted indoles. The rate of the reaction is comparable with the rate of the allylation with the appropriate allyl carbonates.



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### Nitrosating Intermediates in NO<sup>+</sup> Oxidation

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The reaction of nitrogen monoxide with dioxygen to nitrogen dioxide



does not only play an important environmental role but is also of major importance in physiological processes. The human body produces a constant flux of nitrogen monoxide and holds a level of at least 10<sup>-9</sup> M [1]. The partial pressure of dioxygen is a great deal higher.

Therefore, postulated reactive intermediates in the overall reaction 1 [2], such as dioxido(oxido)nitrogen (ONOO<sup>•</sup>) and  $\mu$ -dioxido-bis(oxidonitrogen) (ONOONO), can reach sufficiently high levels that lead to physiological relevant side reactions. These can comprise alternative nitration or nitrosation mechanisms, which have been under investigation for decades [3].

Different nitrosation reagents specific to nitrosation were exposed to adjustable mixtures of nitrogen monoxide and dioxygen. Product analysis shows, that different nitrosation types can emerge during the different stages of nitrogen monoxide oxidation.

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### Copper coordination to the plant metallothionein *Cicer arietinum* MT2

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After iron and zinc, copper is the most abundant transition metal ion in humans and essential for all organisms. However, as free copper ions are highly reactive and can be toxic, their concentration is tightly regulated in the cell by a number of specific metal ion binding proteins or smaller biological chelators. The p2-type plant metallothionein from chickpea (*Cicer arietinum* MT2) is one example for such a metal ion chelating protein. *C. arietinum* MT2 is a small protein (M<sub>r</sub> ~ 8 kDa) with the characteristic cysteine distribution pattern of members of the p2 subfamily. Its high binding affinity for divalent d<sup>10</sup> metal ions was recently studied in our lab.[1] As *Arabidopsis thaliana* MT2a mRNA levels in seedlings are known to increase significantly after CuSO<sub>4</sub> treatment and, additionally, *A. thaliana* MT2 over-expression has been shown to restore CuSO<sub>4</sub> tolerance of a MT-deficient yeast mutant,[2] we also started to investigate copper coordination to *C. arietinum* MT2. Titrations with Cu<sup>I</sup> show the coordination in form of metal-thiolate clusters. In the presence of Cu<sup>II</sup> ions, reduction to Cu<sup>I</sup> accompanied by the oxidation of cysteine thiolate groups to disulfide bridges is observed as expected, with concomitant Cu<sup>I</sup> coordination to not oxidized thiolate groups. EPR measurements on a protein sample treated with an excess of Cu<sup>II</sup> also revealed binding of Cu<sup>II</sup> to the protein, which, according to UV and CD spectroscopic measurements, is distinctively different from the Cu<sup>I</sup> coordination mode. In the absence of histidine, possible coordination sites might be e.g. the amide groups of the protein backbone or tyrosine residues.

Financial support for this project comes from the Swiss National Science Foundation (200020-113728/1 to EF).

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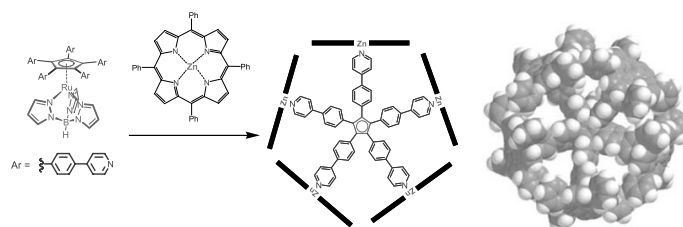
### Complexation studies of a star-shaped pentapyridyl ligand with metallated porphyrins

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Arrays of five or more porphyrin units have been constructed either through self-assembly of porphyrins bearing molecular recognition units or the synthesis of covalent porphyrin oligomers.[1-2] To create larger arrays, the self-assembly approach making use of molecular recognition becomes an attractive alternative to the traditional covalent strategy.

Here, we show that a penta pyridyl star-shaped ligand may be used to assemble up to five porphyrins.



