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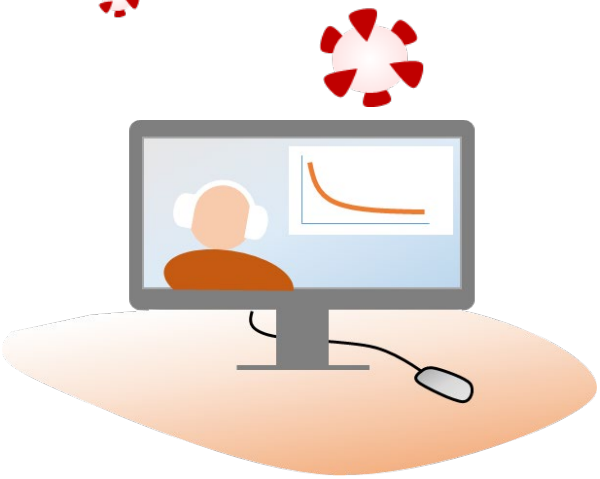

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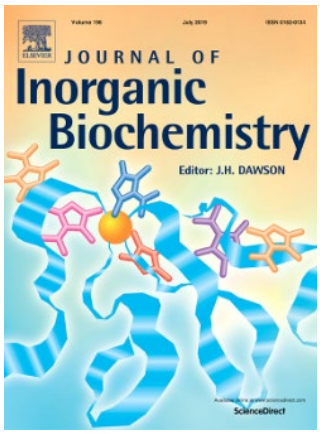

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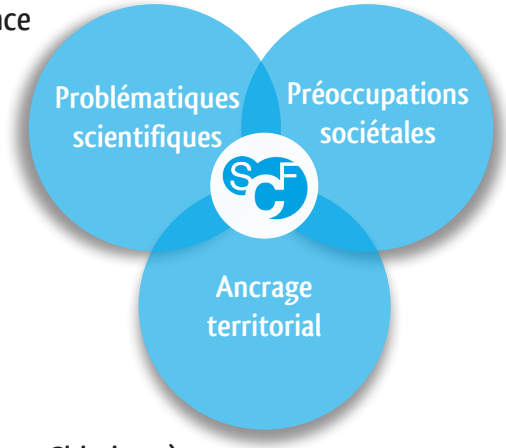

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Monday, October 12th ..... pages 1-28

High Spin (*main room*)		Low Spin	
Welcome			
PL.1	Herres-Pawlis		
KL.1	Ray		
HS-OP.1	Brazzolotto	LS-OP.1	Munzone
HS-OP.2	Torelli	LS-OP.2	Mazurenko
Coffee break — Q&A			
HS-OP.3	Schulz	LS-OP.3	Arnoux
HS-OP.4	Kostopoulos	LS-OP.4	Berteau
HS-OP.5	Mendoza	LS-OP.5	Chanthavong
HS-OP.6	Elvers	LS-OP.6	Staicu
Coffee break — Q&A			
Poster Session 1	P.1-P.6 & P.10		
Poster Session 2	P.8-P.15 & P.17		

Tuesday, October 13th ..... pages 31-60

PL.2	Einsle		
HS-OP.7	Frostegard	LS-OP.7	Bertrand
HS-OP.8	Merakeb	LS-OP.8	Lin
HS-OP.9	Reckziegel	LS-OP.9	Falcone
Coffee break — Q&A			
HS-OP.10	Das	LS-OP.10	Yang
HS-OP.11	Hüppe	LS-OP.11	Contaldo
HS-OP.12	Dobbelaar	LS-OP.12	Felbek
HS-OP.13	Csire	LS-OP.13	Orio
Group Picture & sponsor's presentation			
Coffee break — Q&A			
Poster Session 3	P.16-P.24		
Poster Session 4	P.25-P.30		

Wednesday, October 14th ..... pages 64-71

General Assembly of the GIS FrenchBIC	
PL.3	Policar
KL.2	Ortega
KL.3	Ilbert
Coffee break — Q&A	
KL.4	Dorlet
KL.5	Michaud-Soret
KL.6	Sorokin
KL.7	Hess
Coffee break — Q&A	
Closing Remarks for FrenchBIC 2020	

Monday, October 12th

	High Spin (*main room*)			Low Spin		
12:30-12:40	*Welcome*					
12:40-13:30	PL.1	Herres-Pawlis	page 2			
	Charge, electrons, oxygen – copper can transfer them all!					
13:30-14:00	KL.1	Ray	page 3			
	Small molecule activation at transition metal centers: structure-function correlations					
14:00-14:20	HS-OP.1	Brazzolotto	page 4	LS-OP.1	Munzone	page 5
	Multicopper enzymes for oxygen reduction reaction in PEMFC			Variability at the copper active site in bacterial lytic polysaccharide monooxygenases (LPMOs): influence on substrate binding properties.		
14:20-14:40	HS-OP.2	Torelli	page 6	LS-OP.2	Mazurenko	page 7
	Controlling O_2 reduction using Cu_2S cores: a case study			Revealing cuprous oxidase activity of laccase from *Thermus thermophilus* using electrochemistry		
14:40-15:10	*Coffee break — Q&A*					
15:10-15:30	HS-OP.3	Schulz	page 8	LS-OP.3	Arnoux	page 9
	Biological methane activation: A computational closeup on the Q intermediate of sMMO			PCuAC from R. sphaeroides, a copper chaperone with a catalytic activity?		
15:30-15:50	HS-OP.4	Kostopoulos	page 10	LS-OP.4	Berteau	page 11
	Electrochemical O_2 reductive activation by Fe porphyrins. Towards electrocatalytic substrate oxidation			Radically new catalysis for peptides and natural product biosynthesis		
15:50-16:10	HS-OP.5	Mendoza	page 12	LS-OP.5	Chanthavong	page 13
	Operando X-ray absorption spectroelectrochemistry: new insights in the catalysis of CO_2 by Fe porphyrins			Dinuclear Zinc complexes for phosphatidylserine detection		
16:10-16:30	HS-OP.6	Elvers	page 14	LS-OP.6	Staicu	page 15
	Monodithiolene complexes of molybdenum and tungsten as potential redox catalysts for small molecule activation			Selenium respiration in bacteria: energy trade-off		
16:30-17:00	*Coffee break — Q&A*					
17:00-17:30	Poster Session 1			P.1-P.6 & P.10		pages 17-22
17:30-18:00	Poster Session 2			P.8-P.15 & P.17		pages 23-28 & 49

Charge, electrons, oxygen - copper can transfer them all!

Sonja Herres-Pawlis[a*]

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Copper proteins mediate oxygen activation and transfer as well as electron transfer in very efficient ways – optimised by millions of years of evolution.(1)] With chemical models, we try to harness their superior reactivity. Oxygen transfer is efficiently mediated by tyrosinases to convert phenols to quinones. Numerous model complexes have been reported but only few with catalytic ability.(2) For several years, we have studied bis(pyrazolyl)methanes(3) and guanidines(4) as ligands for tyrosinase models and found subtle ligand influences to be crucial for the catalytic reactivity.
Using guanidinoquinolines, we could model the entatic state found in blue copper proteins.(5) The resulting copper complexes are the fastest pure N-donor electron transfer models(6) and show also entatic behavior during photoexcitation.(7) Latest developments in both fields will be presented.

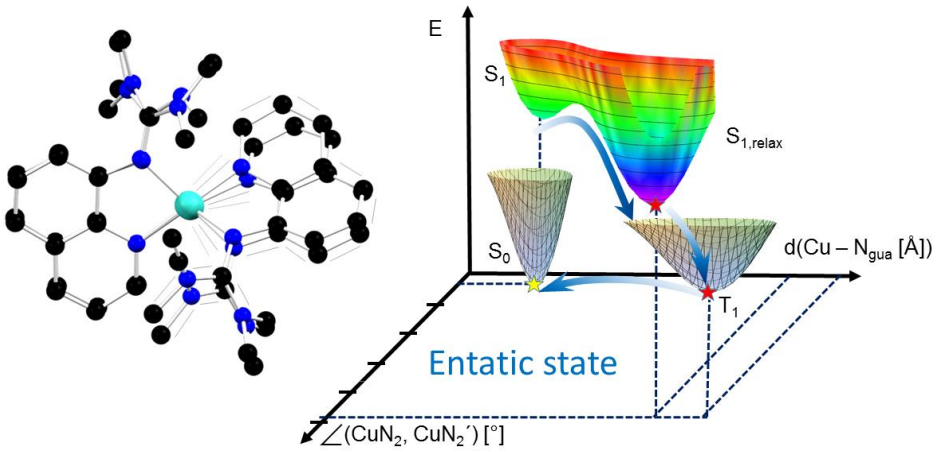

Figure 1. Copper guanidinoquinoline complexes as entatic state models.(7)

[1] a) E. I. Solomon, D. E. Heppner, E. M. Johnston, J. W. Ginsbach, J. Cirera, M. Qayyum, M. T. Kieber-Emmons, C. H. Kjaergaard, R. G. Hadt, L. Tian, *Chem. Rev*. **2014**, *114*, 3659–3853; b) C. E. Elwell, N. L. Gagnon, B. D. Neisen, D. Dhar, A. D. Spaeth, G. M. Yee, W. B. Tolman, *Chem. Rev*. **2017**, *117*, 2059–2107.

[2] P. Liebhäuser, A. Hoffmann, S. Herres-Pawlis, "Tyrosinase Models: Synthesis, Spectroscopy, Theory, and Catalysis in Molecular Sciences and Chemical Engineering", Waltham, MA, Elsevier, **2019**. doi.org/10.1016/B978-0-12-409547-2.11554-9

[3] a) C. Wilfer, P. Liebhäuser, A. Hoffmann, H. Erdmann, O. Grossmann, L. Runtsch, E. Pfaffenholz, R. Schepper, R. Dick, M. Bauer, M. Dürr, I. Ivanovíc-Burmazovíc, S. Herres-Pawlis, *Chem. Eur. J*. **2015**, *21*, 17639 – 17649 ; b) P. Liebhäuser, K. Keisers, A. Hoffmann, T. Schnappinger, I. Sommer, A. Thoma, C. Wilfer, R. Schoch, K. Stührenberg, M. Bauer, M. Dürr, I. Ivanović-Burmazović, S. Herres-Pawlis, *Chem. Eur. J*. **2017**, *23*, 12171 – 12183.

[4] a) S. Herres-Pawlis, P. Verma, R. Haase, P. Kang, C. T. Lyons, E. C. Wasinger, U. Flörke, G. Henkel, T. D. P. Stack, *J. Am. Chem. Soc*. **2009**, *131*, 1154–1169; b) A. Hoffmann, M. Wern, T. Hoppe, M. Witte, R. Haase, P. Liebhäuser, J. Glatthaar, S. Herres-Pawlis, S. Schindler, *Eur. J. Inorg. Chem*. **2016**, 4744 – 4751.

[5] J. Stanek, A. Hoffmann, S. Herres-Pawlis, *Coord. Chem. Rev*. **2018**, *365*, 103 – 121.

[6] J. Stanek, N. Sackers, F. Fink, M. Paul, L. Peters, R. Grunzke, A. Hoffmann, S. Herres-Pawlis, *Chem. Eur. J*. **2017**, *23*, 15738 – 15745.

[7] B. Dicke, A. Hoffmann, J. Stanek, M. S. Rampp, B. Grimm-Lebsanft, F. Biebl, D. Rukser, B. Maerz, D. Göries, M. Naumova, M. Biednov, G. Neuber, A. Wetzel, S. M. Hofmann, P. Roedig, A. Meents, J. Bielecki, J. Andreasson, K. R. Beyerlein, H. N. Chapman, C. Bressler, W. Zinth, M. Rübhausen, S. Herres-Pawlis, *Nat. Chem*. **2018**, *10*, 355 – 362.

SMALL MOLECULE ACTIVATION AT TRANSITION METAL CENTERS: STRUCTURE-FUNCTION CORRELATIONS

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Small molecule activation constitutes one of the main frontiers of inorganic and organometallic chemistry, with much effort directed towards the development of new processes for the selective and sustainable transformation of abundant small molecules such as dioxygen (O_2), water (H_2O), hydrogen peroxide (H_2O_2) or protons (H^+) into high-value chemical feedstocks and energy resources. Because nature mostly uses metal ions to activate these relatively inert molecules and modulate their reactivity, much inspiration for the field has come from bioinorganic chemistry. This talk will focus on some of the recent highlights from our group on homogenously catalyzed bioinspired activation of small molecules, as well as stoichiometric reactions that further our understanding towards such ends. It will cover many aspects of small molecule activation including: organometallic chemistry, spectroscopy, synthesis, and detailed mechanistic studies involving trapping of reactive intermediates. The demonstrated examples will help to emphasize the continuous effort of our group in uncovering the structure-reactivity relationships of biomimetic model complexes, which may allow vital insights into the prerequisites necessary for the design of efficient catalysts for the selective functionalization of unactivated C–H bonds, O_2/H_2O/H_2O_2 activations, or H^+ reductions by using cheap and readily available first-row transition metals under ambient conditions.

Multicopper enzymes for oxygen reduction reaction in PEMFC

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Proton-exchange-membrane fuel cell (PEMFC) represents a major challenge for the development of hydrogen fuel cells especially at an industrial scale. Noble metal such as platinum (Pt) is used in conventional PEMFC to produce electrical energy from the electrocatalytic H_2 oxidation and O_2 reduction with minimal overpotential and great catalytic efficiency. In particular, base-metal catalysts are investigated at the cathode to provide an alternative to high Pt loadings required to achieve efficient Oxygen Reduction Reaction (ORR). Taking advantage of low overpotentials and high catalytic efficiency, Multicopper-oxidases such as laccase or bilirubine oxidase (BOD) have also been investigated in fuel cells.[1, 2]. In this work, we have studied the direct electrochemistry of POXC, a laccase from *Pleurotus ostreatus* and BOD from *Myrothecium verrucaria* and their integration at the cathode of PEMFC.[3, 4] Multi-walled-carbon-nanotube (MWCNT)-coated glassy carbon electrodes were modified by grafting different diazonium salts. We demonstrate that such functionalization strategy leads to the formation of a thin organic layer on the surface of MWCNTs, thus inducing a favorable and specific interaction with the metalloenzymes, promoting direct electron transfer. These functionalized MWCNTs have been finally integrated in specifically-designed PEMFC.

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1. I. Sorrentino, S. Gentil, Y. Nedellec, S. Cosnier, A. Piscitelli, P. Giardina, A. Le Goff, *ChemElectroChem.,* **2018**, 5, 1–6.
2. S. Gentil, S. M. Che Mansor, H. Jamet, S. Cosnier, C. Cavazza, A. Le Goff, *ACS Catal,.* **2018**, 3957–3964.
3. S. Gentil, D. Serre, C. Philouze, M. Holzinger, F. Thomas, A. Le Goff, *Angew. Chem. Int. Ed.,* **2016**, 55, 2517–2520.
4. S. Gentil, N. Lalaoui, A. Dutta, Y. Nedellec, S. Cosnier, W. J. Shaw, V. Artero, A. Le Goff, *Angew. Chem. Int. Ed.,* **2017**, 56, 1845–1849.

Variability at the copper active site in bacterial lytic polysaccharide monooxygenases (LPMOs): influence on substrate binding properties.

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Lytic polysaccharide monooxygenases (LPMOs) are bacterial or fungal mononuclear copper monooxygenases that participate in the degradation of recalcitrant polysaccharides (cellulose or chitin) in synergy with glycosyl hydrolases [1]. LPMOs possess a solvent-exposed active site with a unique topology among copper-containing oxygenases [1,2]. The mononuclear copper(II) ion is characteristically coordinated by both the side chain nitrogen and the main-chain amino group of the *N*-terminal histidine, and by a second histidine side chain, forming a motif known as ''histidine brace''. This peculiar active site allows for the oxidative cleavage of glycosidic bonds in cellulose or chitin, in the presence of dioxygen or hydrogen peroxide as co-substrate and an electron donor [3,4]. However, the reaction mechanism is still under debate and no reactive intermediate has been experimentally characterised yet.

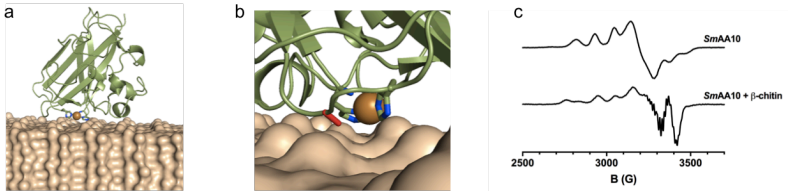

Figure 1. (a) Molecular dynamics simulation of LPMO-chitin interactions with focus on (b) the conserved active site Ala residue in close proximity to the substrate. (c) EPR spectra of a bacterial chitin-active LPMO in the absence and presence of chitin, highlighting copper coordination geometry change upon substrate binding.

The present study investigates the role of the conserved second coordination sphere alanine residue (~ 4 Å from the copper ion) in bacterial LPMOs. Although this residue was proposed to orient the co-substrate (dioxygen or hydrogen peroxide) binding toward a specific position of the metal active site [2], its role is still unclear. We recently put in evidence that other amino acids (bulkier and/or charged) can be found in place of this alanine in bacterial LPMOs [5]. We showed that the LPMO from *Photorhabdus luminescens* (*Pl*AA10) harbours an isoleucine and possesses a chitin-degrading activity. Moreover, the Ile does not affect the geometry of the copper active site, but it can potentially change the topology of the substrate-binding surface. A computational study gave some hints on the interaction between the enzyme and its substrate, notably with the active site alanine residue in close proximity to the polysaccharide chain. More importantly, the coordination geometry around the Cu(II) ion was calculated to change upon substrate binding, which was confirmed experimentally by EPR spectroscopy [6]. Based on this, the present work uses EPR spectroscopy to study the effects of second coordination sphere alanine substitution on the substrate binding properties. On-going studies aim at correlating the aforementioned EPR characterization with biochemical, structural, and other biophysical data.

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1. Vaaje-Kolstad, G.; Westereng, B.; Horn, S. J.; Liu, Z.; Zhai, H.; Sørlie, M.; Eijsink, V.G.H. *Science* **2010**, 330, 219-222.
2. Hemsworth, G.R.; Taylor, E.J.; Kim, R.Q.; Gregory, R.C.; Lewis, S.J.; Turkenburg, J.P.; Parkin. A.; Davies, G.J.; Walton, P.H. *J. Am. Chem. Soc.* **2013**, 135, 16, 6069-6077.
3. Walton, P.H.; Davies, G.J. *Curr. Opin. Chem. Biol.*, **2016**, 31, 195-207.
4. Bissaro, B.; Røhr, Å.K.; Müller, G.; Chylenski, P.; Skaugen, M.; Forsberg, Z.; Horn, S.J.; Vaaje-Kolstad. G.; Eijsink, V.G.H. *Nat. Chem. Biol*. **2017**, 13, 1123-1128.
5. Munzone, A.; El Kerdi, B.; Fanuel, M.; Rogniaux, H.; Ropartz, D.; Réglier, M.; Royant, A.; Simaan, A.J.; Decroos, C. *FEBS J*. **2020**, In press, doi:10.1111/febs.15203.
6. Bissaro, B.; Isaksen, I.; Vaaje-Kolstad, G.; Eijsink, V.G.H.; Røhr, Å.K. *Biochemistry*, **2018**, 57, 1893-1906.

Controlling O_2 reduction using Cu_2S cores: a case study

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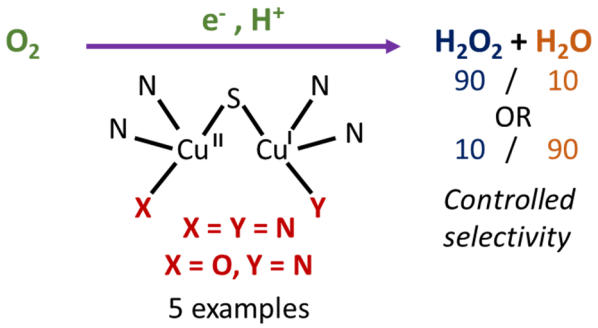
Oxygen Reduction Reactions (ORR) is a key process in Nature for cellular respiration[1] or biotransformation.[2] In this line, the efficiency of metal-containing enzymes has paved the way for intensive research to reach high catalytic efficiencies derived from O_2 activation using transition metal complexes. Applications for fuel cells technology (formation of H_2O and/or H_2O_2 through coupled e^-/H^+ reactions) are particularly at stake.[3] H_2O_2 has for instance recently emerged as a potential fuel for mono-compartmental cells.[4]

However, the ability to control the fate of the ORR is crucial to discriminate between H_2O and H_2O_2 formation that depends on the targeted application. We recently showed that mixed-valent copper complexes containing a Cu_2S core are perfectly suitable for ORR with a tuneable H_2O/H_2O_2 selectivity obtained by regulating the amount of sacrificial electron source present in solution.[5] Several examples will be presented, as well as a complete study focused on a member of the family and future developments will be briefly discussed.