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**Structure conversion of an oligonucleotide containing artificial imidazole nucleosides in presence of Ag(I) ions**Silke Johannsen<sup>1</sup>, Dominik Böhme<sup>2</sup>, Jens Müller<sup>2</sup> and Roland K. O. Sigel<sup>1</sup><sup>1</sup>Institute of Inorganic Chemistry, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland<sup>2</sup>Department of Chemistry, University of Dortmund, Otto-Hahn-Strasse 6, 44227 Dortmund, Germany

Aside from the eminent role of DNA and RNA for all organisms, metal-modified oligonucleotides with artificial bases gain more and more importance for use in nanodevices and as tools for biotechnology. Incorporation of metal ions into the helix by the aid of artificial base pairs is one promising way to build-up and trigger electrical properties into oligonucleotides. Here a 17 nt DNA was synthesised including three imidazole moieties as nucleobase surrogates [1]. Melting temperature analysis suggests a structural conversion from hairpin to double helix upon addition of Ag(I) ions. For a detailed understanding we investigated the transformation of the hairpin to the 34 nt duplex upon addition of Ag(I) ions by NMR and solved the three-dimensional structures of the hairpin and the duplex. By determination of the hydrodynamic radius with the help of DOSY (Diffusion Ordered Spectroscopy) and DLS (Dynamic Light Scattering) we could confirm the hairpin structure in the absence and accordingly the duplex formation in presence of Ag(I) ions. Furthermore, detailed analysis of the acid-base properties of each imidazole in the hairpin yields an increased basicity of these moieties by up to 0.9 log units compared to the free imidazole nucleoside.

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Financial support by the European ERANet-Chemistry, the Swiss National Science Foundation (SNF-Förderungsprofessur to R. K. O. S.), and the *Deutsche Forschungsgemeinschaft* (Emmy Noether programme, J. M.) is gratefully acknowledged.

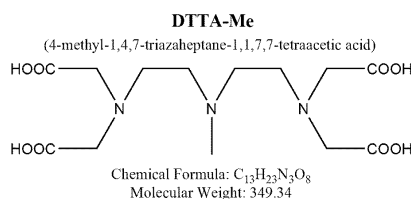
**Physico-chemical and relaxometric studies of the ligand DTTA-Me and its Gd<sup>3+</sup> complex**

Loïck Moriggi, Caroline Cannizzo, Florent Beyrière, Cora Prestinari, André E. Merbach, Lothar Helm

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In 1957, Schwarzenbach and al. presented pK<sub>a</sub> values and the K<sub>ML</sub> constants of the so called DTTA-Me ligand (4-methyl-1,4,7-triazaheptane-1,1,7,7-tetraacetic acid) for complexes with some bivalent ions [1]. Within the last few years, our group used this DTTA chelate unit for several self-assembled Gd<sup>3+</sup> complexes showing high relaxivities [2][3][4]. Gd-DTTA complexes present the advantage to have two water molecules in their first sphere of coordination providing an efficient contrast agent.

We are presenting here pK<sub>a</sub> values of the ligand DTTA-Me as well as the K<sub>ML</sub> for complexes with Gd<sup>3+</sup> and Zn<sup>2+</sup>. Furthermore, we studied by relaxometry the competition of Gd-DTTA-Me / Gd-DTPA-BMA and the transmetallation observed for the complex Gd-DTTA-Me in presence of Zn<sup>2+</sup>.



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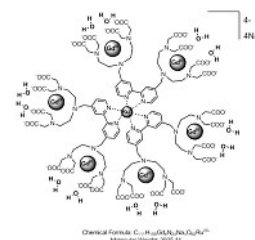
**A Ruthenium-based Metallostar: a multi imaging system?**

Loïck Moriggi, Caroline Cannizzo, Angélique Sour, André E. Merbach, Lothar Helm

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The first so called Metallostar, composed of Fe<sup>3+</sup> surrounded by 3 [(bipy)DTTA<sub>2</sub>Gd<sub>2</sub>](H<sub>2</sub>O)<sub>4</sub>]<sup>2-</sup> has been synthesized and characterized by Livramento and al. [1] in 2005. This iron-based Metallostar contains thus three DTTA (diethylenetriamine tetraacetate) chelating units, providing a possible MRI contrast agent with twelve inner sphere water molecules. Despite its interesting density of relaxivity, this Metallostar present an insufficient stability due to the relatively weak iron-amino bonds [2].

We present here a Ruthenium-based Metallostar with similar structure, presenting no lack of stability and which could have interest as a multiple imaging system (fluorescence + MRI). The characterization of the compound has been carried out by <sup>1</sup>H-NMR spectra, UV/Vis spectrophotometry and NMR relaxivity.



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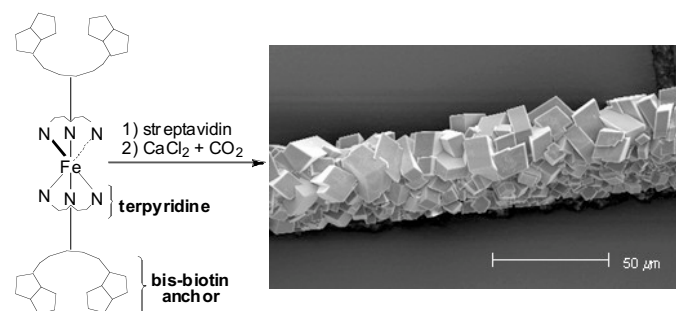
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**Hierarchical Self-Assembly of One Dimensional Streptavidin Bundles as Collagen Mimetic for the Biomineralization of Calcite**

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**Extending the concept of coordination polymers:** Introduction of streptavidin (as a linker) between two Fe(II)(terpyridine-bis-biotin) connectors affords a one dimensional Metal-Organic Protein Framework (MOPF). In the presence of calcium ions and carbon dioxide vapors, these MOPF aggregate to form protein bundles which template the biomineralization of calcite.



[1] Sabina Burazerovic, Julieta Gradinaru, Julien Pierron, Thomas R. Ward, *Angew. Chem. Int. Ed.*, in press.

**Oxidation Kinetics of Cytochrome P450 Enzymes**

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Cytochromes P450 are well-known and ubiquitous redox enzymes which carry out a variety of oxidations, mainly hydroxylations, using dioxygen. The iron(III)-heme center in these enzymes undergoes sequential transitions during the oxidation process that is not completely understood.

Peracids are most suitable to generate cytochromes P450 in high oxidation states [1, 2]. In the past they were always used in excess with respect to cytochrome P450, giving rise to the possibility of unwanted side-reactions. Peroxynitrite used in these experiments was prepared [2] by a method that suffers from substantial contamination (> 50%) with nitrite.

In order to overcome these complications we oxidized cytochrome P450 variants with substoichiometric amounts of peracid in a stopped-flow spectrometer. We also used a P450 variant in which cysteine as the axial iron ligand replaced by selenocysteine. Peroxynitrite was prepared by a method known to be contamination-free. We found three distinct sequential reactions showing up as synchronous changes in the optical spectrum, having the same rate constants. The first step was the peracid to iron(III) coordination preceding the actual oxidation, as was suspected earlier [1]. Directions of absorbance changes differed in some parts of the spectrum for cysteine and selenocysteine species, reflecting the different donor strength of sulfide and selenide ligand.

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**Short, Facile and High Yield Synthesis of Extremely Efficient Pincer-Type Suzuki-Catalysts**

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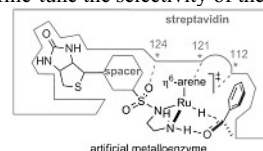
The Suzuki-Miyaura cross-coupling is one of the most efficient methods for C-C bond formation, which is in our days an indispensable tool in organic synthesis for the catalytic formation of symmetric and non-symmetric biaryls. Many palladium complexes have been used to promote the Suzuki coupling and, whilst some are very efficient, allowing the use of sterically hindered substrates, and even aryl chlorides at very low catalyst loadings and sometimes at room temperature, many suffer from their poor thermal stability, as well as poor stability towards air and moisture. Moreover, the catalyst syntheses are often time consuming, difficult and/or require the use of expensive substrates. We would like to introduce extremely efficient Suzuki-catalysts, which are easily synthesized in high yields.