1. Babcock, G. T.; Wikström, M., Oxygen activation and the conservation of energy in cell respiration. *Nature* **1992,** *356* (6367), 301-309.
2. Nam, W., Dioxygen Activation by Metalloenzymes and Models. *Acc. Chem. Res.* **2007,** *40* (7), 465-465.
3. Pegis, M. L.; Wise, C. F.; Martin, D. J.; Mayer, J. M., Oxygen Reduction by Homogeneous Molecular Catalysts and Electrocatalysts. *Chem. Rev.* **2018,** *118* (5), 2340-2391.
4. Yamada, Y.; Fukunishi, Y.; Yamazaki, S.-i.; Fukuzumi, S., Hydrogen peroxide as sustainable fuel: electrocatalysts for production with a solar cell and decomposition with a fuel cell. *Chem. Commun.* **2010,** *46* (39), 7334-7336.
5. Mangue, J.; Gondre, C.; Pécaut, J.; Duboc, C.; Ménage, S.; Torelli, S., Controlled O_2 reduction at a mixed-valent (II,I) Cu2S core. *Chem. Commun.* **2020,** *56* (67), 9636-9639.

Revealing cuprous oxidase activity of laccase from *Thermus thermophilus* using electrochemistry

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Multicopper oxidases (MCO) are a group of oxidoreductases containing a couple of Cu-centers: mononuclear T1 and trinuclear T2/T3. These enzymes are able of four-electron oxygen reduction at high potentials reaching 0.78 V (NHE) which is beneficial for different enzymatic and biohybrid fuel cells.[1] A subgroup of MCO called laccases can perform low-specificity oxidation of aromatic compounds which can also be exploited for bioremediation purposes.

In this work we present the electrochemical characterization of the laccase from a hyperthermophilic bacterium *Thermus thermophilus*[2] on various CNT-modified electrodes. The as-purified laccase demonstrates direct electron transfer in 4-electron oxygen reduction reaction with current densities that vary significantly depending on the charge and chemical functionalization of CNTs as a consequence of different preferred enzyme orientation.

In addition, we discovered an additional unusual catalytic wave upon the addition of Cu(II) into the electrochemical cell appearing only in the presence of active immobilized laccase. The onset potential and the magnitude of this wave depends on Cu(II) concentration and on the type of CNTs. In homogeneous assays, such activation by Cu(II) is known for other MCOs, notably for copper efflux oxidase from *E.coli* (CueO), an enzyme responsible for Cu(I) detoxication of the periplasm.[3] It was suggested that it involves copper binding to the methionine-rich domain near the T1 centre.[4,5] Although the laccase from *T. thermophilus* shares only 31% of sequence identity with CueO, a similar methionine-rich domain can be identified suggesting possible copper binding. We thus propose that the observed Cu-dependent wave is related to Cu(I) generation, binding and cuprous oxidase activity displayed by laccase. We use electrochemistry to investigate the mechanism of laccase-Cu interaction and demonstrate the utility of electrochemical methods to study the metal-oxidase activity of enzymes.[6]

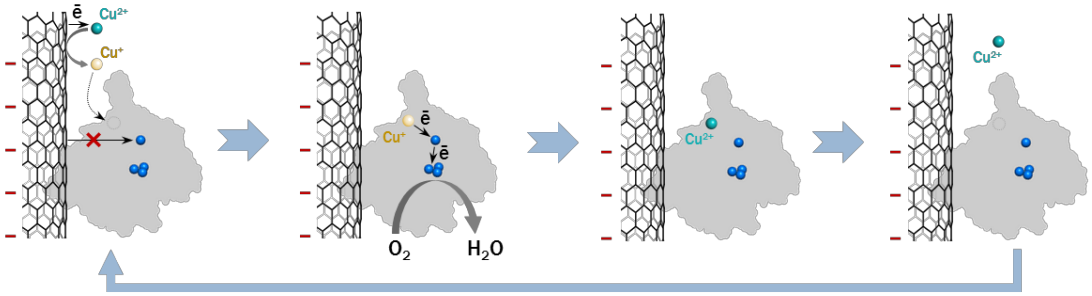

Figure 1. Mechanism of cuprous oxidase activity displayed by *T. thermophilus* laccase *on CNT-electrode*

1. N. Mano, A. de Poulpiquet, *Chem. Rev*., **2018**, 118, 2392–2468.
2. P. Agbo, J.R. Heath, H.B. Gray, *J. Phys. Chem. B,* **2013**, 117, 527–534.
3. S.A. Roberts, A. Weichsel, G. Grass, K. Thakali, J.T. Hazzard, G. Tollin, C. Rensing, W.R. Montfort, *Proc. Natl. Acad. Sci.*, **2002**, 99, 2766–2771.
4. K.Y. Djoko, L.X. Chong, A.G. Wedd, Z. Xiao, *J. Am. Chem. Soc.*, **2010**, 132, 2005–2015.
5. S.K. Singh, S.A. Roberts, S.F. McDevitt, A. Weichsel, G.F. Wildner, G.B. Grass, C. Rensing, W.R. Montfort, *J. Biol. Chem*., **2011**, 286, 37849–37857.
6. V. Pratap Hitaishi, R. Clement, L. Quattrocchi, P. Parent, D. Duche, L. Zuily, M. Ilbert, E. Lojou, I. Mazurenko, *J. Am. Chem. Soc.*, **2019**, *in press*

Biological Methane Activation: A computational closeup on the Q intermediate of sMMO

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Biological methane oxidation is facilitated by methane monooxygenases, using a diiron core in soluble methane monooxygenase (sMMO). Its Fe2O2 active site has been studied extensively to characterize the reactive intermediates and propose a mechanism. However, the final intermediate before methane binding and activation, intermediate Q, remains under debate. While previous studies favoured a diamond (bis-μ-oxo) core,[1] new spectroscopic evidence suggested an open (μ-oxo) core,[2,3] which is more consistent with the activity of biomimetic model complexes in methane oxidation.[4]

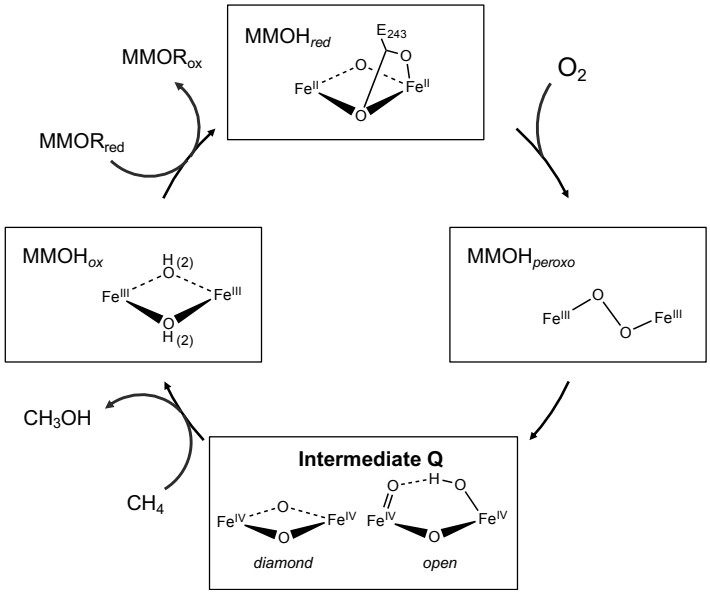

Figure 1. Catalytic cycle of sMMO, highlighting the central intermediates.

Here we revisit the active site of sMMO using QM/MM models to draw correlations between structure and spectroscopy. After calibration of methods using the MMOHox resting state, both open and diamond core models for the Q intermediate are considered. They are compared based on their geometries and relevant spectroscopic parameters such as Mössbauer spectroscopy, XAS and Raman spectroscopy. These spectroscopic trends are compared with both model complexes and experiment to provide a consistent interpretation of the Q geometry and electronic structure. The current results overturn the commonly accepted diamond core model and point towards a hydrogen bond mediated open core geometry in the Q intermediate.

1. M. O. Ross, A. C. Rosenzweig, *J Biol. Inorg. Chem.* **2017**, *22*, 307-319.
2. R. G. Castillo, et al., *J. Am. Chem. Soc.* **2017**, *139*, 18024-18033.,
3. G. E. Cutsail, et al. , *J. Am. Chem. Soc.* **2018**, *140*, 16807-16820.
4. G. Xue, R. De Hont, E. Münck, L. Que, *Nat. Chem.* **2010**, *2*, 400-405.

PCuAC from *R. sphaeroides*, a copper chaperone with a catalytic activity?

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PCuAC is a periplasmic copper chaperone involved in the maturation of CuA centre of the respiratory cytochrome c oxidase. PCuAC bind one copper ion through a $HX_nMX_{22}HXM$ motif, with some homologues binding an additional copper ion through a histidine-rich C-terminal tail (1,2). Contrary to this, we found that PCuAC from *Rhodobacter sphaeroides* does not possess such a C-terminal extension whereas it is able to bind two copper ions. We therefore sought to understand this unusual property by solving the structure of RsPCuAC by X-ray crystallography. We were able to confirm the binding of two copper ions on RsPCuAC, with very little structural changes between apo- and copper bound structures.

In the quest of a copper-bound structure of RsPCuAC we obtained and characterized salt crystals, which turned out to be Metal Organic Frameworks (MOF) made of an undescribed small molecule (X in Figure 1) in complex with copper. X comes from a transformation of a small molecule that was used in the crystallization buffer, which imply that RsPCuAC does have catalytic properties. These catalytic properties are currently being investigated and will be discussed.

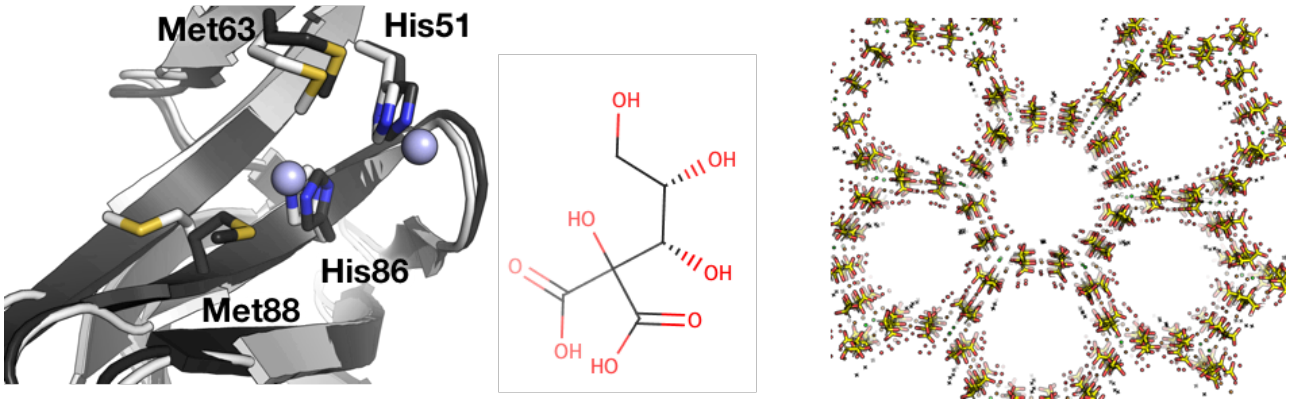

Figure 1: Structure of PCuAC and discovery of a MOF. Left: structural superimposition of RsPCuAC in its apo form (in white) and in its complex with copper (blue). **Middle:** chemical structure of X. **Right:** Crystal structure of the MOF made of X in complex with copper ions.

1. Fisher, O.S., Sendzik, M.R., Ross, M.O., Lawton, T.J., Hoffman, B.M., Rosenzweig, A.C. 2019. PCuAC domains from methane-oxidizing bacteria use a histidine brace to bind copper. J. Biol. Chem. 294, 16351–16363.
2. Canonica F, Klose D, Ledermann R, Sauer MM, Abicht HK, Quade N, Gossert AD,Chesnov S, Fischer HM, Jeschke G, Hennecke H, Glockshuber R. 2019. Structural basis and mechanism for metallochaperone-assisted assembly of the Cu(A) center in cytochrome oxidase. Sci Adv. 5, 1-16

Electrochemical O_2 reductive activation by Fe porphyrins. Towards electrocatalytic substrate oxidation

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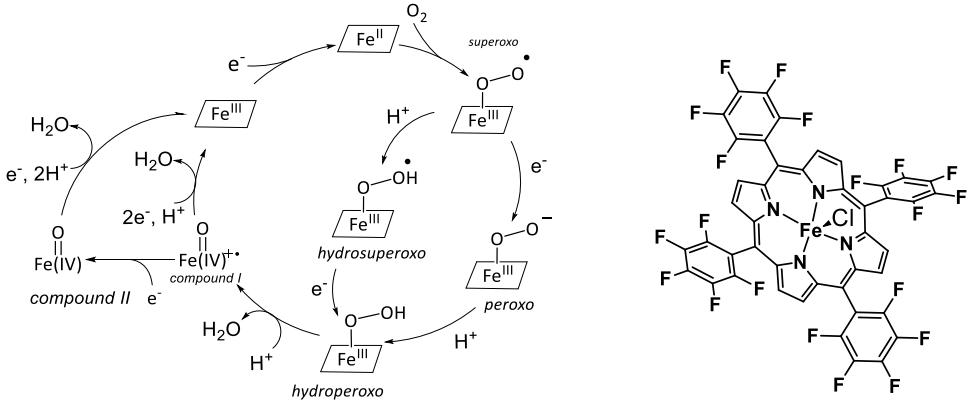
Oxidation of hydrocarbons are reactions of great importance for the preparation of various organic molecules in an industrial scale. Hazardous chemical agents and/or noble metal catalysts are often necessary in these processes because O_2, despite its potent oxidizing power, is kinetically stable preventing it from reacting in ambient conditions.[1]

Metalloenzymes such as CytP450 constitute a great source of inspiration as they are able to efficiently and selectively oxidize organic molecules under mild conditions, throughout the reductive activation of O_2. The latter consists of the partial and controlled reduction of O_2 bound at the metal active site *via* sequential e^- and H^+ transfers to achieve O-O bond cleavage and generate the reactive high valent Fe-oxo (FeO) species (scheme 1).[2] Chemically prepared intermediates such as Fe-superoxo (FeOO•), Fe-peroxo ($FeOO^-$), Fe-hydroperoxo (FeOOH) as well as Fe-oxo (FeO) of Fe porphyrin complexes (models of the enzymes' active site) have been characterized and the Fe-oxo have been shown to be able to oxidize organic substrates e.g. cyclohexane.[3] We propose an alternative, electrochemical approach for the generation of Fe-Oxygen porphyrin intermediates, which circumvents the need for chemical oxidants and uses O_2 from air instead. By this approach, our group has previously evidenced the formation of the $Fe(III)OO^-$ and Fe(III)OOH using the [$FeTPPF_{20}Cl$] (scheme 1).[4]



Scheme 1. Intermediate species in the electrocatalytic O_2 activation by Fe porphyrins and structure of $FeTPPF_{20}Cl$

Herein, we will first, briefly describe the electrochemical study of the $FeTPPF_{20}Cl/H^+/O_2$ system. We will then present the characterization of different intermediates (shown in scheme 1), by means of various spectroscopies, such as low temperature UV-Vis spectroelectrochemistry.
We will also present promising results of electrocatalysis experiments with our system towards oxidation of substrates.

[1] F. Cavani, J. H. Teles, *ChemSusChem.* **2009**, *2*, 508-534

[2] I. G. Denisov, T. M. Makris, S. G. Sligar, I. Schlichting, *Chem. Rev.* **2005**, *105*, 2253-2278

[3] X. Huang, J. T. Groves, *Chem Rev.* **2018**, *118*, 2491-2553

[4] R. Oliveira, W. Zouari, C. Herrero, F. Banse, B. Schöllhorn, C. Fave, E. Anxolabéhère-Mallart, *Inorg.chem.* **2016**, *55*, 12204-12210

Radically new catalysis for peptides and natural product biosynthesis

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Radical SAM enzymes are an emerging family of metalloenzymes catalyzing a broad range of radical-based reactions, many of them having no precedent in biology [**1**]. Recently, radical SAM enzymes have been shown to play a major role in the biosynthesis of bioactive peptides called: ribosomally-synthesized and post-translationally modified peptides (RiPPs). For instance, we and other groups have shown that radical SAM enzymes catalyze unrelated biochemical transformations such as methylation [**2**-**4**], peptide epimerization [**5**, **6**], complex rearrangements, carbon-carbon [**7**] and thioether bridges formation (**Figure 1**).

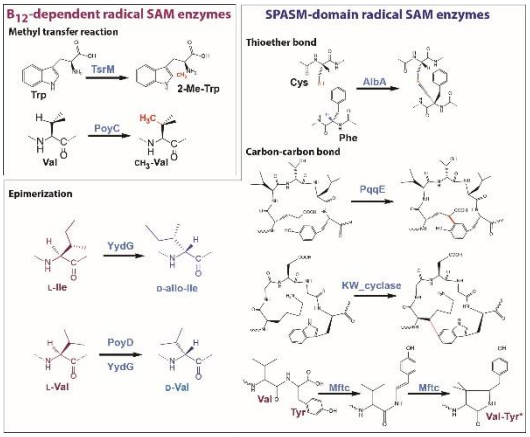

Figure 1. Reactions catalyzed by radical SAM enzymes in RiPPs biosynthesis

Because of their biological properties such as antibiotic, and their role in the human microbiota, RiPPs are attracting a considerable interest. A better understanding of their biosynthesis and of the enzymes catalyzing post-translational modifications is thus required to develop innovative antibiotics.

Recent advances on key reactions catalyzed by radical SAM enzymes have shown how using a similar radical-based mechanism, radical SAM enzymes can catalyze different reactions such as peptide epimerization and thioether bond formation. In addition, recent study from our laboratory also shed new lights on novel plausible reaction intermediates.

1. Benjdia *et al*, **2017** *Front Chem*. **5**, 87
2. Benjdia, A *et al*. **2015** *Nat*. *Commun*. **6**, 8377
3. Pierre, S et al. **2012** *Nat*. *Chem*. *Biol*. **8**, 957-959
4. Parent, A et al. **2016***J Am Chem Soc*. **138**, 15515-15518
5. Benjdia, A *et al*, **2017** *Nat Chem*. **9**, 698-707
6. Parent, A et al. **2018** *J Am Chem Soc*. **140**, 2469-2477
7. Benjdia *et al*, **2017** *J Biol Chem*. *292, 10835-10844*
8. Benjdia *et al*, **2016** *Chem Commun (Camb)*. **52**, 6249-6252
9. Balty *et al*. **2019** *J Biol Chem*. **294**, 14512-14525

Operando X-ray absorption spectroelectrochemistry: new insights in the catalysis of CO_2 by Fe porphyrins.

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Greenhouse gas have kept the required climate to make the conditions in Earth habitable. Nevertheless, the atmospheric level of these gas are nowadays increasing drastically, threatening life on our planet. The most prevalent, and long-lived gas is undoubtedly CO_2, which emissions are expected to increase global temperatures up to 1.5 degrees in the coming years[1]. One way to cope with this increase is by electrochemically reducing CO_2 into fuels or building blocks such as CO, CH_4, HCHO, CH_3OH_2 etc. However, the kinetic inertness and thermodynamic stability of CO_2 makes its activation rather difficult, requiring the use of catalysts. Molecular catalysts, such as iron porphyrins, have been the focus of studies for many years, including in our laboratory. These bio-inspired molecules have shown high activity, durability and selectivity, being equally good catalysts both in organic and aqueous solutions[2,3].

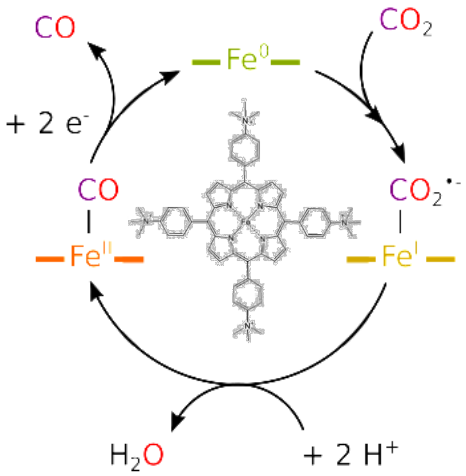

Figure 1. Simplified mechanism for the electrochemical reduction of CO_2 by iron porphyrins

Even if some kinetic parameters have been elucidated and some pathways and possible structures have been proposed, as shown in figure 1, a complete mechanistic picture is still missing mostly because of the lack of spectroscopic data. Such data are key to fully understand the process and to improve catalysis to obtain highly reduced products, including C-C coupling products. One way toward this goal is to combine electrochemistry with X-ray spectroscopy. We have developed an X-ray spectroelectrochemical cell to better understand structure-activity relationship for selected iron porphyrins under operando conditions, both in organic and aqueous media. Data obtained under catalytic and non-catalytic conditions led us to propose intermediate species during the catalytic cycle.

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1. Tong, D, Zhang, Q, Zheng, Y, Caldeira, K, Shearer, C, Hong, C, Qin, Y, David, SJ. *Nature*., **2019,** *572(7769)*. 373-377.
2. Costentin, C, Robert, M, Savéant, JM. *ChemSocRev*. **2013**, *42*, 2423-2436.
3. Costentin, C, Robert, M, Savéant, JM, Tatin, A. *PNAS*; **2015**, 112(22), 6882-6886.

Dinuclear Zinc Complexes for Phosphatidylserine Detection

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The human cell membrane separates the intracellular from the extracellular world. It is composed of embedded proteins and a non-uniform phospholipid bilayer. Phosphatidylserine (PS) is an anionic phospholipid commonly located in the inner leaflet of the membrane. In response to different stimuli (cellular activation, stimulation with proinflammatory, prothrombotic or proapoptotic substances, high stress), PS will be exposed on the outer leaflet and leads to the release of membrane microvesicles (MVs) [1].

Those MVs are known for their procoagulant activity and determinant of thrombosis in various vascular and systemic diseases including myocardial infarction and diabetes. For that reason, an increase in circulating MVs has also been associated with ischemic cerebrovascular accidents, sclerosis and cerebral malaria [2]. Furthermore, MVs contain information about their parent cell so there is a real interest in diagnostic and therapeutic potential of detecting MVs.

In a first approach, a set of bimetallic Zn(II) and Cu(II) complexes based on dipicolylamine ligand with a phenoxo spacer has been synthesized. Those complexes have been grafted on solid surface to test and validate their interaction with PS presented in model vesicles. To reproduce MVs, small unilamellar vesicles (SUVs) of defined size and composition were formed. The interaction between both complexes and SUVs were studied using surface-sensitive analysis technics: surface plasmon resonance (SPR) and biolayer interferometry (BLI).

Then, a new generation of complexes based on quinoline unit, chosen for its fluorescent properties, has been synthesized (Figure 1) [3]. Results with it will be presented.

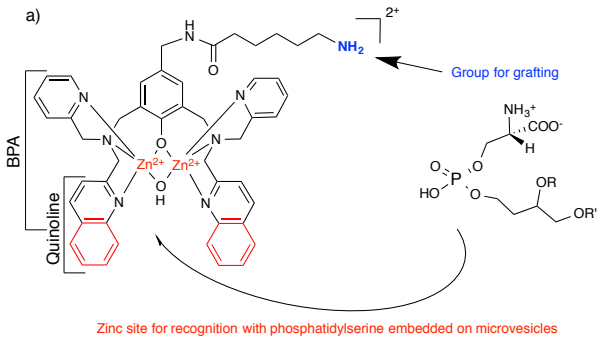

Figure 1 : Binuclear Zinc complex for PS recognition

1. S. Mause, C. Weber, *Circ Res*, **2010**, 107, 1047-1057
2. L. Doeuvre, L. Plawinski, F. Toti and E. Anglés-Cano, *J. Neurochem*, **2009**, 110, 457-468
3. Y. Mikata, A. Ugai, R. Ohnishi, H. Konno, *Inorg Chem* **2013**, 52, 18, 10223-102

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Monodithiolene complexes of molybdenum and tungsten as potential redox catalysts for small molecule activation

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Ene-1,2-dithiols (dt) represent a well-known member of the group of *non-innocent* ligands. This ligand type can modulate the electron density of its coordinated metal to catalyse reactions such as oxygen atom transfer reactions in the case of oxidoreductases. Thus, the combination of dithiolene and molybdenum is well known to catalyse redox reactions.[1] Additionally, molybdenum has the outstanding ability to serve as active site metal in the most efficient form of nitrogenases for the activation of dinitrogen.

Within our project we unite dithiolene ligands with low-valent metal centres (Mo, W) to form a potentially effective catalyst for small molecule activation. In particular, small molecules like N_2 and CO_2 require a very high electron density at the metal coordination site.[2,3] The incorporation of redox active ligands (such as the *non-innocent* dithiolene ligand) was already put forward as a desired step for a higher catalytic efficiency in nitrogen activation.[4]

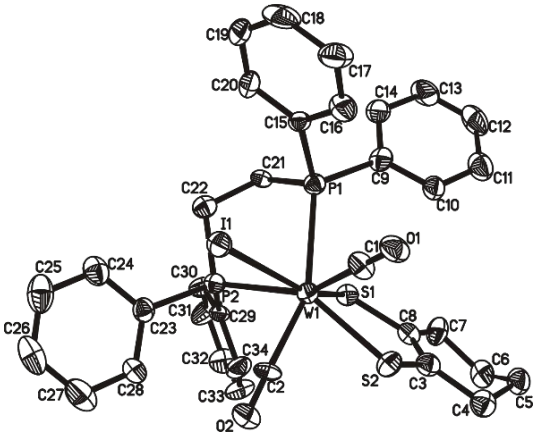

Figure 1: Representation of the solid-state structure of $[W(CO)_2(cydt)(dppe)(I)]^+$ at 50% probability ellipsoids. Hydrogen atoms and counter ion are omitted for clarity.

We have recently succeeded in creating a versatile synthetic route for the preparation of monodithiolene complexes of type $[M(CO)_2(dt)(dppe)]$ (M = Mo, W; dppe = 1,2-bis(diphenylphosphino)-ethane).[5] Their electrochemical and spectroscopic properties were studied in detail using SEC-IR and SEC-UV-vis techniques.[6] Various chemical modifications have been carried out based on the acquired feedback on route to obtaining a 'designed catalyst'. The results of our experiments carried out so far will be presented.

1. Yan et al., Inorg Chem. 2012, 51, 346-361
2. Stucke, N., et al., Eur. J. Inorg. Chem. 2018, 1337-1355.
3. Lindley, B.M., et al., JACS 2018, 7922-7935.
4. K.C. MacLeod and P.L. Holland, Nature Chem. 2013, 559-565.
5. Elvers, B.J., et al., Eur. J. Inorg. Chem. 2019, 23, 2796–2805
6. Elvers, B.J., et al., in preparation.

Selenium respiration in bacteria: energy trade-off

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Selenium (Se) respiration in bacteria was experimentally revealed for the first time on *Thauera selenatis*, a β-Proteobacterium capable of using selenate as terminal electron acceptor, while oxidizing acetate to CO_2 and PHA (1). This transformation is thermodynamically-favourable and energy-dense, being subsequently documented in phylogenetically-diverse bacteria (2). The fact this respiratory type is spread along various branches of Bacteria and Archaea might indicate selenium was a respiratory substrate employed on a larger scale before the Great Oxidation Event. However, this metabolic process appears to be accompanied by a number of challenges and numerous unanswered questions (3). Selenium oxyanions, SeO_4^{2-} and SeO_3^{2-}, are enzymatically reduced to elemental Se, Se(0), through anaerobic respiration, the end product being solid and displaying a considerable size (up to 500 nm) for the bacterial scale. Compared to other electron acceptors used in anaerobic respiration (e.g. N, S, Fe, Mn, As), Se is the only element whose end product is solid and often deposited intracellularly (**Figure 1**). Moreover, various allotropic forms and shapes of biogenic Se(0) (e.g. crystalline needle-shaped etc.) are potentially detrimental for cellular integrity and homeostasis. Furthermore, unlike other known bacterial intracellular accumulations such as volutin (inorganic polyphosphate), S(0), glycogen or magnetite, Se(0) has not been assigned a nutritional or ecological role for its host nor it displays any other known biological function (4). In the context of anaerobic respiration of Se oxyanions, biogenic Se(0) appears to be a by-product, a waste that needs proper handling; and this raises the question of the evolutionary implications of this process. Why would bacteria select for a metabolic process that is useful, in the first place, and then highly detrimental? Interestingly, in certain artificial ecosystems (e.g. upflow bioreactors), Se(0) might help bacterial cells to increase their buoyancy and thus avoid biomass wash-out, ensuring survival. However, this process has only been documented for "recent" man-made ecosystems and mixed microbial communities (granular sludge) (5). This paper explores the thermodynamics, enzyme systems, genetic determinants and the evolutionary implications of selenium respiration in bacteria, attempting to answer a number of questions such as i) where does the nucleation process of Se(0) occur in bacteria, ii) are there any viable possibilities for Se(0) extracellular transport, and iii) what are the evolutionary implications for bacteria that adopted this strategy to generate cellular energy.

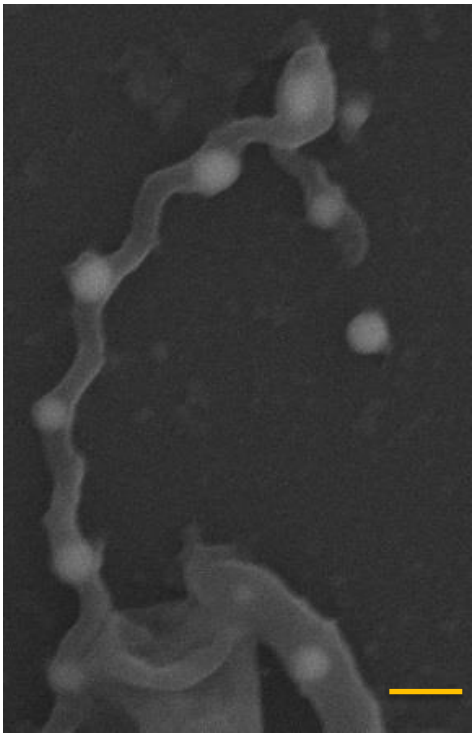

Figure 1. Intracellular biogenic Se(0) taken by SEM (unpublished). Scale: 300 nm.

Acknowledgements: Lucian Staicu was supported by NCN 2017/26/D/NZ1/00408 research grant (Poland).

1. Macy, JM; Michel, TA; Kirsch, DG, *FEMS Microbiol. Lett.*, **1989**, *61*, 195-198.
2. Stolz, JF; Oremland, RS, *FEMS Microbiol. Rev.*, **1999**, *23*, 615-627.
3. Staicu, LC; Barton, LL, Microbial metabolism of selenium, Springer, **2017**.
4. Shively, J et al., Bacterial and Archaeal Inclusions. John Wiley & Sons, Ltd: Chichester, **2011**.
5. Cordoba, P; Staicu, LC, *Fuel*, **2018**, *223*, 268-276.

Poster's list - Monday

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Ruthenium and osmium-based metalloenzyme mimics of the [Fe]-hydrogenase

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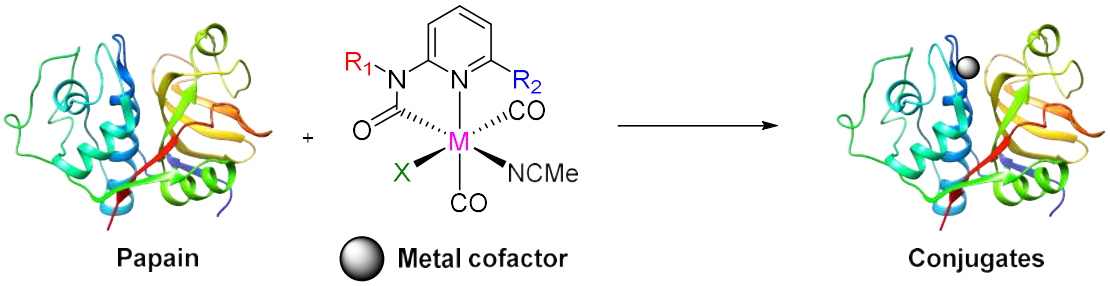
Hydrogenases are a class of enzymes that catalyse the reversible uptake of molecular hydrogen.[1] Of the three classes of hydrogenases, only the mononuclear [Fe]-hydrogenase catalyse the hetereolytic cleavage of hydrogen.[2] Our work aims to create a metalloenzyme mimic of the [Fe]-hydrogenase by first synthesising heavier group VIII metal analogues of the iron cofactor, followed by conjugating the metal cofactor onto a simple protein with a free cysteine residue (Scheme 1). Papain from *Carica papaya*, an affordable and well-characterised cysteine protease, is the choice of protein host. A study of how the different cofactors influence the conjugation process, protein host and *vice versa,* will be presented.



Scheme 1.

1. Stephenson, M.; Stickland, L. H. *Biochem. J.* **1931**, *25* (1), 205 - 214.
2. Zirngibl, C.; Hedderich, R.; Thauer, R. *FEBS Lett.* **1990**, *261* (1), 112-116.

Theranostics guided by artificial metallo-enzymes

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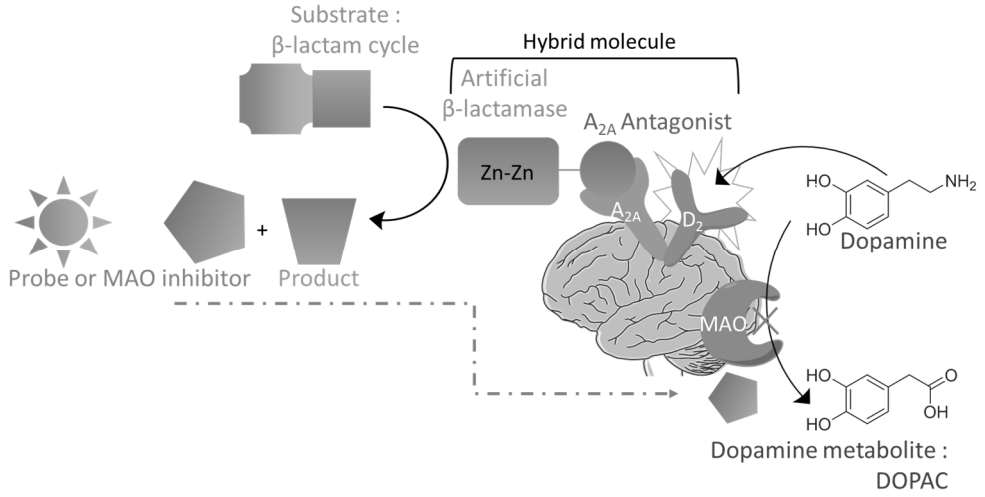
Parkinson's Disease (PD) is a degenerative disorder of the central nervous system that mainly affects the motor system. The main symptoms are shaking, rigidity, slowness of movement, depression, sleep problem and dementia. PD is caused by the death of the dopaminergic neurons, leading to a decrease in dopamine concentration in the brain. Current treatments are typically composed by three molecules: L-DOPA, a dopamine precursor, and two inhibitors comprising a MonoAmine Oxidase (MAO) inhibitor, since this enzyme oxidizes the remaining dopamine in the brain and an Aromatic L-Amino acid DeCarboxylase (AADC) inhibitor because this enzyme transforms L-DOPA before reaching the brain into dopamine. Unfortunately, these treatments are not curative and show fluctuation in effectiveness. Moreover, there are no reliable diagnostic tools for following PD's progression.[1]

In the scope of finding new effective treatments and reliable diagnostic tools for PD, we aim at coupling a current treatment (MAO inhibitors) with a treatment in development known for its neuroprotective abilities *i.e.* an A_{2A} antagonist. Indeed, the A_{2A} adenosine receptor is an allosteric modulator of dopamine D_2 receptor and A_{2A} antagonists have been shown to activate and stimulate the dopaminergic D_2 receptor.[2]
Therefore, we plan to covalently bind an A_{2A} antagonist to a catalyst *i.e.* a dinuclear zinc complex capable of miming of β-lactamases activity thus able to hydrolyse β-lactame cycles. Such a hybrid molecule would be able to act as an A_{2A} antagonist and stimulate the dopaminergic D2 receptors. This allows to start the treatment of PD and targets the affected region of the brain. Simultaneously, the hybrid molecules would be able to release a MAO inhibitor masked in a β-lactame cycle thus enabling a second treatment of PD.[3] Alternatively, an imaging probe could be masked in a β-lactame cycle and used in combination with the hybrid molecule to enable the imaging of the affected region of the brain at different stages of the disease (Scheme 1).



Scheme 1. General strategy developed in the project for the elaboration of theranostic tools using artificial metalloenzymes for the treatment of PD

Initial results showed that the current model complexes of metallo-β-lactamases are inefficient.[4] Bio-inspired by the active sites of metallo-β-lactamases,[5] our aim is to design more efficient model complexes of these enzymes and to rapidly screen their activity *via* a colorimetric assay.[6]

1. Poewe W. *et al.*, *Nat. Rev.*, **2017**, *3*, 17013.
2. Müller C. *et al.*, *ChemMedChem*, **2016**, *11*, 1-16.
3. Youdim M. *et al.*, *Nat. Rev. Neurosci.*, **2006**, *7*, 295-309.
4. Meyer F., *Eur. J. Inorg. Chem.*, **2006**, 3789-3800.
5. Palzkill T., *Ann. N.Y. Acad. Sci.*, **2013**, 91-104.
6. Lippard S. *et al.*, *J. Am.Chem. Soc.*, **2000**, *122*, 6411-6422.

Effects of organic and metallic pollutants on the glycaemia in an experimental animal model

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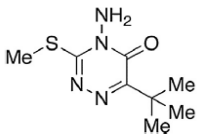
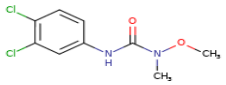
Abstarct

Introduction: Organochlorine and phosphorus compounds and heavy metals are often part of the composition of several materials (fertilizers, insecticides, paints and detergents). Excessive and uncontrolled use of these chemicals, in high doses, induces long-term hormonal and metabolic disorders (1-4). This study aimed to assess the effects of two insecticides (Metribuzin & Linuron) and two metal salts ($CdCl_2$ and $CuSO_4$) on the changes of blood sugar in wistar rats.





Material and methods: **A**nimals were divided into five groups and treated with pollutants for a period of 30 days; controls (G1), rats received orally 133.33 mg / kg metribuzin (G2), rats received 120 mg / kg linuron (G3), others received cadmium chloride 18 mg / kg (G4) and rats received copper sulfate 20 mg / kg (G5). The biochemical parameters (glycemia, urea, creatinine and transaminases) were measured. An anatomopathological study of the liver tissue was carried out. **Results:** A decrease in weight was observed in the G5 and G5 (173.22 ± 1.96 and 160.78 ± 0.21 g respectively) compared to the controls G1 (219 ± 0.19 g). Blood glucose level was significantly high in G5 (3.96 ± 0.3 g / L) and slightly elevated in G3 and G4 (1.22 ± 0.12 and 1.26 ± 0.01 g / L respectively) compared to G1 (1.03 ± 0.03 g / L). Urea levels were high in G2, G3 and G4 (0.93 ± 0.29, 0.64 ± 0.04 and 10.84 ± 1.23 g / L respectively) *versus* G1 (0.35 ± 0.03 g / L). Animals treated with the pollutants showed tissue damage associated with hepatocyte damage, blood vessel congestion and inflammatory reactions marked by lymphocytic infiltration within the liver tissue. **Conclusion**: The doses of organometallic pollutants used have been correlated with a fall in body weight, hyperglycemia and more or less high uremia. These results were indicative of metabolic disorders. The relationship between environmental factors and risk of diabetes will need to be supported by other studies.

Keywords: Heavy metals, Insecticides, Metabolic disorders, Blood sugar, Pollutants, Diabetes.

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1. Chiali FZ, Merzouk H, Merzouk SA, Medjdoub A, Narce M. Chronic low level metribuzin exposure induces metabolic alterations in rats. Pesticide Biochemistry and Physiology, 106 (2013): 38–44
2. Vickie S. Wilson∗, Christy R. Lambright, Johnathan R. Furr, Kembra L. Howdeshell, L. Earl Gray Jr. The herbicide linuron reduces testosterone production from the fetal rat testis during both in utero and in vitro exposures. Toxicology Letters 186 (2009) 73–77
3. H. Dellaoui, A. Berroukche, B. Bouzouira, N. Taibi, M. Zouidi, B. Belatbi. Effects of *Myrtus communis* leaf extracts on CdCl2-induced metabolic disturbance in male wistar rats. South Asian J Exp Biol; 9 (5): 185-192; 2019
4. W. Lansari, A. Berroukche, K. Hachem. Preventive effects of *Petroselinum crispum* seed essential oil on hematological disruption coppersulfate-induced in rat. PONTE International Journal of Sciences and Research, 2019; 75 (9-1): 118-127.

CuTMPA(CO) from organic to aqueous solvent, adaptation to biological relevant media

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The brain of Alzheimer's disease patients present a significant level of oxidative damage associated with an abnormal extracellular increase of amyloid-β peptide (Aβ) concentration leading to the formation of the senile plaques. Increasing evidence suggests an important role played by biometals including zinc and copper (Cu) in neurodegeneration, as they can bind to Aβ under physiological concentrations and are found in high amount in senile plaques. Moreover, *in vitro* studies have shown that Cu-Aβ is able to catalyze the formation of Reactive Oxygen Species (ROS) in the presence of O_2 and a reducing agent such as ascorbate by cycling between the +I and +II oxidative states, involving a nitrogen coordination. However, its mechanism of action is not yet well understood, especially the fundamental aspect of Cu^I(Aβ) chemistry with O_2.[1,2] The aim of the started work is to better understand the mechanism of ROS production by the Cu(Aβ) complex by forming and spectroscopic characterizing intermediates resulting from the reaction between Cu^I(Aβ) and dioxygen. However, this kind of oxidation process is usually too fast to detect any intermediates. Lowering the temperature, which has been developed in organic solvents to overcome this issue, is not usable in our aqueous conditions. Conversely, the strategy consisting to use CO (a Cu^I specific ligand) as an O_2 surrogate to provide insights into coordination number and ligand donation ability is applicable here.[3,4]

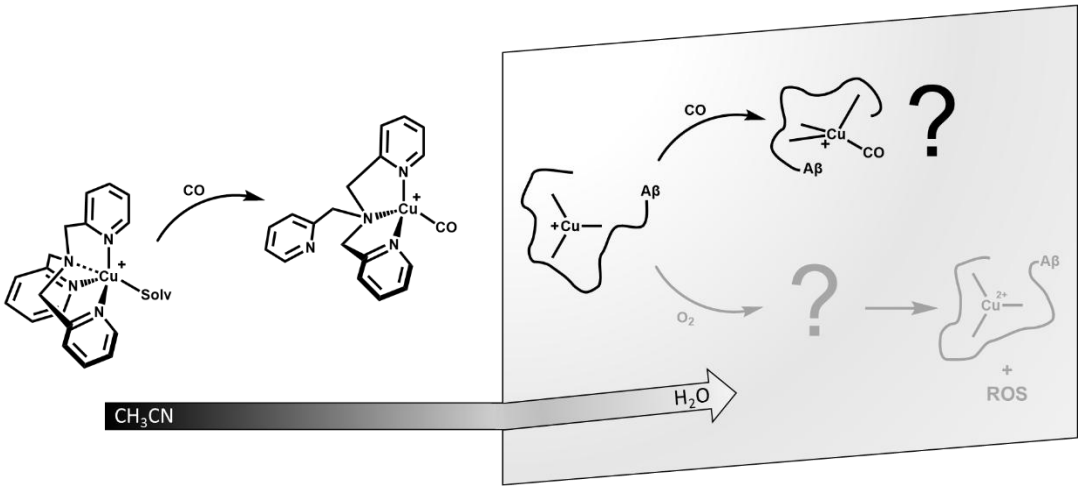

Figure 1: From CuTMPA(CO) in organic solvent to Cu(Aβ)(CO) in aqueous solvent.