**Designed Evolution of Artificial Transfer Hydrogenases Based on the Biotin-Streptavidin Technology**

Anca Pordea, Thibaud Rossel, Alessia Sardo, Anita Ivanova, Marc Creus, Thomas R. Ward\*

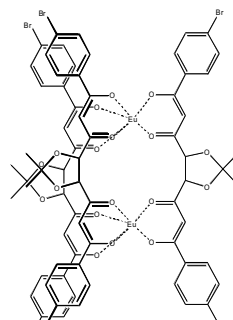
Institute of Chemistry, University of Neuchâtel, Av. Bellevaux 51, CP 158, CH-2009 Neuchâtel, Switzerland. E-mail: anca.pordea@unine.ch, thibaud.rossel@unine.ch.

Incorporation of biotinylated racemic three-legged  $d^6$ -piano stool complexes in streptavidin yields enantioselective transfer hydrogenation artificial metalloenzymes for the reduction of ketones<sup>1</sup>. In a previous screening step, we identified S112A and S112K streptavidin mutants as the best (*R*)-, respectively (*S*)-selective streptavidin mutants for the reduction of acetophenone derivatives<sup>2</sup>. A recent X-ray structure analysis of S112K containing the biotinylated Ru-complex proved that the success of S112 mutagenesis may be due to its proximity to the metal. In addition, the structure allowed to identify two additional residues that are likely to interact with the complex. In a second screening step, we performed a double saturation mutagenesis at positions K121 and L124 while conserving the S112K and S112A mutations. We speculated that this directed double mutagenesis could increase or inverse the selectivity of the reaction by synergic or non-synergic interactions with the catalyst. We demonstrate with this screen that it is possible to use rational design to fine-tune the selectivity of the reduction of ketones.



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**Luminescence studies of polystyrene nanoparticles doped with a triple-stranded trivalent europium complex**Sabrina Dehn<sup>a</sup>, Nicole Jagielski<sup>b</sup>, Annina Aebischer<sup>c</sup>, Frédéric Gumy<sup>c</sup>, Markus Albrecht<sup>a</sup>, Katharina Landfester<sup>b</sup>, Jean-Claude Bünzli<sup>c</sup><sup>a</sup>Institut für Organische Chemie, RWTH Aachen, Landoltweg 1, 52074 Aachen, Germany<sup>b</sup>Department of Organic Chemistry III, University of Ulm, Albert-Einstein-Allee 11, 89081 Ulm, Germany<sup>c</sup>Laboratory of Lanthanide Supramolecular Chemistry, École Polytechnique Fédérale de Lausanne, BCH 1402, 1015 Lausanne, Switzerland

The dinuclear triple stranded Eu(III) complex (see Figure) is a new member of the widely studied  $\beta$ -diketonatolanthanide(III) complexes. The pure compound as well as polystyrene nanoparticles of the core-shell type ( $\varnothing = 50$ -100 nm) doped with different amounts of this Eu(III) complex do show intense red luminescence upon excitation in the ultraviolet. The samples have been addressed by high-resolution optical spectroscopy using Eu(III) as a structural probe.<sup>1</sup> Interestingly, the photophysical properties of the doped nanoparticles are improved with respect to the pure complex, (e.g. luminescence quantum yields up to 18%). Since the surface of such nanoparticles can be easily modified with water solubilizing groups and biomolecules, the samples investigated here are interesting candidates as luminescent biolabels.

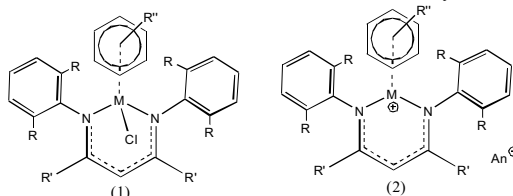
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### New Insights into the Reactivity of Arene Coordinated Ruthenium- and Osmium- $\beta$ -Diketiminato Complexes

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The  $\beta$ -diketiminato class of ligands is renowned for the stabilization of coordinatively unsaturated main-group and transition metal complexes. We report on the synthesis, characterization and hydrogenation capabilities of a series of  $\eta^6$ -arene Ru- and Os- $\beta$ -diketiminato complexes (1). Facile chloride exchange with different anions affords coordinatively unsaturated species (2) that readily undergo thermo-reversible [4+2] cycloaddition with alkenes, alkynes and  $H_2$ . [1] DFT calculations, in conjunction with high pressure NMR-deuterium labeling experiments, reveal a concerted heterolytic cleavage mechanism with a low energy barrier. Through steric and electronic variation of the  $\beta$ -diketiminato ligand, the efficiency of styrene and cyclohexene hydrogenation is shown to be highly tunable.  $^{19}F$ - $^1H$  HOESY and diffusion NMR experiments reveal different degrees of cation-anion interaction which has been demonstrated to influence catalytic activity.