We have then decided to start our investigation with the extensively studied CuTMPA (TMPA = (tris(2-pyridylmethyl)amine)) model complex.[5] As its reactivity toward CO or O_2 in organic solvents is well established, it is soluble in water and Cu is bound by nitrogen donor atoms, CuTMPA was use here to set up the reactivity conditions. The conditions of CuTMPA reactivity toward CO were successfully adapted from organic solvent to aqueous solvent and are now applied to Aβ. Challenges and results using UV-vis, FT-IR and electrochemistry will be presented.

1. Cheignon, C.; Tomas, M.; Bonnefont-Rousselot, D.; Faller, P.; Hureau, C.; Collin, F. *Redox Biology*, **2018**, *14*,450-464.
2. Atrián-Blasco, E.; Gonzalez, P.; Santoro, A.; Alies, B.; Faller, P.; Hureau, C. *Coord. Chem. Rev.*, **2018**, *371*, 38-55.
3. Himes, R; Young Park, G.; Barry, A. N.; Blackburn, N. J.; Karlin, K. D. *J. Am. Chem. Soc*, **2007**, *129*, 5352-5353
4. Young Park, G.; Yoon Lee, J.; Himes, R.; Thomas, G. S.; Blackburn, N. J.; Karlin, K. D. *J. Am. Chem. Soc*, **2014**, *136*, 12532-12535
5. Fry, H. C.; Lucas, H. R.; Narducci Sarjeant, A. A.; Karlin, K. D.; Meyer, G. J. *Inorg. Chem.*, **2008,***47*,241-256.

Chimeric enzymes for catalysis of enantioselective reaction in cascade

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In the context of environmentally friendly green chemistry, artificial enzymes are first-class catalysts that enable the synthesis of fine chemicals including pharmaceuticals and food and feed industries.[1]

Cupines are one of the largest family of enzymes and possess one of the most diverse activity profiles. The common structural features characteristic of cupines are barrel domains composed of β-sheets, which are linked by variable interdomains essentially composed of α-helices.[2]

Recently in our laboratory, we obtained the crystal structure of mannose-6-phosphate isomerase of Candida albicans (CaPMI) an enzyme belonging to the cupine family (Figure 1 left).[3] Aiming at the preparation of artificial enzymes, we substituted the Zn(II) cation of its active site by a Cu(II) cation.

Pirin-Like-Protein (PLP) also belongs to the family of cupines and its crystalline structure resembles that of the CaPMI (Figure 1 right). Its active site contains an Fe(III) cation but its function is not confirmed. PLP has also been transformed into an artificial enzyme *via* the substitution of its Fe(III) cation by a Cu(II) cation, which provided a quercetinase activity. Pirin-Like-Protein (PLP) is a protein also belonging to the family of cupines and its crystalline structure resembles that of the CaPMI (Figure 1 right). Its active site contains an Fe(III) cation and although its function is not confirmed. PLP has also been transformed into an artificial enzyme via the substitution of its Fe(III) cation by a Cu(II) cation, which provided it with quercetinase activity.[4]

CaPMI and PLP are so-called bicupines because they are formed of two domains composed each of one barrel of β-sheets and connected by a single inter-domain consisting of α-helixes. The CaPMI active site is found in the β-sheet barrel domain of the C-terminal side, while that of PLP is located in the β-sheet barrel domain of the N-terminal side.

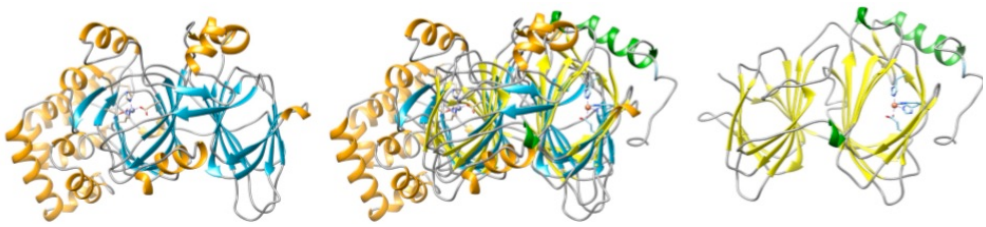

Figure 1. Left: 3D structure of CaPMI; Middle: Structure of the chimeric bicupine CaPMI-Pirin; Right: Crystallin structure of PLP

A bicupine chimera CaPMI-PLP is being prepared by fusion at the inter-domains of the two original bicupines (Figure 1 middle). Inspired by natural and artificial enzymatic catalysis, the CaPMI-PLP chimera will be used with its natural cations and with artificially introduced ones to catalyze different reactions and cascades of reactions.

1. Lewis, J. C. *ACS Catal*. **2013**, *3*, 2954.
2. Dunwell, J. M.; Purvis, A.; Khuri, S. *Phytochemistry*, **2004,** *65*, 7.
3. Ahmad, L.; Plancqueel, S.; Dubosclard, V.; Lazar, N.; Ghattas, W.; Li de la Sierra-Gallay, I.; van Tilbeurgh, H.; Salmon. *FEBS Lett.* **2018**, *592*, 1667.
4. Widiatningrum, T.; Maeda, S.; Kataoka, K.; Sakurai, T. A. *Biochem. Biophys. Rep*. **2015**, *3*, 144.

PolyoxoMetallates to target Cu-related toxic events in the context of Alzheimer's disease

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Copper ions may play a key role in Alzheimer's Disease (AD), because they can modulate the aggregation of the amyloid-β (Aβ) peptides and can catalyse the formation of Reactive Oxygen Species, two events closely related to the aetiology of the pathology [1,2]. Hence one therapeutic approach relies on the use of Cu(II) ligands to remove the ion from its interaction with Aβ and lessen associated deleterious effects (ROS and possible stabilization of Aβ oligomers regarded as the most toxic species present during the aggregation of the peptide).[2-4] During the last years, we and others have explored many approaches[3]. Here we sought for a supramolecular edifice able to prevent the formation of ROS by Cu(Aβ) in presence of ascorbate and dioxygen but also to alter the aggregation of Aβ.

Polyoxometalate (POM) are polyanionic oxoclusters of early transition metal ions that have found applications in various fields from catalysis to material science [5-7]. Controlled basic degradation of POMs can lead to lacunary POMs, which are very efficient all-inorganic ligands [8], making them interesting candidates for chelating Cu(II) out of Aβ. In addition, POMs can modulate the aggregation of amyloidogenic peptides, including Aβ [9] due to electrostatic interactions with positively charged amino-acid residues.

The double ability of the monolacunary POM of Keggin type $K_8[\alpha\text{-}SiW_{11}O_{39}]$ ($K_8\alpha[\mathbf{K}_\ell]\cdot 18H_2O$) on Cu-Aβ ROS production and apo and Cu-altered aggregation of Aβ will be shown (see figure below). In addition, the influence of metal-substituted counterparts of $\mathbf{K}_\ell$, $\mathbf{K_M}$ (M = d-block ions), on the apo-Aβ aggregation will be briefly commented on.

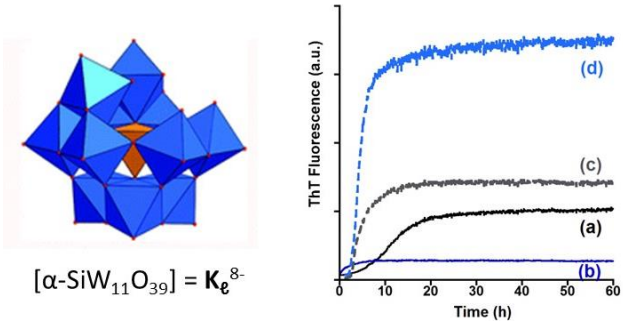

Figure 1. (Left) Lacunary Keggin POM edifice under study here and (Right) Aggregation kinetic curves of Aβ (a), Cu(Aβ) (b) and Aβ (c), Cu(Aβ) (d) in presence of one equiv. of $\mathbf{K}_\ell$.

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[1] E. Atrian-Blasco, P. Gonzalez, A. Santoro, B. Alies, P. Faller, C. Hureau, Coord. Chem. Rev. 371 (2018) 38-55.
[2] C. Hureau, In Encyclopedia of Inorganic and Bioinorganic Chemistry; Scott, R. A. Ed., 2019.
[3] C. Esmieu, D. Guettas, A. Conte-Daban, L. Sabater, P. Faller, C. Hureau, Inorg. Chem. 58 (2019), 13509-13527.
[4] M. G. Savelieff, G. Nam, J. Kang, H. J. Lee, M. Lee, M. H. Lim, Chem. Rev. 119 (2019) 1221-1322.
[5] S.-S. Wang, G.-Y. Yang, Chem. Rev. 115 (2015) 4893–4962
[6] Y.-F. Song, R. Tsunashima, Chem. Soc. Rev. 41 (2012) 7384 -7402
[7] A. Bijelic, A. Rompel, Coord. Chem. Rev. 299 (2015) 22– 38
[8] Z.-J. Liu, X.-L. Wang, C. Qin, Z.-M. Zhang, Y.-G. Li, W.-L. Chen, E.-B. Wang, Coord. Chem. Rev., 313 (2016) 94-110
[9] J. Geng, M. Li, J. Ren, E. Wang, X. Qu, Angew. Chem. Int. Ed. 50 (2011) 4184-4188.

1-hydroxy-2(1H)-pyridinone-based Chelators as Neuroprotective Agents in an In Vitro Model of Parkinson's Disease

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Parkinson's disease (PD) associates with the progressive degeneration of nigro-striatal dopaminergic (DAergic) neurons in the substantia nigra pars compacta (SNpc), resulting in the development of motor symptoms such as resting tremor, muscle rigidity and bradykinesia.[1] Although the exact cause of idiopathic PD remains unknown, excessive cellular oxidative stress and iron dyshomeostasis are key to substantia nigra dopaminergic neuronal degeneration in Parkinson's disease (PD).[2]

In this context, our objective is to develop novel therapeutic and/or alleviation strategies based on compounds able to hit both causative effects by combining coordination and antioxidant properties into a single active molecule. We present a detailed *in vitro* physicochemical and biochemical study of ligands based on 1-hydroxy-2(1H)-pyridinone, which shows the neuroprotective potential of our ligands and suggests that this cellular preservation relates to the compounds' iron chelating capabilities and subsequent reduced capacity of iron to form reactive oxygen species (ROS).[3]

1. Poewe, W.; Mahlknecht, P. *Parkinsonism Relat Disord* **2009**, 15, S28–32.
2. Sian-Hülsmann, J.; Mandel, S.; Youdim, M.B.H.; Riederer, P.J. *Neurochem* **2011**, 118, 939–957.
3. Lewis, F.W.; ·Fairooz, S.; Elson, J.L.; Hubscher‑Bruder, V.; Brandel, J.; Soundararajan, M.; Smith, D.; Dexter, D.T.; Tétard, D.; Pienaar, I.S. *Arch*. *Toxicol*. **2020**, https://doi.org/10.1007/s00204-020-02672-y

Water-Soluble aza-BODIPYs: biocompatible organic dyes for high contrast *in vivo* NIR-II imaging

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Among molecular imaging techniques, optical imaging appears more and more as a key modality[1]. Indeed, optical imaging is a non-ionizing and relatively cheap technique and presents many advantages such as high sensitivity and high resolution, which permit analyses from the subcellular level to *in vivo* investigations. Nowadays, the development of fluorophores emitting in the NIR-I region (from 700 to 900 nm) allows deeper tissues penetration and makes optical imaging an attractive tool at clinical stage for fluorescence guided surgery[2]. Another region of electromagnetic spectrum generated an increasing attention: NIR-II (1000-1700 nm) also called shortwave infrared region (SWIR) because it permits to image tissues more deeply. The recent development of this modality can be explained by its strong capacity to reduce diffusion and to increase the resolution with respect to NIR-I imaging. While some anatomical structures are highly autofluorescent in the NIR-I, in particular tendons, their autofluorescence is limited or absent in the NIR-II optical windows. However, nowadays, few biocompatible NIR-II fluorophores are available and only two types of organic compounds are reported: polymethines and donor-acceptor-donor compounds like CH1055[3]. Thus, there is a huge need of developing new NIR-II emitting fluorophores for biological applications. Very recently, working on aza-BODIPYs for NIR-I imaging, we noticed the potential of some of them as fluorophores emitting in NIR-II. Thanks to a previous strategy based on boron functionalization[4], a water-soluble aza-BODIPY (WAZABY) emitting in NIR-II was developed *(Figure 1)* and studied *in vitro* and *in vivo*. The structurally simple compound can be observed by NIR-II imaging. *In vitro*, the fluorophore quickly accumulated in 2D and 3D cell cultures. *In vivo*, it rapidly reached the tumor in rodents and a high NIR-II contrast remained for up to one week. These preliminary results highlight its strong potential as NIR-II contrast agent.

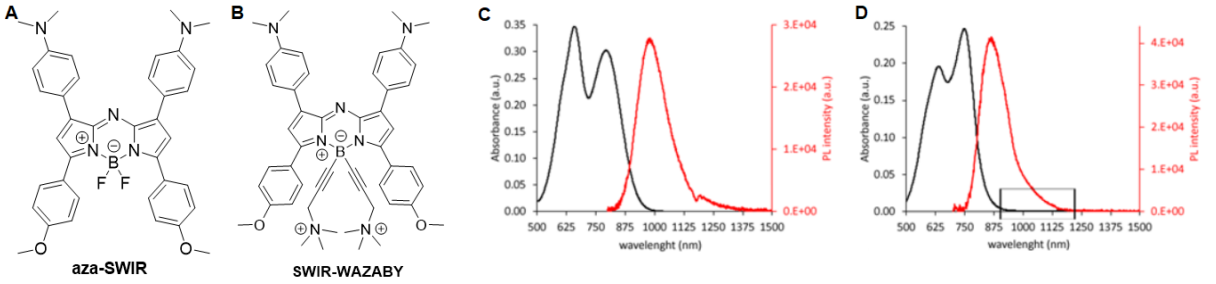

Figure 1. Structure of the NIR-II aza-BODIPY dyes (A-B). Absorption and normalized fluorescence emission spectra in DMSO for aza-SWIR, λ_{exc} = 707 nm, emission between 800 and 1 500 nm (C) and in mouse serum for SWIR-WAZABY, λ_{exc} = 638 nm, emission between 720 and 1,200 nm (D)

1. Luker, G. D.; Luker, K. E., *J. Nucl. Med.* **2008**, 49(1), 1-4.
2. Zhu, S.; Tian, R.; Antaris, A. L.; Chen, X.; Dai, H., *Adv. Mater.* **2019,** *31*, 1900321.
3. Yang, Q.; Ma, Z.; Wang, H.; Zhou, B.; Zhu, S.; Zhong, Y.; Wang, J.; Wan, H.; Antaris, A.; Ma, R.; Zhang, X.; Yang, J.; Zhang, X.; Sun, H.; Liu, W.; Liang, Y.; Dai, H., *Adv. Mater.* **2017,** *29* (12), 1605497.3. Ge, Y.; O'Shea, D. F., *Chem Soc Rev* **2016,** *45* (14), 3846-64.
4. Pliquett, J.; Dubois, A.; Racoeur, C.; Mabrouk, N.; Amor, S.; Lescure, R.; Bettaieb, A.; Collin, B.; Bernhard, C.; Denat, F.; Bellaye, P. S.; Paul, C.; Bodio, E.; Goze, C., *Bioconjug. Chem.* **2019,** *30* (4), 1061-1066.

On the understanding and design of bidirectional and reversible catalysts of multielectron, multistep reactions

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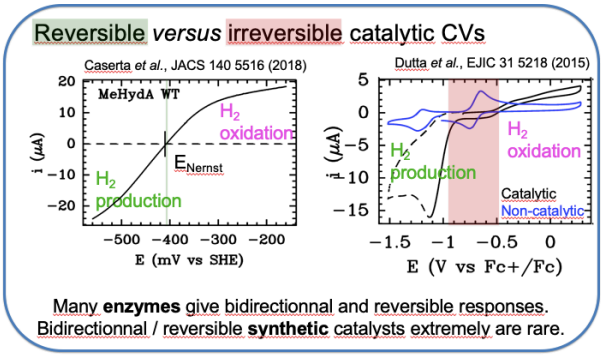
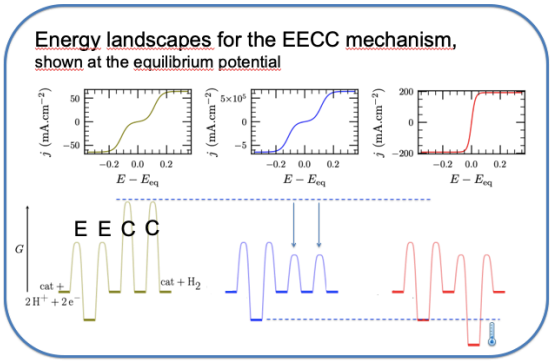
Some enzymes, including those that are involved in the activation of small molecules such as H_2 or CO_2, can be wired to electrodes and function in either direction of the reaction depending on the electrochemical driving force and display a significant rate at very small deviations from the equilibrium potential.[1] We call the former property "bidirectionality" and the latter "reversibility". This performance sets very high standards for chemists who aim at designing synthetic electrocatalysts. Only recently, in the particular case of the hydrogen production/evolution reaction, has it been possible to produce inorganic catalysts that function bidirectionally, with an even smaller number that also function reversibly.[2] This raises the question of how to engineer such desirable properties in other synthetic catalysts.

We introduced the kinetic modeling of bidirectional two-electron-redox reactions in the case of molecular catalysts and enzymes that are either attached to an electrode or diffusing in solution in the vicinity of an electrode.[3]

We emphasize that trying to discuss bidirectionality and reversibility in relation to a single redox potential leads to an impasse: the catalyst undergoes two redox transitions, and therefore two catalytic potentials must be defined, which in most cases will depart from the two potentials measured in the absence of catalysis. We describe how the sequence of events in the bidirectional catalytic cycle can be elucidated on the basis of the voltammetric responses.[3]

Further, we discuss the design principles of bidirectionality and reversibility in terms of thermodynamics and kinetics and conclude that neither bidirectionality nor reversibility requires that the catalytic energy landscape be flat.[3]





1. M. Del Barrio, M. Sensi, C. Baffert, S. Dementin, V. Fourmond and C. Léger, "Electrochemical investigations of enzymes that produce and use solar fuels" Acc. Chem. Res. 51 769 (2018).
2. Priyadarshani N, Dutta A, Ginovska B, et al. Achieving Reversible H_2/H^+ Interconversion at Room Temperature with Enzyme-Inspired Molecular Complexes: A Mechanistic Study. ACS Catal. 6, 6037 (2016).
3. V. Fourmond, E. Wiedner, W. Shaw, C. Léger "On the understanding and design of bidirectional and reversible catalysts of multielectron, multistep reactions" J. Am. Chem. Soc. 141 16734 (2019) Download at https://frama.link/reversibility

Synthesis and reactivity of a low coordinate [Fe^{II}-S-Fe^{II}]-complex

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Iron chalcogenide clusters are essential for numerous metalloproteins such as the Rieske-protein[1] and bacterial nitrogenases.[2] The latter are enzymes which catalyze the reduction of N_2 to NH_3, whereas an iron sulfur cofactor (fig. 1) constitutes the active site for substrate binding and conversion. The cleavage of the central Fe-S-Fe bond is proposed to be a key step for substrate activation.[3] Molecular models of this subunit that might give valuable insights into its properties are rare.

Herein we report the synthesis of a novel low coordinate [Fe^{II}-S-Fe^{II}]-complex from the reaction of an iron (I) precursor and elemental sulfur. The complex can be oxidized incrementally to form a series of isostructural [Fe-S-Fe]-complexes in biological relevant oxidation states. Furthermore, the complex reacts with CS_2, a competitive inhibitor of FeMoco.[4] This leads to the rupture of the Fe-S-Fe-motif and the formation of a thiocarbonate complex.

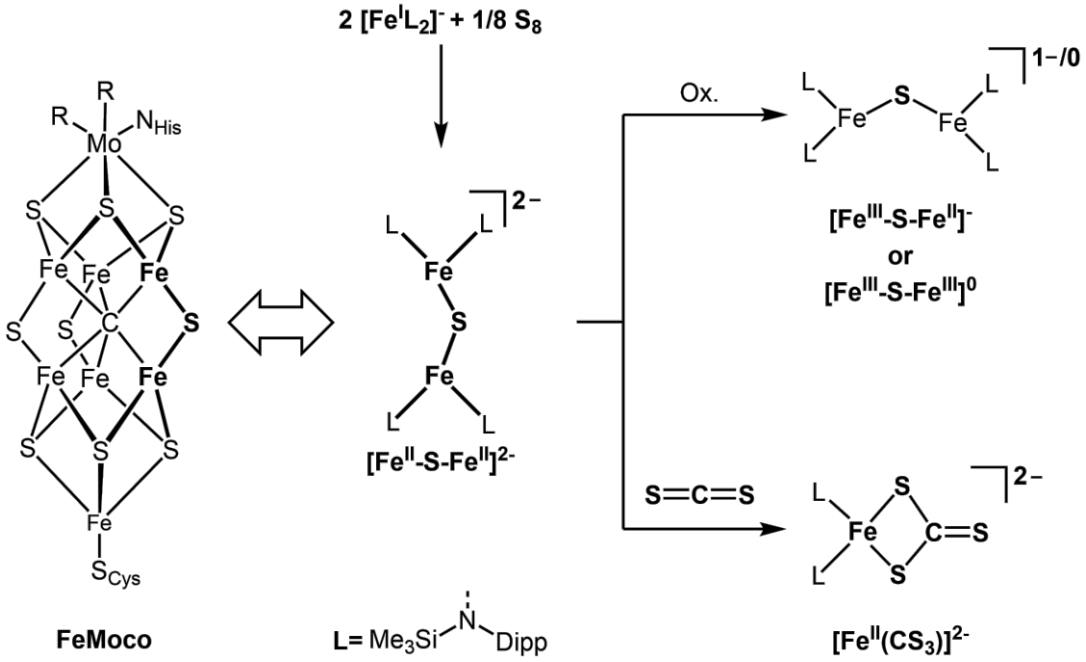

Figure 1. Synthesis and reactivity of [Fe^{II}-S-Fe^{II}]. K^+{18-crown-6} counterions are omitted.

1. H. Beinert, R. H. Holm, E. Münck, *Science* **1997**, 277, 653-659.
2. Coric, B. Q. Mercado, E. Bill, D. J. Vinyard, P. L. Holland, *Nature* **2015**, 526, 1407-1410.
3. I. Coric, P. L. Holland, *J. Am. Chem. Soc.* **2016**, 138, 7200-7211.
4. M. E. Rasche, L. C. Seefeldt, *Biochemistry* **1997**, 36, 8574-8585.

From mineral to enzyme, the key to understand bioenergetics mechanisms at the origin of life?

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Research on biological energy conversion has shown that the catalytic centres of the implicated enzymes are clusters of transition metals which strongly resemble certain minerals prompting the hypothesis that the emergence of life on our planet may have been initiated by mineral-borne metals. Our project proposes a first experimental test of this hypothesis via comparison of the catalytic properties of di-iron hydrolases and in particular soluble methane monooxygenase (sMMO) to those of the structurally affine mineral fougerite. By a multidisciplinary approach combining molecular biology, biochemistry and biophysics on sMMO with innovative approaches on the characterization of the mineral fougérite by different spectroscopies and microscopy, we are working on the elucidation of the mechanism of conversion of methane to methanol by sMMO that we are comparing with reactions performed by fougerite.

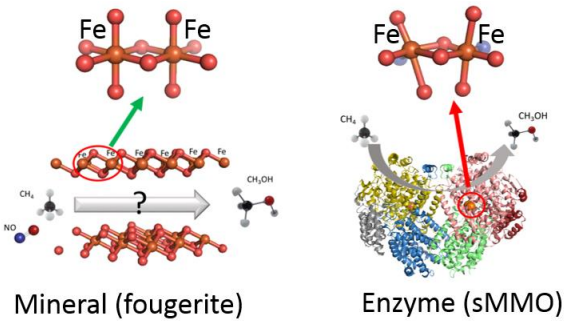

Figure 1: structural comparison between fougerite and the active site of soluble methane mono-oxygenase (sMMO)

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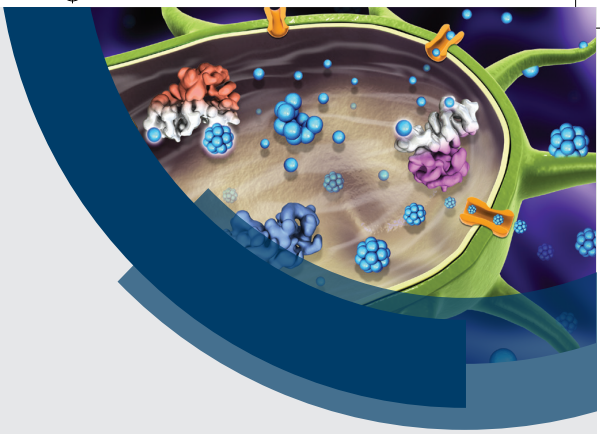

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	High Spin (*main room*)			Low Spin		
12:30-13:20	**PL.2**	**Einsle**	page 32			
	Nitrogenase: unraveling an impossible enzyme mechanism					
13:20-13:40	**HS-OP.7**	**Frostegard**	page 33	**LS-OP.7**	**Bertrand**	page 34
	Impaired synthesis of N_2O reductase leads to high emissions from acidic soils			Heterobimetallic Pt(II)/Re(I) complexes for the IR detection of a new class of platinum anticancer drugs		
13:40-14:00	**HS-OP.8**	**Merakeb**	page 35	**LS-OP.8**	**Lin**	page 36
	Towards nitrogen electrochemical activation using a molybdenum complex			Metal-carbonyl Rhenium complex as selective luminescent and vibrational candidate probe for amyloid fibrils		
14:00-14:20	**HS-OP.9**	**Reckziegel**	page 37	**LS-OP.9**	**Falcone**	page 38
	C–H bond activation by an imido Cobalt(III) and the resulting amido cobalt(II) complex			Towards reversible and specific luminescent sensing of Cu^{2+} in biological media		
14:20-14:50	***Coffee break — Q&A***					
14:50-15:10	**HS-OP.10**	**Das**	page 39	**LS-OP.10**	**Yang**	page 40
	New metal complexes with bioinspired redox active ligands: synthesis, EPR studies and reactivity			Targeted Supported Laccase-based Hybrid Systems for Continuous Flow Catalysis		
15:10-15:30	**HS-OP.11**	**Hüppe**	page 41	**LS-OP.11**	**Contaldo**	page 42
	Fantastic four: tetradentate N-donor ligand enabling a catalytically active non-heme iron(IV)-oxo complex			In vitro biological water-gas shift reaction: characterization and grafting of recombinant *Rhodospirillum rubrum* CODH		
15:30-15:50	**HS-OP.12**	**Dobbelaar**	page 43	**LS-OP.12**	**Felbek**	page 44
	Reactivity studies on a novel structural model complex for the rabbit-lipoxygenase			Built-in safety lock in FeFe hydrogenase: a flexible cysteine ligand protects the active site from oxygen attack		
15:50-16:10	**HS-OP.13**	**Csire**	page 45	**LS-OP.13**	**Orio**	page 47
	Iron(III)-chelating model peptides as bioinspired antioxidants			Hydrogen evolution reaction with a bioinspired nickel complex: Experimental and theoretical studies		
16:10-16:40	***Group Picture & sponsor's presentation***					
16:30-17:00	***Coffee break — Q&A***					
17:00-17:30	**Poster Session 3**			**P.16-P.24**		pages 48-54
17:30-18:00	**Poster Session 4**			**P.25-P.30**		pages 55-60

Nitrogenase: Unraveling an Impossible Enzyme Mechanism

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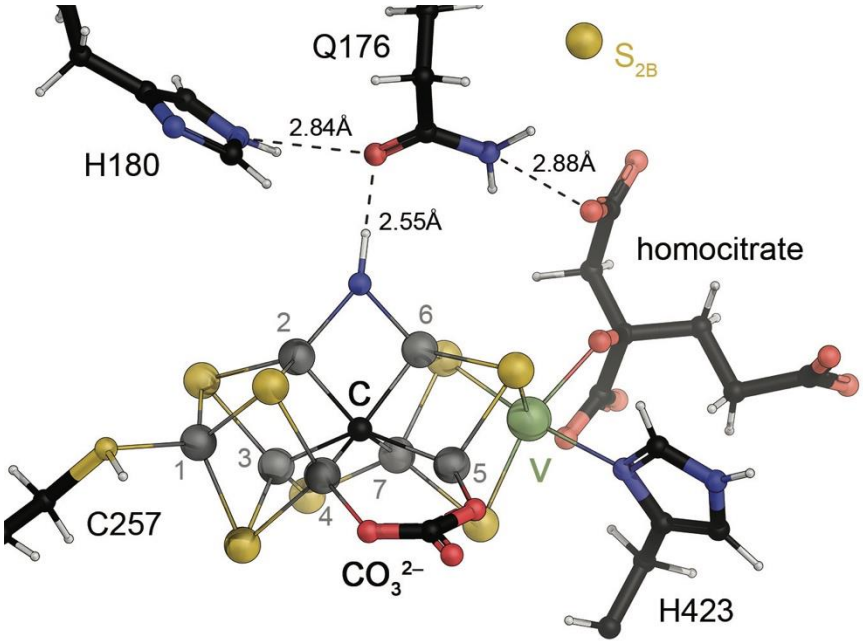
In the biological fixation of nitrogen, the unique, Mo- or V- and Fe-containing catalytic cofactor has the ability to generate a highly reduced and reactive species that is able to convert highly inert substrate molecules such as cyanide, carbon monoxide and of course the physiological substrate dinitrogen (N_2). This activation is most likely achieved by the stoichiometric reductive elimination of H_2 after a four-electron reduction of the cofactor. A series of studies in recent years has shown that a particular position on the cofactor can reversible eliminate a μ^2-bridging sulfide, opening a dinuclear binding site formed by Fe2 and Fe6 of the cluster and providing experimental evidence for the mode and position of ligand binding to the cofactor.



The definition of a precise binding site for substrates and inhibitors – and most likely also for the hydride ions generated during the charging process – now provides a basis for the integration of biochemical and biophysical data with theoretical calculations in order to eventually elucidate the reactivity and mechanism of the enigmatic nitrogenase enzymes.

References

Spatzal, T., Perez, K. A., Einsle, O., Howard, J. B. & Rees, D. C. (2014). *Science* 345, 1620-1623.

Sippel, D. & Einsle, O. (2017). *Nature Chem. Biol.* 13, 956.

Sippel, D., Rohde, M., Netzer, J., Trncik, C., Gies, J., Grunau, K., Djurdjevic, I., Decamps, L., Andrade, S. L. A. & Einsle, O. (2018). *Science* 359, 1484-1489.

Rohde. M., Sippel, D., Trncik, C., Andrade, S.L.A. & Einsle, O. (2018). *Biochemistry* 57, 5497.

Impaired synthesis of N_2O reductase leads to high emissions from acidic soils

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Nitrous oxide (N_2O) is the third most important greenhouse gas, but it has until now received less attention than carbon dioxide (CO_2) and methane (CH_4). Emissions of N_2O are rising steadily since the start of industrialization, and the Intergovernmental Panel on Climate Change (IPCC) predicts that they, unlike CO_2 emissions, will continue to escalate unless novel mitigation options are implemented. N_2O can be produced and liberated to the atmosphere by several human-induced processes, but the dominate source of the anthropogenic N_2O emissions is microbial processes in agricultural soils. The enzyme N_2O reductase (NOS), which is a multi-copper enzyme, is only found in some types of bacteria and in some archaea and is the only known biological sink for N_2O. It reduces N_2O to harmless N_2-gas, the main constituent of the air in our biosphere. One of the major environmental controllers of N_2O emissions is pH, and acidic soils are known to release larger amounts of N_2O than neutral soils. This is a global problem since, in addition to naturally occurring acidic soils, many soils are acidified due to excessive use of synthetic fertilizers. Although the negative correlation between pH and N_2O/N_2 product ratios (the fraction of added N released as N_2O *vs* N_2) has been known for decades, the biological mechanisms leading to this have not been understood. Our studies of denitrifying bacteria in pure culture showed that transcription of the gene *nosZ* (encoding NOS) did take place under acidic conditions (pH 5.7-6.1) during periods of active denitrification but with negligible or strongly delayed N_2O reduction, and we also showed that the NOS apo-protein was transported to the periplasm. If the organisms were instead allowed to synthesize the protein at neutral pH they readily reduced N_2O at acidic pH, but at a lower rate[1]. Studies of complex soil bacterial communities corroborated several of these findings and showed that the phenomenon is general to a wide range of bacteria[2,3,4]. Recent metagenome- and metatranscriptome analyses of soils of pH 4 and 7 showed similar abundance of *nosZ* genes and transcripts (*nosZ* clades I + II), thus lending little support for a direct, causal relationship between *nosZ* abundance and N_2O emissions. The results also demonstrated that other accessory genes in the *nos* operon were transcribed. These included *nosR* encoding an enzyme involved in activation of transcription and in electron transport to NOS; *nosL* encoding an enzyme delivering Cu to NOS; and the ORF *nosDFY* encoding NosD, suggested to be involved in NosZ maturation, and the ABC-transporter NosFY. Taken together, our findings point to one or more post-transcriptional mechanisms affecting the maturation of the NOS apo-protein after transport to the periplasm. Further studies will dive deeper into the NOS structure after synthesis at different pH levels. We will also try to understand why the NOS function is restored after prolonged incubation under denitrifying conditions, suggesting that successful NOS maturation does take place stochastically at low pH, resulting in growth of some organisms.

[1]Bergaust L, Mao Y, Bakken LR, Frostegård Å. Denitrification response patterns during the transition to anoxic respiration and posttranscriptional effects of suboptimal ph on nitrogen oxide reductase in paracoccus denitrificans. *Appl Environ Microbiol* 2010; **76**: 6387–6396.
[2]Liu B, Mørkved PT, Frostegård Å, Bakken LR. Denitrification gene pools, transcription and kinetics of NO, N 2O and N2 production as affected by soil pH. *FEMS Microbiol Ecol* 2010; **72**: 407–417
[3]Liu B, Frostegård Å, Bakken LR. Impaired reduction of N2O to N2 in acid soils is due to a posttranscriptional interference with the expression of nosZ. *MBio* 2014; **5**.
[4]Bakken LR, Frostegård Å. Sources and sinks for N2O, can microbiologist help to mitigate N2O emissions? *Environ Microbiol* 2017; **19**: 4801–4805.

Heterobimetallic Pt(II)/Re(I) complexes for the IR detection of a new class of platinum anticancer drugs

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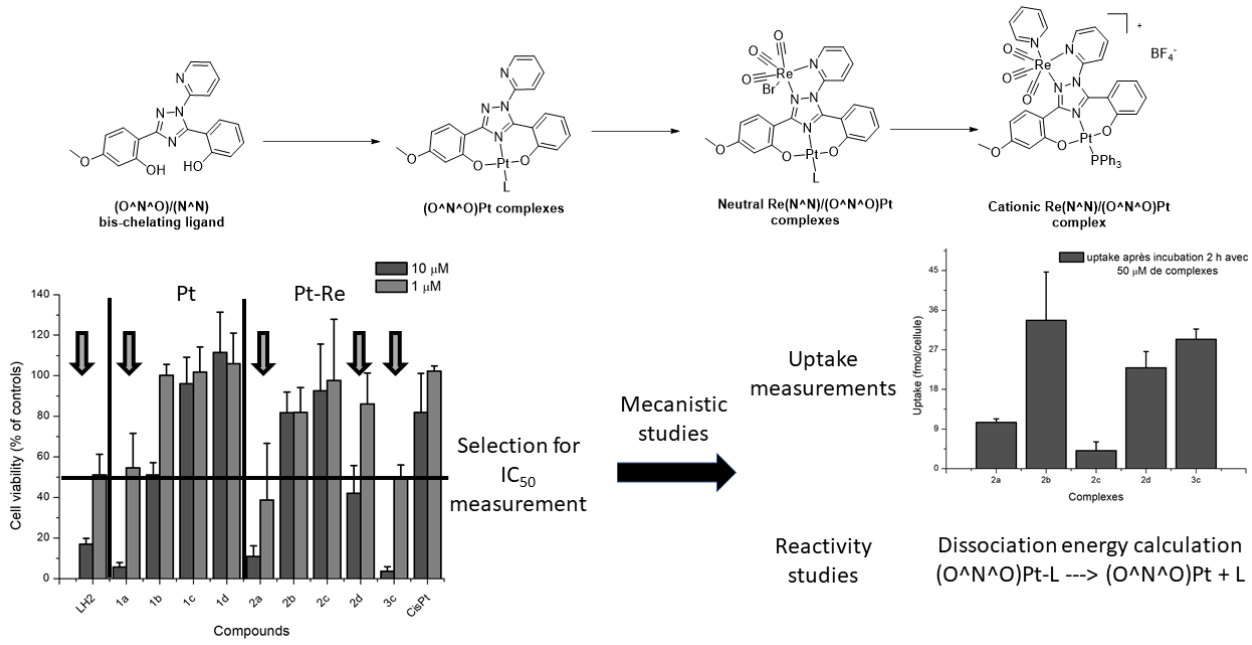
Platinum(II) complexes are the standards of care for many type of cancers including lung, testicular or colon cancer. However, despite the hundreds of compounds synthesized and tested only three complexes have reached worldwide approval. Considering that most of the tested complexes were build on the same scaffold, they presented similar efficacy and side effects and were though rejected.[1] In that context, exploration of new scaffolds seems necessary to overcome the limitations of the current treatment. We have developed a ligand presenting a (O^N^O) chelating ligand and an (N^N) chelating ligand. We synthesized a family of (O^N^O)Pt(II) complexes with various ancillary ligands and the corresponding heterobimetallic complexes Re(I)(N^N)/(O^N^O)Pt(II) complexes. The best candidates presented IC50 values up to 10 times more potent than the reference compound cisplatin.[2] The presence of the $Re(CO)_3$ moiety enabled us to measure the uptake of the Re/Pt complexes by FT-IR spectroscopy following a protocol developed in our group.[3] By combining the uptake informations with the lipophilicity measures and the calculations of the bound dissociation energy of the ancillary ligands, we could rationalize the antiproliferative properties and draw potential way to further improve the anticancer properties of that new class of Pt(II) complexes.



1. R. Oun, Y. E. Moussa and N. J. Wheate, *Dalton Trans.,* **2018**, *47*, 6645-6653.
2. manuscript in redaction
3. C. Policar, J. B. Waern, M.-A. Plamont, S. Clède, C. Mayet, R. Prazeres, J.-M. Ortega, A. Vessières and A. Dazzi, *Angew. Chem. Int. Ed.,* **2011**, *50*, 860-864.

Towards Nitrogen Electrochemical Activation Using a Molybdenum Complex

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Nitrogen is the most abundant molecule in the atmosphere. Its transformation into ammonia is one of the most important reactions of the chemical industry (fertilizers building block, manufacture ...). However, the strong N≡N triple bond makes it inert, and the use of catalysts is necessary to conduct nitrogen reduction. Up to this day, the most important process for nitrogen fixation is the Haber - Bosch process, converting N_2 to ammonia by reacting it with molecular H_2 (originating from fossil sources) over an iron catalyst, under harsh operating conditions[1]. The use of a renewable source of hydrogen (HER) is not compatible with such a process because it would need to be fed continuously to the reactor, while renewables are intrinsically intermittent. Other strategies for ammonia synthesis are thus needed.

Over the last years, chemists have been designing molecular catalysts able to react with N_2, cleave it and functionalize it. These synthetic systems include molybdenum[2,3] , iron[4] and rhenium[5] complexes. In particular, it has been shown that a tridentate phosphine molybdenum complex can reduce N_2 into silylamines in a catalytic fashion. The first step of this process is the stoichiometric splitting of nitrogen with the Mo complex, thus forming a Mo - nitrido species. This latter then reacts with silanes to produce silylamines[6].

In this work, we investigate the reactivity of this Molybdenum complex using cyclic voltammetry and develop an electrochemical approach to split nitrogen.

1. Shlögl, Angew. Chem. Int. Ed., 42, **2003**, 2004-2008
2. Schrock and Yandulov, Science, 3012, **2003**, 76-78
3. Nishibayashi *et al.*, Nature, 568, **2019**, 536-540
4. Peters *et al.*, Nature, 501, **2013**, 84-87
5. Schneider *et al.*, J. Am. Chem. Soc., 140, **2018**, 7922-7935
6. Mézailles *et al.*, Angew. Chem. Int. Ed., 55, **2016**, 11212-11216

Metal-Carbonyl Rhenium Complex as Selective Luminescent and Vibrational Candidate probe for Amyloid Fibrils

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Developing molecular probes for detecting Amyloid-Beta (Aβ) peptides is crucial for a better understanding of Alzheimer Disease (AD). Rhenium-based carbonyl complexes ($Re(CO)_3$) are promising since such metal-carbonyl complexes show intense CO absorption bands in the range 2200-1800 cm^{-1}, where biological media are almost transparent. In addition, luminescent properties of $LRe(CO)_3$ can also be useful for bio-applications. Along these lines, we seek to synthesize aryl-benzothiazole (ABT)-$Re(CO)_3$ complex as novel vibrational bio-imaging probes targeting the amyloidogenic process involving the Aβ peptide, where the ABT moiety is known to interact with amyloid fibrils.