M = Ru, Os. An = OTf, BPh<sub>4</sub>, BF<sub>4</sub>, PF<sub>6</sub>, BA<sub>4</sub>F. R = Me, iPr, OMe, H. R' = <sup>t</sup>Bu, Me, CF<sub>3</sub>, R'' = C<sub>6</sub>H<sub>5</sub>, C<sub>6</sub>H<sub>4</sub>Me, *p*-MeC<sub>6</sub>H<sub>4</sub>Pr, C<sub>6</sub>Me<sub>6</sub>, etc.

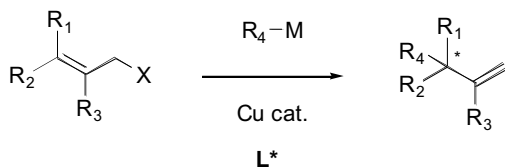
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### Allylic Substrates for the Copper Catalyzed Asymmetric S<sub>N</sub>2' Reaction

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The formation of chiral centers via a copper catalyzed asymmetric allylic alkylation using external chiral ligands has already shown very good enantioselectivities. Our group has previously demonstrated that monodentate phosphoramidite ligands are good chiral inductors and alkyl functions through diverse organometallic reagents can be added to allylic substrates with excellent enantiomeric excess [1-2].



Herein we present that small functionalized allylic substrates can be versatile starting material and show good enantioselectivities for the copper catalyzed addition of organometallic reagents (up to >99% ee) with excellent regioselectivities [3-4]. Various reactions can then be carried out with no loss of the optical purity for the further derivatization of these products.

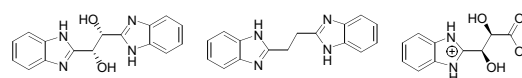
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### The Clash of the Synthons: Crystal Structures of Benzimidazole-alcohol carboxylic acids

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Desiraju has introduced the notion of the supramolecular synthon to characterize a link (or predict an intermolecular interaction) between molecules in the solid state. [1] The identification of synthons can allow the rationalization of observed solid state structures. For molecules with several functional groups several synthons may be identified and the question arises as to which will be expressed. In this work we compare the structures of a number of compounds such as those shown below which we have used elsewhere as ligands. [2] They carry benzimidazole functions which can undergo stacking interactions. [3] alcohol and carboxylic acid functions able to undergo hydrogen bonding.



The results show that stacking interactions are less favorable than hydrogen bonding. Hydrogen bonds are formed preferentially between groups with similar pK<sub>a</sub>.

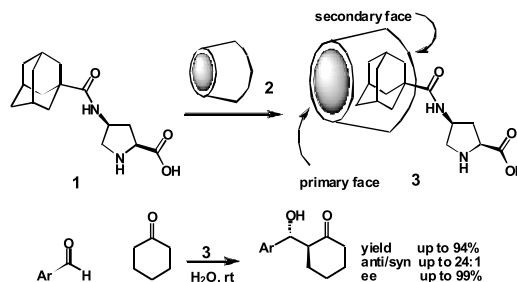
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### Aldol reactions in water using a $\beta$ -cyclodextrin-binding proline derivative

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The adamantoyl amide of S,S-4-amino proline **1** binds well to  $\beta$ -cyclodextrin **2** entering the cavity from the secondary face; the binding constant  $K_a = 1.4 \times 10^4 M^{-1}$  was calculated from NMR-titration experiments. The water soluble inclusion complex **3** catalyzes aldol reactions of various aromatic aldehydes with cyclohexanone in good yield and high enantiomeric excess (ee). The catalyst can be easily recovered and reused with only small changes in reactivity and enantioselectivity.



The easy access and recycling of the catalyst and the high enantio- and diastereoselectivity of the reaction makes this procedure an attractive alternative to other methods for the synthesis of  $\beta$ -hydroxy ketones in water.