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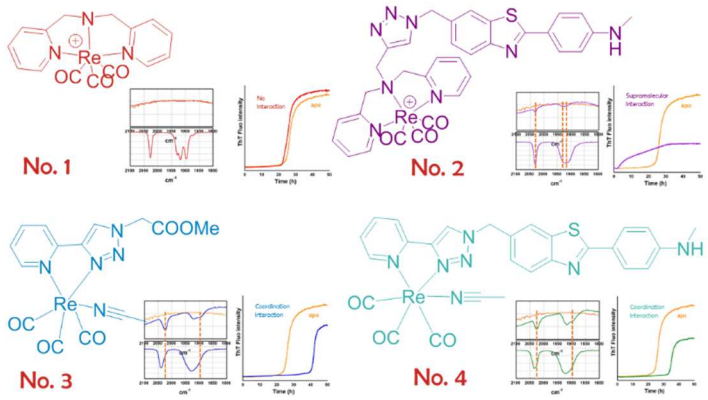

Synthesis of small organic (Aryl-Benzothiazole) and related inorganic complexes (Re) will be shown which are expected to be modulators of the aggregation of the amyloid-β peptide and/or potential probes for the progress of Alzheimer's disease. Their primary effect on Aβ peptides fibrillation is characterized by a kinetic curve (monitored by ThT assay), which proves the potential interaction between Re complexes and Aβ peptides. No.2 interacts stronger than 1 due to supramolecular interaction between ABT moiety and Aβ. Meanwhile, a stronger interaction with complexes No.3 and 4 (compared with 1 and 2) are observed due to the likely replacement of the labile ACN by Imidazole of peptides.

1. P. Hildebrandt, *Angew. Chem. Int. Ed.*, **2010**, *49*, 4540-4541
2. M. T. Gabr.; F. C., Pigge. Chem. Eur. J., **2018**, *24*, 11729-11737
3. S. Clede, C. Policar, Chem. Eur. J., **2015**, *21*, 942-958
4. CY. Chan, P. Barnard, Chem. Commun.,**2017**, *53*, 2311-2314
5. S. Noel, C. Hureau, Chem. Soc. Rev., **2013**, *42*, 7747-7762

C−H Bond Activation by an Imido Cobalt(III) and the Resulting Amido Cobalt(II) Complex

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The 3d-metal mediated nitrene transfer is under intense scrutiny due to its potential as an atom economic and ecologically benign way for the directed amination of (un)functionalized C−H bonds.[1] The impact of the electronic situation including the influence of the coordination number, electronic spin, as well as oxidation state, towards their reactivity could not be clarified so far. Late transition metal complexes (Co - Cu) can be assumed to show a higher reactivity due to decreased back bonding of the imido ligand, and thus weakening of the metal nitrogen bond.[2,3]
We recently reported the synthesis of a two coordinated cobalt(I) complex (**1**), which exhibits a weak ligand field.[4] Reaction of **1** with *tert*-butylazide leads to the isolation and characterization of a rare, trigonal imido cobalt(III) complex (**2**), which bears an exceptionally long cobalt−imido bond.[4] It can cleanly cleave strong C−H bonds with a bond dissociation energy of up to 92 kcal/mol in an intermolecular fashion, unprecedented for imido cobalt complexes. This resulted in the amido cobalt(II) complex $[Co(hmds)_2(NH^tBu)]^-$ (**3**). Kinetic studies on this reaction revealed an H atom transfer (**HAT**) mechanism with a kinetic isotope effect of 6.5(2). Remarkably, the cobalt(II) amide itself is capable of mediating H atom abstraction (**HAT**) or stepwise proton/electron transfer (**PT**/**ET**) depending on the substrate. A cobalt mediated catalytic application for substrate dehydrogenation using an organoazide is presented.

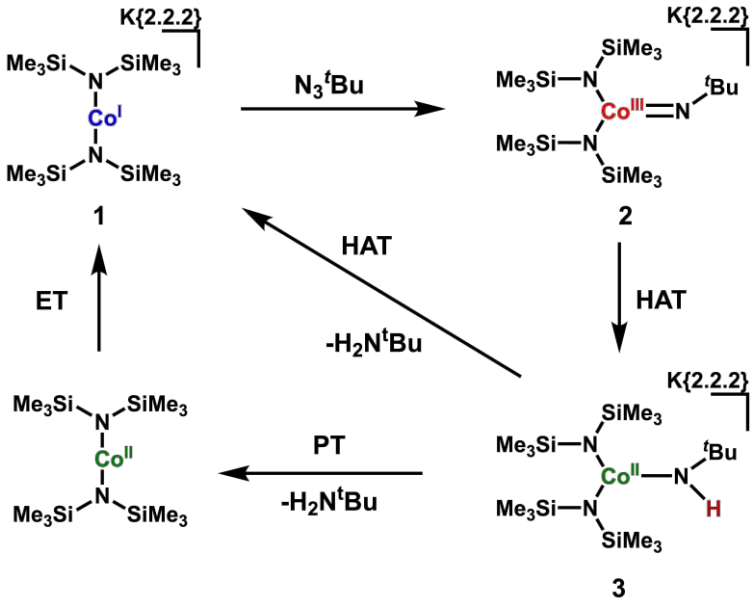

Figure 1. Synthesis and H atom transfer (**HAT**) capability of K{crypt.222}[$Co(hmds)_2N^tBu$] (**2**) as well as dichotomic reactivity (**HAT** and **PT**/**ET**) of K{crypt.222}[$Co(hmds)_2NH^tBu$] (**3**).

[1] K. Ray, F. Heims, F. F. Pfaff, *Eur. J. Inorg. Chem.* **2013**, *22-23*, 3784-3807.
[2] Y. Baek, T. A. Betley, *J. Am. Chem. Soc.* **2019**, *19*, 7797-7806.
[3] K. M. Carsch, I. M. DiMucci, D. A. Iovan, A. Li, S. Zheng, C. J. Titus, S. J. Lee, K. D. Irwin, D. Nordlund, K. M. Lancaster, T. A. Betley, *Science* **2019**, *6458*, 1138-1143.
[4] C. G. Werncke, E. Suturina, P. C. Bunting, L. Vendier, J. R. Long, M. Atanasov, F. Neese, S. Sabo-Etienne, S. Bontemps, *Chem. Eur. J.* **2016**, *5*, 1668-1674.
[5] A. Reckziegel, C. Pietzonka, F. Kraus, C. G. Werncke, **2020**, *under revision*.

Towards reversible and specific luminescent sensing of Cu^{2+} in biological media

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Copper is an essential metal for most organisms, since it is implicated as redox factor in fundamental biological functions. Notwithstanding, excess of loosely bound copper can be toxic as its redox cycling between Cu^{2+} and Cu^{+} effectively catalyses Reactive Oxygen Species (ROS) production. Therefore, copper levels in the body are strictly controlled by its tight coordination to extracellular carriers, membrane transporters and intracellular metallo-chaperones. Interestingly, increased serum copper levels have been arisen as potential markers of some pathologies related to copper dyshomestasis, such as Wilson's disease and Alzheimer's disease.[1] Hence the development of sensors for Cu detection in biological media is of momentous interest. In particular, reversible sensors for the two Cu^{+}/Cu^{2+} redox states are sought. Among fluorescent probes, those based on fluorescence turn-on are preferred to those based on fluorescence turn-off, since the latter can also occur by other mechanisms such as degradation of the fluorophore or the inner filter effect. Nowadays, several turn-on fluorescent sensors for Cu^{+} have been reported in the literature and applied to biological studies. In contrast, turn-on fluorophores for Cu^{2+} sensing are very challenging, as the paramagnetic Cu^{2+} generally quenches fluorescence. In this respect, we recently re-investigated an alleged turn-on binding-based probe,[2] showing that it actually works through irreversible Cu^{2+}-induced oxidation, only in presence of a Cu^{+}-stabilizing solvent.[3] This restricts enormously the application of such a sensor for biological applications and shows the challenge for establishing a reversible Cu^{2+} turn-on sensor. Nowithstanding the above mentioned shortcoming, the design of turn-off appears instead straightforward. Hence, we recently developed a turn-off probe suitable for specific and reversible Cu^{2+} sensing in biological media. In this regard, fluorescent sensing in biological media is also challenged by the intrinsic fluorescence background of biomolecules such as proteins and cofactors. In order to overcome this issue, we designed a turn-off Tb^{3+} luminescent peptide probe combining the selectivity and suitable affinity of the ATCUN (Amino Terminal Cu^{2+}- and Ni^{2+}-binding) *Xxx-Zzz-His* motif with the long-lifetime emission of the lanthanide (Figure 1). Indeed, the sensor showed selective and reversible response towards Cu^{2+}. In addition, time-delayed detection of Tb^{3+} luminescence enabled the measurement of Cu^{2+} fluctuations in complex media with high fluorescent background. Finally, we also show that the modulation of the peptide sequence allows to tune the affinity and the kinetic response of the sensor.

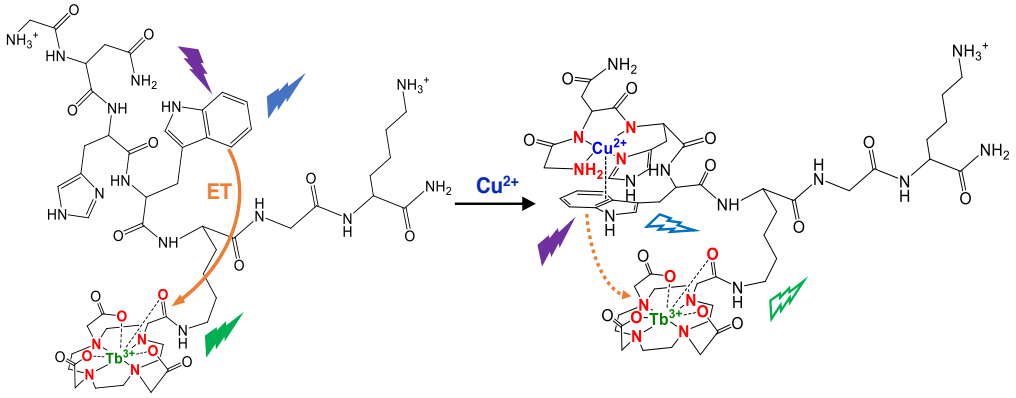

Figure 1. Structure and schematic mechanism of the ATCUN-Tb^{3+} sensor developed. A tryptophan (Trp) residues works as "antenna" for the sensitivation of Tb^{3+}, which is complexed by the ligand DOTA grafted on the side chain of a lysine residue. In absence of Cu^{2+}, Trp excitation (violet flash) gives rise to Trp (blue flash) emission and also Tb^{3+} (green flash) emission via energy transfer (ET, orange arrow); upon Cu^{2+}-binding to the peptide ATCUN motif (*Xxx-Zzz-His*), both Trp and Tb^{3+} luminescence is quenched.

1. R. Squitti, R. Ghidoni, I. Simonelli, I. D. Ivanova, N. A. Colabufo, M. Zuin, L. Benussi, G. Binetti, E. Cassetta, M. Rongioletti and M. Siotto, J. Trace Elem. Med. Biol., 2018, 45, 181–188.
2. P. Venkatesan and S. P. Wu, RSC Adv., 2015, 5, 42591–42596.
3. E. Falcone, A. Sour, V. Lebrun, G. Ulrich, L. Raibaut and P. Faller, Dalt. Trans., 2019, 48, 14233–14237.

New metal complexes with bioinspired redox active ligands: synthesis, EPR studies and reactivity

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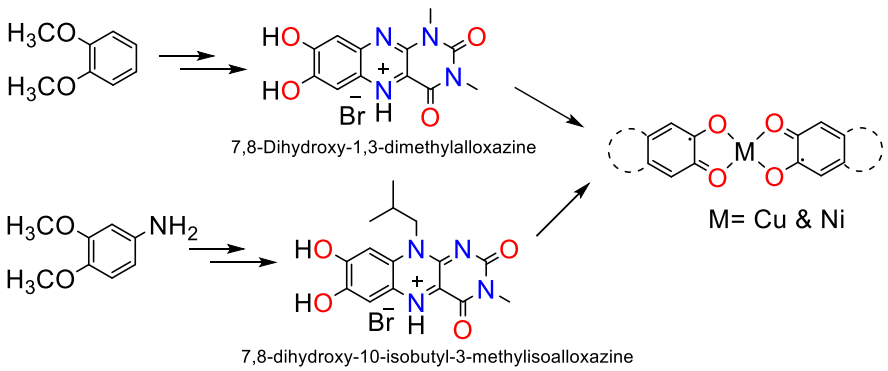
Nature's catalytic reactions performed by metalloenzymes are very important in our daily life. These natural catalysts are selective for a specific substrate and can perform a wide range of chemical reactions. Their most attractive feature is that these metalloenzymes are capable of doing such catalysis at ambient conditions and rely on low cost first-row transition metals. They often rely on ligand radical species, which participate by donating/accepting electrons or by forming and/or breaking substrate bonds. For this redox specificity, these ligands have been classified as **redox** or "**non-innocent ligands**" (NILs).[1-3]

Flavin subunits have two isomers: isoalloxazine and alloxazine, isoalloxazine is the natural isomer and can be found in vitamin riboflavin (B_2). Both can undergo oxido-reduction reactions by two electrons either in one or two steps. These flavin subunits are also photoreducible,[4] which implies light could be used as a cheap source for activation. We thus selected flavin[5],[6] as a core unit to prepare a family of redox active ligands.

We report here two new ligands combining two well-known redox-active catechol and flavin subunits. Copper and nickel complexes were prepared and characterized using EPR and other spectroscopic techniques. We also report X-ray crystal structures of the ligands and nickel complex. These complexes were further studied in single electron transfer (SET) reactivity.



References

1. P. J. Chirik, K. Wieghardt, *Science* **2010**, *327*, 794–795.
2. J. Jacquet, S. Blanchard, E. Derat, M. Desage-El Murr, L. Fensterbank, *Chem. Sci.* **2016**, *7*, 2030–2036.
3. J. Jacquet, P. Chaumont, G. Gontard, M. Orio, H. Vezin, S. Blanchard, M. Desage-El Murr, L. Fensterbank, *Angew. Chem. Int. Ed.* **2016**, *128*, 10870–10874.
4. V. Massey, M. Stankovich, P. Hemmerich, *Biochem.* **1978**, *17*, 1–8.
5. S. Chen, M. S. Hossain, F. W. Foss, *Org. Lett.* **2012**, *14*, 2806–2809.
6. Y.-M. Legrand, M. Gray, G. Cooke, V. M. Rotello, *J. Am. Chem. Soc.* **2003**, *125*, 15789–15795.

Targeted Supported Laccase-based Hybrid Systems for Continuous Flow Catalysis

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Our project aims at developing new supported hybrid catalyst for cooperative oxidative transformation of alcohols. We aim at vectorizing an oxidant module represented by a transition metal-based-catalyst at the surface and close vicinity of the active copper centre of a robust laccase to perform safe dioxygen reduction into water in a cooperative mode. This hybrid catalyst will then be confined in tailor-made silicabased nanomaterials to provide new properties to the hybrid catalyst dealing with stability, selectivity, efficiency and recyclability. Immobilizing both the catalyst and the biocatalyst into the same cavity of a macroporous heterogeneous support we aim at creating a local environment where every species can work in close vicinity which will promote cooperativity.To this end, I have focus my attention on the exploitation and integration of different scientific approaches to build up and study the different components of the system: production of recyclable hybrid catalyst; immobilization of the hybrid catalyst; catalytic efficiency of the supported catalyst on model reaction; optimization of a new material for continuous flow catalysis.

Our preliminary results show that laccase and transition metal complex have to be covalently bound to the foam to promote activity. As a part of this whole project, I will present my results on a heterogeneous biocatalyst based on the grafting of laccase and its variants into macrocellular Si(HIPE) materials. Due to the host intrinsic high porosity and monolithic character, on-line catalytic process is easily reached. This biocatalyst was applied to the decolorizations of Reactive black 5 (RB-5) and Remazol Brilliant Blue (RBBR). In presence of 1.5 mM the redox mediator 1-hydroxybenzotriazole (HBT), the decolorization efficiency for RB-5 and RBBR is 75% and 85%, respectively after 24h. We balanced the immobilization yield with the resulting rate of decolorization by fine tuning of immobilization conditions. Beyond, this enzymatic-based heterogeneous catalyst can be reused after two or even four months' storage while maintaining its decolorization efficiency (Figure 1). This study shows that this biocatalyst has great potential toward dyestuff treatments. Preliminary results on laccase orientation at the surface of silica foams will also be presented.

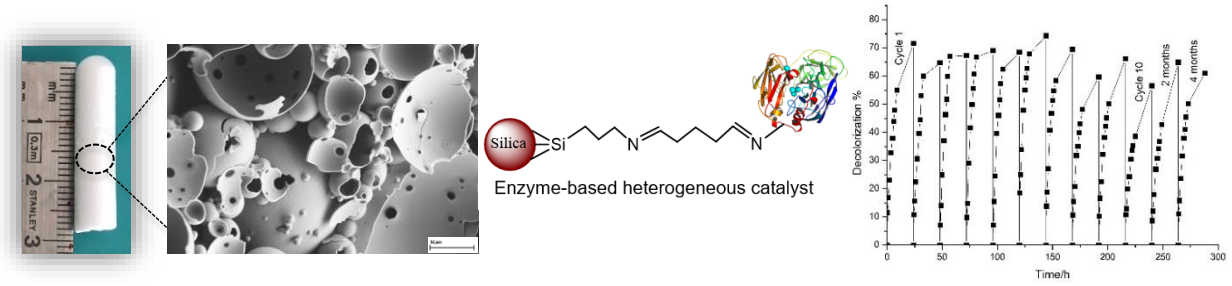

Figure 1 Preliminary results on laccase immobilization onto random modified silica monoliths and decolorization activity test. Hybrid nanomaterial active over 10 cycles and few months.

1. Daâssi, D., et al. *International Biodeterioration & Biodegradation*, **2014**, 90, 71-78.
2. Kunamneni, A., et al. *Process Biochemistry*, **2008**, 43(2): 169-178.
3. Pezzella, C., et al. *Biomed Res Int*, **2014**, 308613.
4. Hitaishi, P. V., et al. *Catalysts*, **2018**, 8(5).

Fantastic four: Tetradentate *N*-donor ligand enabling a catalytically active non-heme iron(IV)oxo complex

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A common motive for active species in natural enzymes are high-valent iron-oxo centres. Since the breakthroughs in 2003 where the first natural non-heme iron-oxo enzyme was trapped and characterised and the first non-heme iron(IV)oxo complex was characterised via X-ray crystallography even more research was performed in this field. Besides the closer understanding of the structure and functionality of the natural non-heme iron-oxo enzymes, their catalytic abilities are of great interest. They are able to catalyse some of the most challenging oxidation reactions. One of these reactions is the oxidation of quite inert C−H bonds with high selectivity. Model complexes of these non-heme iron-enzymes can be synthesised with a wide range of tetra- and pentadentate ligands. Common motives for *N*-donor ligands are amine or pyridine-based ligands. Furthermore, iron is a very abundant metal which makes it a good candidate for cheap and moreover non-toxic transition metal catalysis. [1−3]

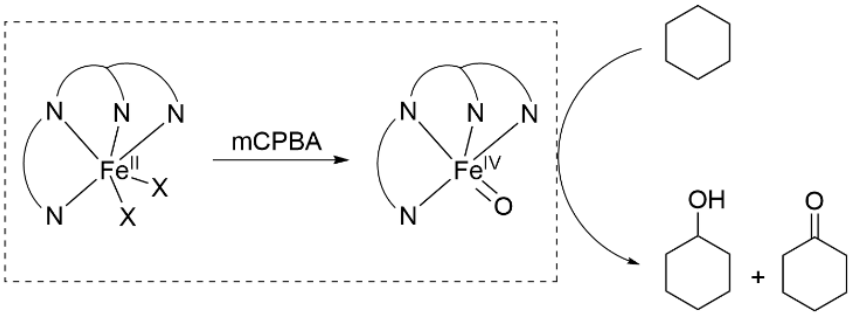

Figure 1. Generation of a non-heme iron(IV)oxo complex with *meta*-chloroperoxybenzoic acid (mCPBA) and subsequent oxidation catalysis of cyclohexane.

Herein, we present a new member in the family of non-heme iron(IV)oxo model complexes. The use of a tetradentate *N*-donor ligand enables two *cis*-labile coordination sites, which gives room for the generation of an iron(IV)oxo species with mCBPA as oxidising agent. Besides the characterisation via UV/Vis and Cryo-ESI we systematically investigated the catalytic abilities of this species. Therefore, a substrate with strong C−H bonds like cyclohexane and a substrate for investigation of regioselectivity like adamantane were used. [4]

1. S. Kal, S. Xu, L. Que, *Angew. Chem. Int. Ed.* **2019**, 10.1002/anie.201906551.
2. M. Puri, L. Que, *Acc. Chem. Res.* **2015**, *48*, 2443–2452.
3. X. Engelmann, I. Monte-Pérez, K. Ray, *Angew. Chem. Int. Ed.*, **2016**, *55*, 7632–7649; *Angew. Chem.* **2016**, *128*, 7760.
4. Manusript in preparation.

In vitro biological water-gas shift reaction: characterization and grafting of recombinant *Rhodospirillum rubrum* CO-dehydrogenase

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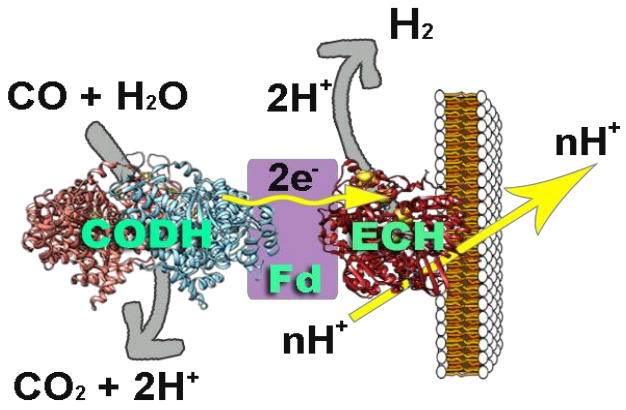
In the perspective of a green economy, one of the main challenges is the discovery of low-cost environmental friendly fuels. One interesting candidate is syngas, produced by the gasification of biomass or from waste, resulting in a variable mixture of H_2 and CO. Achieving the accurate control of this ratio is fundamental to exploit syngas at the industrial level. Currently, one of the most utilized methods is the water gas shift reaction (WGSR).

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

In spite of its potential, this reaction requires inorganic catalysts working at high temperature and pressure, with low specificity, which hinder its sustainability. As often happens in recent years, nature offers an alternative solution. Carbon monoxide dehydrogenase (CODH), an enzyme able to catalyze the oxidation of CO to CO_2, can be coupled with [NiFe]-hydrogenase to perform the biological WGSR[1].



In order to efficiently use micro-organisms, it is fundamental to deeply understand how this process occurs. Our goal is to optimize the large-scale production of fully active CODH in the easy-to-grow bacterium, *Escherichia coli.*

Here we present a novel method for the production and purification of *Rhodospirillum rubrum* CODH in *E. coli*, as well as its biochemical, spectroscopical and electrochemical characterisation. The recombinant enzyme purified with a good yield shows an efficient CO oxidation activity. Moreover, the enzyme was successfully immobilized on carbon nanotubes and we observed for the first time a the direct electron transfer. The further step will be the in vitro or in vivo coupling of the recombinant *Rr*CODH with a [NiFe]-hydrogenase to optimize the efficiency of the biological WGSR.

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[1] Alfano and Cavazza, *Sustainable Energy & Fuels,* **2018**, *2*, 1653-1670.

Reactivity Studies on a Novel Structural Model Complex for the Rabbit-Lipoxygenase

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Lipoxygenases belong to the class of oxidoreductases and are found in both plants and animals.[1] They catalyse the hydroperoxidation of unsaturated fatty acids with oxygen. More accurately they stereo- and regioselectively oxidise (*Z*,*Z*)-1,4-pentadiene units (linoleic acid / arachidonic acid).[2] The active component was found to be a ferric hydroxide species. Here we report the first examples of model complexes for the active site of the rabbit lipoxygenase in both oxidation states that mimic both structural and functional properties of the enzyme.[3],[4],[5] Both the ferric and the ferrous complexes involved in the proposed radical mechanism were synthesised with the tetradentate macrocyclic ligand *N*,*N*'-di-tert-butyl-2,11-diaza[3.3](2,6)-pyridinophane ($LN_4{}^tBu_2$).[6] The octahedral coordination sphere was saturated with a benzoate and a hydroxide ligand in the ferric and an aqua ligand in the ferrous compound, respectively. The H-atom abstraction reactivity of the oxidised model complex is demonstrated. It is proposed to be the initial step in the radical mechanisms of lipoxygenases.[7],[8] The resulting formation of a ferrous complex as well as the reoxidation under aerobic conditions to the active ferric complex can be observed (Fig. 1). Both involved iron complexes can be isolated and characterised structurally and spectroscopically. The novel ferric complex is a rare example of a mononuclear ferric hydroxide complex.[9]

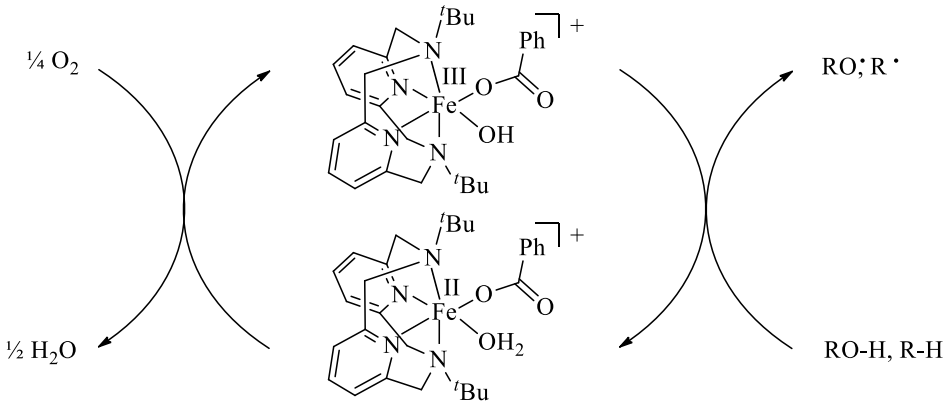

Fig. 1. Proposed cycle for the oxidation catalysis of the model complex

Quantitative EPR studies show the complete conversion of TEMPOH under anaerobic conditions to the TEMPO$^{\cdot}$-radical. Accordingly the formation of the ferrous complex is observed by ESI-MS. The reaction with 2,4,6-tri-*tert*-butylphenol (TTBP) under aerobic conditions reveals catalytic peroxidation. Both reactions are in accordance with an initial H-abstraction from an O-H bond. Moreover, significant amounts of anthraquinone can be obtained in a reaction of the ferric complex with 9,10-Dihydroanthracene under aerobic conditions, demonstrating initial H-abstraction from a C-H bond. Further studies on the mechanism of this functional model with a very close resemblance to the active site in the rabbit lipoxygenase will allow deeper insights into the enzymatic catalysis.

1. SIB ExPASy Bioinformatics Resource Portal https://prosite.expasy.org/PDOC00077, last checked 17:20, 10.01.2020.
2. A. Andreou, I. Feussner, *Phytochemistry*, **2009**, 70, 1504-1510.
3. J. J. M. C. De Groot *et al*., *FEBS Letters*, **1975**, 56 (1), 50-54.
4. S. A. Gilmor *et al*, *Nat*. *Struct*. *Mol*. *Biol*., **1997,** 4, 1003-1009.
5. R. T. Jonas, T. D. P. Stack, *J*. *Am*. *Chem*. *Soc*., **1997**, 119, 8566-8567.
6. Seiji Ogo *et al*., *Angew*. *Chem*., **1998**, 110 (15), 2198-2200.
7. C. R. Goldsmith, R. T. Jonas, T. D. P. Stack, *J*. *Am*. *Chem*. *Soc*., **2002**, 124 (1), 83-96.
8. M. J. Schilstra, G. A. Veldink, J. F. G. Vliegenthart, *Biochemistry*, **1994**, 33, 3974-3979.
9. L. Bénisvy *et al*., *Inorg*. *Chem*., **2006**, 45 (6), 2403-2405.

Built-in safety lock in FeFe hydrogenase: a flexible cysteine ligand protects the active site from oxygen attack

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FeFe Hydrogenase - known as very efficient catalysts for the reversible formation of hydrogen from protons - are quickly destroyed in presence of oxygen. In their active site, these enzymes bear a specific dinuclear iron cluster mainly coordinated by CO and CN ligands. Small ligands such as hydrogen bind to a free coordination site on one of the irons. In this case gas fixation enables catalysis, whereas O_2 coordination leads to ROS formation and enzyme destruction[1].

Recently, it has been proposed that blocking the free coordination site by a divalent sulfide anion makes the enzyme oxygen-resistant while being in an inactive state[2]. In fact, the operating enzyme can repeatedly switch to such a state (called Hinact) upon oxidation in presence of sulfide and back by reduction[2]. Contesting the idea of a sulfide protection, Hinact is also formed in the absence of sulfide in the hydrogenase from the organism *Clostridium beijerinckii* (Hyd_*Cb*)[3].

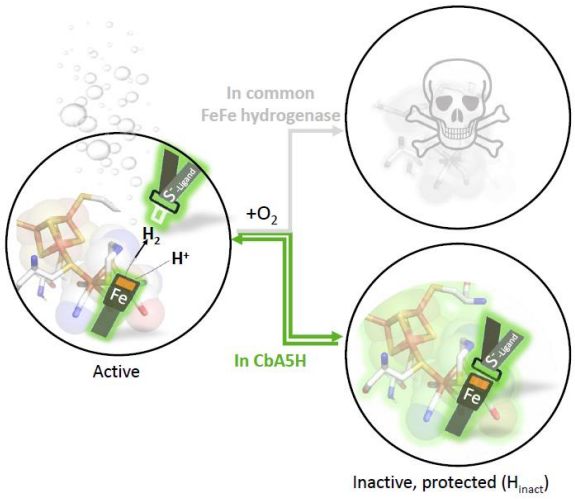

Figure 1: commonly observed aerobic destruction of FeFe hydrogenases and the built-in safety lock discovered in the hydrogenase from *Clostridium beijerinckii (CbA5H)*.

We show using XR crystallography that Hyd_*Cb* is protected by an intrinsic source of coordinating sulfide: the thiolate group of Cystein[367]. This residue is conserved in all FeFe hydrogenases but is normally fixed in a position too far away for a protective coordination to the iron site. In Hyd_*Cb*, the flexibility of the loop bearing Cys[367] allows the sulfide ligand to approach to the active site and bind under oxidative conditions. We demonstrate using direct electrochemistry and site-directed mutagenesis that this flexibility is determined by the size of amino-acids far from the active site interacting with the loop of Cys[367]. Thus, long range effects in the protein scaffold control the active site coordination chemistry.

1. C. Léger *et al*., Nature Chemistry, **2017**, *9*, 88-95.
2. W. Lubitz *et al.,* JACS, **2018**, *140*, 9346–9350.
3. S. Morra, M. Arizzi, F. Valetti, G. Gilardi, Biochemistry, **2016**, *55*, 5897−5900.

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Iron(III)-chelating model peptides as bioinspired antioxidants

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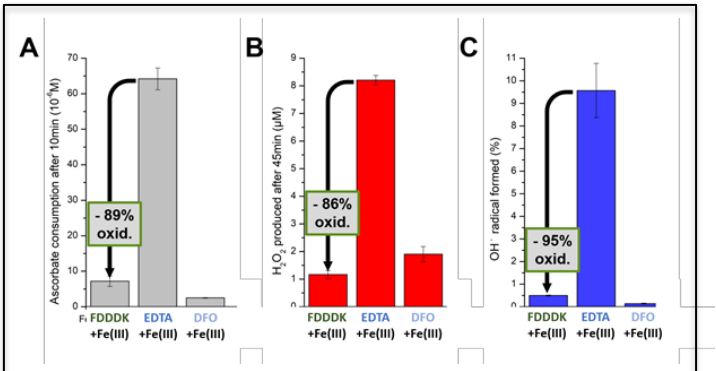
Metal ions are naturally occurring in living organisms and play a key role in many physiological processes, including photosynthesis, respiration, metabolism, transmission of nervous influx, and even protection against pathogenic agents. Proteins provide the most frequent binding sites for metal ions and such interactions play pivotal roles in metalloenzymes, for instance. Concomitantly, iron is essential for the respiratory chain as a key component of both haemoglobin and myoglobin.

Redox active transition metal ions (such as Fe and Cu) may be in their free states and cause significant cell damages, particularly *via* the formation of free radicals called reactive oxygen species (or ROS). The ROS include the superoxide anion radical $O_2^{\bullet -}$ and hydroxyl radical $OH^{\bullet}$ and lead to oxidative stress playing an important role in the development of several pathologies such as cardiovascular and neurodegenerative diseases or cancers. ROS are produced from the reduction of molecular oxygen O_2 *via* Fenton and Haber-Weiss reactions. In this process, reductions of O_2 to $O_2^{\bullet -}$ or of H_2O_2 to $OH^{\bullet}$ require a catalyst.

In order to counteract the deleterious effects of ROS *in vivo*, living organisms have developed defense strategies involving enzymes, vitamins or proteins which regulate ROS production. Interestingly, at low concentrations, ROS contribute to the proper functioning of the organism and are needed in many vital processes. However, this biological ability to regulate ROS concentration depends on several factors and can be deficient, mainly due to environmental factors including smoking, food, pollution, stress, etc.[1-3] This context explains why the research and development of innovative antioxidants is focusing intense interests. Our aim is to prevent the ROS formation from the interaction of oxygen with transition metals by sequestering them. Thus, the redox reactions are subsequently jeopardized, decreasing the ROS production. As sequestrating agents, peptide derivatives have been chosen thanks to their indubitable qualities in terms of biocompatibility, biodegradability and high modularity.

Our results highlight the iron(III) chelating ability of different aspartic and glutamic acid containing peptides and antioxidant activity of their iron(III) complexes. Several investigation techniques were used to prove the thermodynamic properties and structures of the iron(III) complexes, such as pH potentiometry, circular dichroism or paramagnetic NMR. We developed three ROS activity tests to measure the antioxidant level, generated in the presence of ascorbic acid. Even if the stability of the iron(III) complexes is moderate relative to the ethylenediaminetetraacetate (EDTA) and desferrioxamine (DFO), these measurements confirm an highly efficient antioxidant activity of two original pentapeptides (FDDDK, FEEEK).[4]



Graph of the results obtained concerning the consumption of ascorbate (**A**), the formation of H_2O_2 (**B**) and $OH^{\bullet}$ (**C**) at physiological pH (pH 7.4).

1. G. Arena, D. La Mendola, G. Pappalardo, I. Sóvágó, E. Rizzarelli, *Coord. Chem. Rev*. **2012**, *256*, 2202–2218.
2. M. Schieber, N. S. Chandel, *Curr. Biol*. **2014**, *24*, R453–R462.
3. ER. Stadtman, BS. Berlett, *Drug. Metab. Rev*. **1998**, *30,* 225–243
4. G. Csire, M.-C. Averlant-Petit, L. Stefan, K. Selmeczi, *submitted*.

Hydrogen evolution reaction with a bioinspired nickel complex: Experimental and theoretical studies

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Facing the 21st century energy challenge, hydrogen production as an alternative fuel by catalytic water splitting is a central theme in the field of renewable energy storage. The main issue remains with its production. While water electrolysis appears as the most efficient way to produce hydrogen, the flexible proton exchange membrane technology requires the use of platinum, a rare and expensive metal with limited stocks.[1] In the search for an economically competitive way of producing dihydrogen with non-noble metal-based catalysts, Nature can guide us and inspiration can be found with the[NiFe] hydrogenases. This family of enzymes is a very attractive example as it is the most abundant hydrogenases among living organisms. Their active sites are composed of two metal ions, iron and nickel, the latter lying in a rare all-sulfur and distorted tetrahedral coordination geometry.[2,3] Many bio-inspired complexes mimicking this active site can be found in literature[4–6] In this context, we have developed a bio-inspired nickel complex bearing an all-sulfur and constrained ligand that resembles the Ni-center of the enzyme active site with its cysteine-thiolate ligands implicated as bases in proton transfer reactions.[7]

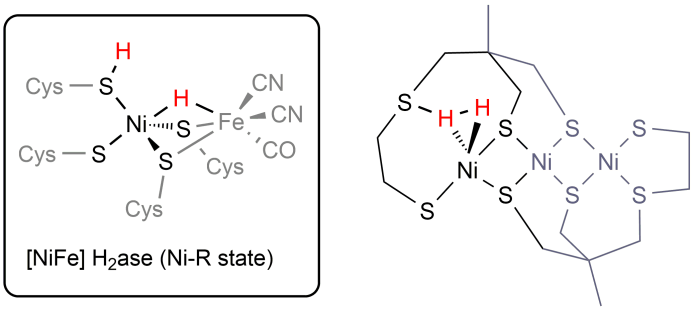

Figure 1. Active site (left) and bio-inspired model (right) of the [Ni-Fe] hydrogenase hydrogenase

1. J. R. McKone, S. C. Marinescu, B. S. Brunschwig, J. R. Winkler andH. B. Gray, *Chem. Sci*., **2014**, *5*, 865.
2. A. Volbeda, M.-H. Charon, C. Piras, E. C. Hatchikian, M. Frey, J.-C. Fontecilla-Camps, *Nature*, **1995**, *373*, 580.
3. W. Lubitz, H. Ogata, O. Rudiger and E. Reijerse, *Chem. Rev*., **2014**, *114*, 4081.
4. T. B. Rauchfuss *Acc. Chem. Res*., **2015**, *48*, 2107.
5. M. Y. Darensbourg, E. J. Lyon and J. J. Smee, *Coord. Chem. Rev*., **2000**, *206*, 533.
6. D. Brazzolotto, M. Gennari, N. Queyriaux, T. R. Simmons, J. Pecaut, S. Demeshko, F. Meyer, M. Orio, V. Artero, C. Duboc *Nat. Chem*., **2016**, *8*, 1054.
7. C. Pieri, A. Bhattacharjee, A. Barrozo, B. Faure, M. Giorgi, J. Fize, M. Réglier, M. Field, M. Orio, V. Artero, R. Hardré *Chem. Comm*., **2020**, DOI: 10.1039/d0cc04174b.

Poster's list - Tuesday

Novel Bispidine-based Mn(II) complexes for PET/MR Imaging

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In MRI, gadolinium-based contrast agents (Gd^{3+}) represent millions of injections worldwide annually for clinical imaging practice. However, for a few years, they have been the subject of a public health concern[1], mainly due to the potential release of the metal in vivo. Gd^{3+} has almost the same ionic radius as the calcium which is vital; hence the interest in the design of contrast agents with good stability and high kinetic inertness. The alternative to other metal complexes takes shape, and the paramagnetic manganese (Mn^{2+}) complexes are particularly interesting, because manganese is biogenic so it is obvious that the stability criteria for its use as contrast agents can be considered as less strict[2]. However, manganese must still be complexed in a stable and inert manner, which is a challenge in coordination chemistry.

Moreover, the isotope $^{52}Mn^{2+}$ enables the radiolabeling for applications in positron emission tomography (PET), yielding potential bimodal MRI/PET probes.

In this context, we are exploring ligands derived from bispidine (3,7-diazobicyclo [3.3.1] nonane), which represent a pre-organized and rigid structure offering various modes of coordination[3], fig 1.

We will present the evaluation of the thermodynamic stability, kinetic inertness and relaxation properties of a bispidine-based Mn^{2+} complex (Mn**L1**). Mn**L1** is a promising candidate for imaging: it is stable (pMn= 9.24, at c_{lig} = 10 mM and c_{Mn} = 1 mM; pH 7.4; 25 °C), has exceptional kinetic inertness and a relaxivity of 4.23 and 6.13 $mM^{-1}s^{-1}$ in water and human serum (25°C at 60 MHz), respectively.

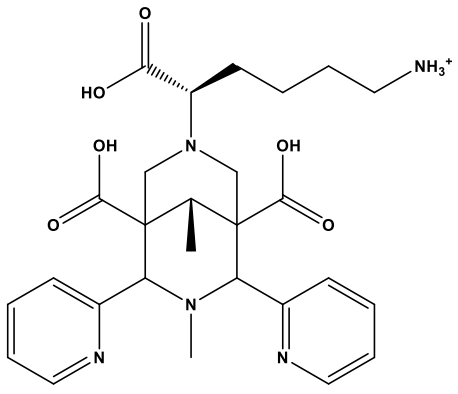

Figure 1: Schematic representation of the ligand **L1** studied.

1. a) Grobner, T. *Nephrology Dialysis Transplantation* 2006, *21*, 1104; b) Kanal, E. ; Tweedle, M.F. *Radiology* **2015**, *275*, 630.
2. Bohuslav Drahos, Vojtech Kubicek, Célia S.Bonnet, Petr Hermann, Ivan Lukes and Eva Toth, *Dalton trans*., **2011**, *40*, 1945-1951.
3. Roux, A; Nonat, A.M.; Brandel, J.; Hubscher-Bruder, V.; Charbonniere, L.J. *Inorganic Chemistry* **2015**, *54*, 4431.

Gold (III) porphyrins with antiretroviral activities

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G-quadruplexes are four-stranded nucleic acid structures that form in guanine-rich regions. Four guanines interact through Hoogsteen hydrogen bonds and form G-quartets that further undergo π-stacking interaction between each other creating the four-stranded nucleic acid. G-quadruplexes are involved in fundamental processes of life (transcription, translation, telomere maintenance …). These peculiar structures, as relevant pharmacological targets, can be targeted by synthetic molecules.
The presence of G-quadruplex structures in the genome of some viruses such as HIV-1, papillomavirus, Epstein-Barr virus, Ebola, Marburg, was recently evidenced (1,2). In the case of HIV-1 the G-quadruplex structures locate in crucial regions for the viral cycle (initiation of reverse transcription, promoter regulation) (3,4). We showed previously that G-quadruplex ligands based on metalloporphyrins inhibit HIV-1 infection *in vitro*. The compounds have IC_{50} values similar to that of AZT, the reference compound, and do not show any cytotoxicity toward the host cells (5).

We report the preparation of functionalized derivatives of the most active gold porphyrin (6) with a biotin moiety. The resulting hybrid molecule will allow the study of the mechanism of action of this G-quadruplex ligand inside HIV-1 infected cells.

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1. M. Métifiot, S. Amrane, S. Litvak, M.-L. Andreola, *Nucleic Acids Res*. 2014, 42, 12352
2. E. Ruggiero, S. N. Richter *Nucleic Acids Res*. 2018, 46, 3270
3. R. Perrone, et al., *J. Med. Chem.* 2015, 58, 9639
4. S. Amrane, et al. *J. Am. Chem. Soc*. 2014, 136, 5249
5. S. Amrane, M.-L. Andreola, G. Pratviel, J.-L. Mergny, patent EP 15306737 (2015)
6. A. Pipier et al. *Dalton Trans*. 2019, 48, 6091

The *cis-trans* isomerase of unsaturated fatty acids as a potential new therapeutic target

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The massive and repeated use of antibiotics has led to the emergence of bacteria resistant to these drugs. Antimicrobial resistance is the cause of 25000 deaths per year in Europe and could become the leading cause of death in the world by 2050.[1] Therefore, it is urgent to study specific mechanisms of bacteria resistance that are not yet used for antibiotic strategies in order to envisage solution to multidrug-resistant bacteria.

We focused on the process of production of *trans*-unsaturated fatty acids (UFA) that in *Pseudomonas* strains plays an important role as adaptation response to the increase in temperature, the presence of organic solvents, heavy metals, osmotic stress and the addition of antibiotics by acting on the membrane properties.[2] In these bacteria, the amount of *trans*-UFA raises by the simultaneous decrease of their *cis* form. The advantage of this conversion comes from the steric differences between *cis* and *trans*-UFA. This transformation contributes significantly to cell survival by decreasing membrane fluidity when a rapid response to environmental stress is required.[3] The isomerization reaction is catalysed by a periplasmic *cis-trans* isomerase (Cti) which is expressed moderately in the absence of stress factors (Figure 1a).

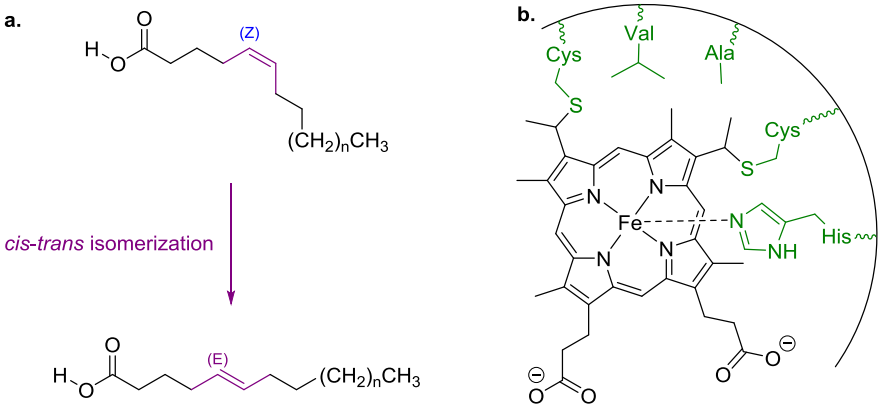

Figure 1: The Cti enzyme: a) Reaction catalyzed by Cti; b) Cytochrome-c type heme

Cti is a monomeric protein of 766 amino acids, corresponding to a molecular weight of 86.9 kDa. The enzyme contains the CXXCH motif responsible of the covalently attachment of a heme nucleus (cytochrome-c type) to the protein *via* two thioether bonds formed between each vinyl group of the heme and a sulfur atom of each two cysteine residue of the motif (Figure 1b).[4] The formation of *trans*-UFA is independent from *de novo* fatty acid biosynthesis, protein synthesis, ATP or any other cofactor.[5]

As the *cis-trans* isomerization of fatty acids is a rapid adaptation mechanism to rigidify the membrane in response to severe environmental conditions where growth is inhibited, it appears as a target for the development of new antibacterial strategies. In this context, we will show the first results of the investigation on the catalytic mechanism of this enzyme.

1. Cassini, A.; Plachouras, D.; Monnet, D. L. *The Lancet Infectious Diseases* **2019**, *19*, *129*.
2. Eberlein, C.; Baumgarten, T.; Starke, S.; Heipieper, H. J. *Applied Microbiology and Biotechnology* **2018**, *102*, 2583.
3. Zhang, Y. M.; Rock, C. O. *Nature reviews. Microbiology* **2008**, *6*, 222.
4. Holtwick, R.; Keweloh, H.; Meinhardt, F. *Applied Environmental Microbiology* **1999**, *65*, 2644.
5. von Wallbrunn, A.; Richnow, H. H.; Neumann, G.; Meinhardt, F.; Heipieper, H. J. *Journal of Bacteriology* **2003**, *185*, 1730.

Biophysical studies of the NO-synthase family in diatoms

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The NO synthase (NOS) family belongs to the hemothiolate protein family. The NOS catalyzes the synthesis of nitric oxide (NO) in two steps using L-Arginine. NO has multiple physiological roles: it is both a cytotoxic weapon (involved in oxidative stress) but also a vital cellular messenger. The first NOS that have been studied are those of mammals then of some bacteria. Thanks to the development of genome sequencing, this family of enzyme has been identified throughout the living kingdom. All NOS are composed of an oxygenase domain with a catalytic heme and a biopterin cofactor. Some NOSs have a reductase domain with binding sites for FMN, FAD and NAD. Only recently, the first NOS from the plant kingdom was expressed and characterized by biophysical methods.[1] This has sparked a renewed interest in the role of these enzymes and of NO in photosynthetic organisms. Last year, a NOS from the cyanobacterium *Synechococcus* PCC7335 was reported.[2,3] This NOS features a new additional globin domain.

In our lab, we are aiming at studying the NOS from a particular family of microalgae: diatoms. Diatoms are essential photosynthetic microorganisms as they are at the base of the marine ecosystem, participating in 20% of the biomass production[4]. The phylogenetic tree of NOSs from diatoms splits into two clades encompassing previously studied NOSs. We have chosen two models, one in each clade, *Conticribra* (formerly *Thalassiosira*) *weissflogii* (with oxygenase and reductase domains) and *Odontella sinensis* (with an additional globin domain). We will present preliminary results mainly focused on the heterologous expression of these proteins.

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1. Weisslocker-Schaetzel, M., André, F., Touazi, N., Foresi, N., Lembrouk, M., Dorlet, P., … Santolini, J. (2017). The NOS-like protein from the microalgae Ostreococcus tauri is a genuine and ultrafast NO-producing enzyme. *Plant Science* **265**, 100-111.
2. Picciano, A. L., & Crane, B. R. (2019). A nitric oxide synthase–like protein from Synechococcus produces NO/NO3− from l-arginine and NAPDH in a tetrahydrobiopterin- and Ca2+-dependent manner. *Journal of Biological Chemistry* **294**, 10708-10719.
3. Correa-Aragunde, N., Foresi, N., Del Castello, F., & Lamattina, L. (2018). A singular nitric oxide synthase with a globin domain found in Synechococcus PCC 7335 mobilizes N from arginine to nitrate. *Scientific Reports* **8**, 12505.
4. Prioretti, L., Avilan, L., Carrière, F., Montané, M.-H., Field, B., Grégori, G., … Gontero, B. (2017). The inhibition of TOR in the model diatom *Phaeodactylum tricornutum* promotes a get-fat growth regime. *Algal Research* **26**, 265-274.

Constrained oligonucleotides-based Catalysts

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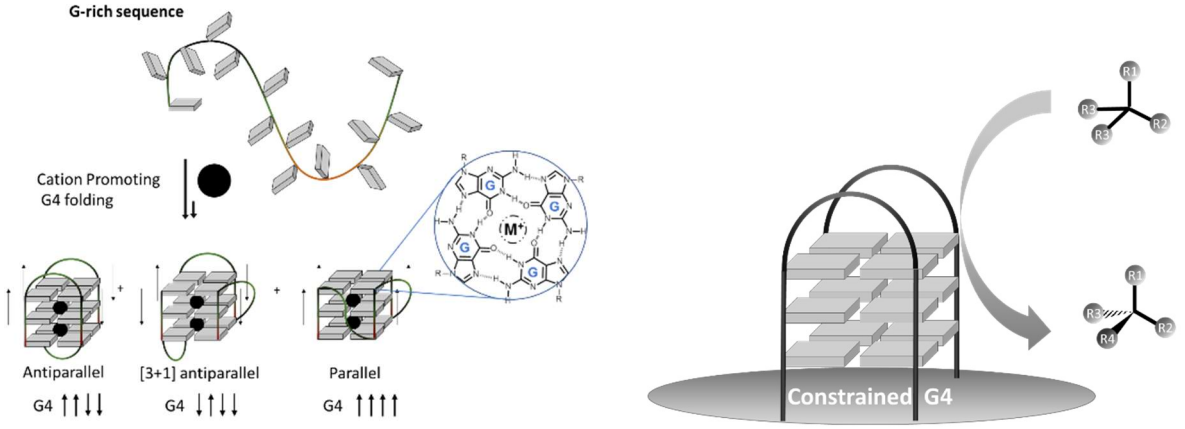
Replacement of stoichiometric reagents for synthetic reactions with catalytic routes is one of the most efficient methods to develop greener, safer, and more cost-effective chemical processes. One of the most promising strategies is the use of natural or engineered enzymes as catalysts as they show remarkable enantio- and regioselectivities and eco-friendly experimental conditions.[1] However, their use still suffers from limitations especially because of their irreversible denaturation and/or inefficiency when exposed to harsh experimental conditions (organic cosolvents, temperature, etc.). In this context G-quadruplex (G4s) have recently attracted a great interest for catalysis owing to their chemical robustness and well-defined small-molecule binding sites. However, the catalytic efficiency and enantiomeric excess (e.e.) of G4-promoted asymmetric transformation depend on the major topology adopted by the G4, i.e. the spatial organization of the four strands.[2]

Our project is based on the topological freezing of G4-forming oligonucleotides on a macrocyclopeptidic template RAFT (for Regioselectively Addressable Functionalized Template). Indeed, it has been demonstrated that it prevents the interconversion and dramatically increases the stability against temperature and denaturing conditions (organic cosolvents, pure water without cations)[3,4] making them good candidates as chiral auxiliaries for asymmetric transformations in combination with metal complexes. Here we report the synthesis of these structures, the tuning of the catalysts and the results obtained so far.



1. B. M. Nestl, S. C. Hammer, B. A. Nebel, B. Hauer, Angew. Chem. Int. Ed. 2014, 53, 3070
2. S. Burge, G. N. Parkinson, P. Hazel, A. K. Todd, S. Neidle, Nucleic Acids Res. 2006, 34, 5402
3. P. Murat, D. Cressend, N. Spinelli, A. Van der Heyden, P. Labbe, P. Dumy, E. Defrancq,ChemBioChem 2008, 9, 2588
4. R. Bonnet, T. Lavergne, B. Gennaro, N. Spinelli, E. Defrancq, Chem. Commun. 2015, 51, 4850

The pH dependent biogenesis and function of N_2O reductase

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The bacterial nitrous oxide reductase (N_2OR) is the only known biological sink for N_2O greenhouse gas. This multi-copper enzyme reduces N_2O to inert N_2, which is the final product of denitrification chain and the main constituent of the atmosphere. The function of N_2OR is strongly controlled by oxygen tension and other environmental factors. The acidity of environment seems to be a critical factor for the biogenesis of functional N_2OR, as soils of low pH are known to release larger amounts of N_2O than neutral soils. This is a general notion emerging from decades of field studies. The problem became global since, in addition to naturally acidic soils, many soils are acidified due to excessive fertilization. Laboratory studies of the denitrifying model bacteria *Paracoccus denitrificans* and *Pseudomonas stutzeri*, and of complex bacterial communities extracted from soil, showed that the organisms were unable to make functional N_2OR under acidic conditions (pH lower than 6), although the N_2OR was not only synthesized at acidic pH, but also transported to the periplasm. If the organisms were instead allowed to synthesize the protein at neutral pH[1] they readily reduced N_2O at acidic pH, albeit at a lower rate. A retarded and weak N_2O reduction also occurred in denitrifying cultures grown at acidic pH, when cells could form aggregates or the buffering system used, was not sufficient, thus either locally at microsites inside the aggregates or generally, bacteria were able to raise the pH while reducing nitrite. Our working hypothesis to explain the lack of N_2O reduction in bacteria growing at acidic pH conditions is that the copper maturation of the N_2OR apoprotein is affected by H^+ ions after its transport to the periplasm. Our previous results from pure cultures and complex soil communities suggested that this is a general mechanism for all bacteria. We were therefore surprised when we recently isolated an organism belonging to the genus *Rhodanobacter*, which effectively reduces N_2O at acidic pH but is completely unable to do so when grown at neutral pH conditions[2], despite the presence of N_2OR protein, as shown by proteomic analysis. The N_2ORs of *Rhodanobacter denitrificans* and *P. denitrificans* are similar, yet completely opposite in respect to activity at tested pHs. Our latest results from ongoing experiments will be presented, including finetuned phenotypic and proteomics analyses of *Rhodanobacter* cultures grown at different pH. We believe that our studies of an organism that contrasts with the general phenomenon of impaired N_2OR activity at low pH, will advance our understanding of N_2OR biogenesis and, in a longer perspective, provide knowledge that will be useful in the search for novel ideas for N_2O mitigation.

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[1] L. Bergaust et al., "Denitrification Response Patterns During the Transition to Anoxic Respiration and Posttranscriptional Effects of Suboptimal pH on Nitrous Oxide Reductase in Paracoccus Denitrificans (Vol 76, Pg 6387, 2010)," *Applied and Environmental Microbiology* 76, no. 24 (2010).

[2] P. Lycus et al., "Phenotypic and Genotypic Richness of Denitrifiers Revealed by a Novel Isolation Strategy," *ISME J* (2017).

Synthesis and activity studies of a series of half-sandwich anticancer iridium complexes

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Increasing interest is currently focused on half-sandwich complexes of iridium (III) as some of them display promising cytotoxic properties in vitro, making them potential anticancer drugs [1]. However, their mechanism of action is still poorly understood at the molecular level [2].

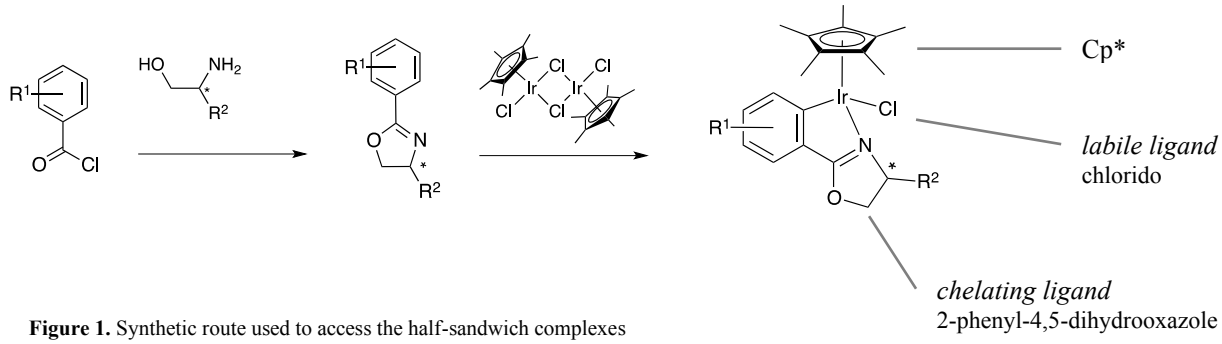

Figure 1. Synthetic route used to access the half-sandwich complexes

A panel of ten new complexes of the general structure presented above has been prepared. Viability assays on the HeLa cervical cancer cell line demonstrated that some of these complexes were very cytotoxic with IC_{50} values in the micromolar range. A large body of data regarding biological and morphological changes in treated HeLa cells was gathered, suggesting that their anticancer mechanism of action differs from that of the metal-based chemotherapies in current use.

The ability of half-sandwich Iridium complexes to accept a hydride from NADH in physiological conditions has been demonstrated triggering a catalytic cycle producing H_2O_2 *in vitro* [3]. This finding has been explored in the context of our study, in which highly sensitive and original H_2O_2 quantification systems were used to compare the behavior of the complexes in aqueous buffer [4] and *in cellulo* [5].

1. Liu, Z.; Habtemariam, A.; Pizarro, A.; Clarkson, G.; Sadler, P. J. *Organometallics,* **2011**, *30*, 4702−4710.
2. Hearn, J. M.; Hughes, G. M.; Romero-Canelón, I.; Munro, A. F.; Rubio-Ruiz, B.; Liu, Z.; Carragher, N. O.; Sadler, P. J. *Metallomics* **2018**, *10* (1), 93– 107.
3. Liu, Z.; Romero-Canelón, I.; Qamar, B.; Hearn, J. M.; Habtemariam, A.; Barry, N. P. E.; Pizarro, A. M.; Clarkson, G. J.; Sadler, P. J. *Angew. Chem. Int. Ed.* **2014**, *53* (15), 3941–3946.
4. Votyakova, T. V.; Reynolds I. J. *Arch. Biochem. Biophys.* **2004**, *281*, 645-650.
5. Bilan, D. S.; Belousov, V. V. *Antioxid. Redox Signal.* **2016**, *24* (13), 731–751.

Artificial enzyme systems – about functional tyrosinase model complexes

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In modern bioinorganic chemistry it is of high interest to mimic active centers of metalloenzymes to profit from the advantages of natural enzyme systems in an artificial context.

Tyrosinase is a ubiquitous enzyme which catalyzes both the ortho hydroxylation of tyrosine to L-DOPA as well as the oxidation of L-DOPA to L-dopaquinone. In nature these are two important steps for the biosynthesis of melanine, the brown pigment in hair and skin.[1] The active center of tyrosinase consists of two copper ions, which are each coordinated by three histidine ligands.[2] In the investigated systems bis(pyrazolyl)methane ligands are used to model the histidine ligands.[2] Comprising three *N* donors they feature excellent donor properties towards the copper centers.[3]

Besides the spectroscopic properties, these complexes mimic also the catalytic activity towards phenolic substrates.[3]

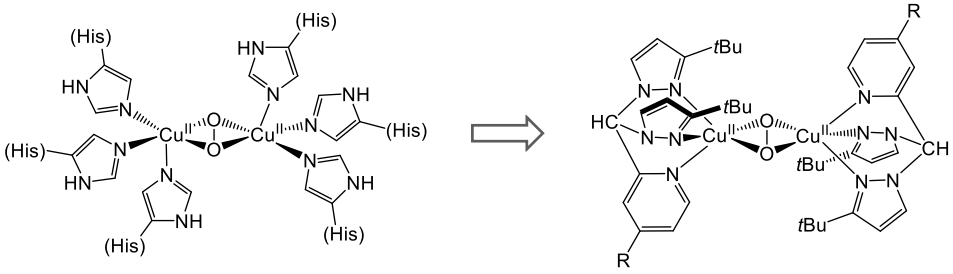

Figure 1. From enzyme to model complex. Left: The active center of natural tyrosinase. Right: This work.

Herein we report maleimide-functionalized (bispyrazolyl)methane as ligand for copper peroxido complexes. Like its natural example the peroxide complex exhibits strong absorption bands which offers the possibility to observe formation and catalytic reactions via UV/Vis spectroscopy. In this study the catalytic activity of these systems was investigated towards artificial substrates as well as for electron transfer processes.

1. Á. Sánchez-Ferrer, J. N. Rodríguez-López, F. García-Cánovas, F. García-Carmona, *Biochim. Biophys. Acta* **1995**, *1247*, 1.
2. Y. Matoba, T. Kumagai, A. Yamamoto, H. Yoshitsu, M. Sugiyama, *J. Biol. Chem.* **2006**, *281*, 8981.
3. a) A. Hoffmann, C. Citek, S. Binder, A. Goos, M. Rübhausen, O. Troeppner, I. Ivanović-Burmazović, E. C. Wasinger, T. D. P. Stack, S. Herres-Pawlis, *Angew. Chem. Int. Ed.* **2013**, *52*, 5398; *Angew. Chem.* **2013**, *125*, 5508. b) C. Wilfer, P. Liebhäuser, A. Hoffmann, H. Erdmann, O. Grossmann, L. Runtsch, E. Paffenholz, R. Schepper, R. Dick, M. Bauer, M. Dürr, I. Ivanović-Burmazović, S. Herres-Pawlis, *Chem. Eur. J.* **2015**, *21*, 17639. c) P. Liebhäuser, K. Keisers, A. Hoffmann, T. Schnappinger, I. Sommer, A. Thoma, C. Wilfer, R. Schoch, K. Stührenberg, M. Bauer, M. Dürr, I. Ivanović-Burmazović, S. Herres-Pawlis, *Chem. Eur. J.* **2017**, *23*, 12171.

GcpE, a potential target for antibacterial drug development

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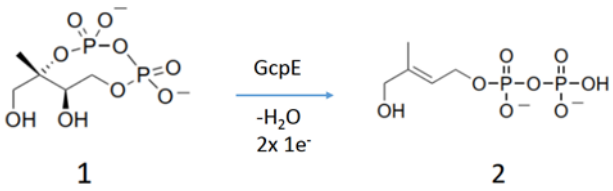
Isoprenoids are essential chemicals for the survival of all organisms as they fulfil a variety of crucial biological functions such as electron transport, membrane stabilisation and signalling.[1] They are all derived from the isopentenyl diphosphate (IPP) and its isomer the dimethylallyl diphosphate (DMAPP). In most bacteria, IPP and DMAPP are synthesised according to the methylerythritol phosphate (MEP) pathway whereas humans utilise the mevalonate pathway to produce isoprenoids.

GcpE (also called IspG) catalyses the penultimate step of the MEP pathway.[2] This metalloenzyme converts 2-C-methyl-D-erythritol 2,4-cyclodiphosphate **1** into (E)-4-hydroxy-3-methylbut-2-enyl diphosphate **2**.[3]



Scheme 1: The reaction catalysed by GcpE

The reaction catalysed by GcpE involves the transfer of two electrons and a water elimination. The active site of GcpE contains an oxygen sensitive [4Fe-4S] cluster linked to the protein by three cysteines and a glutamate.[4,5,6]

Since GcpE is present in many pathogenic bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Salmonella* spp., *Mycobacterium tuberculosis* and *Vibrio cholerae* but not in humans, it is a target for the development of new antibacterial agents to overcome antibacterial resistance.

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(1) Heuston, S.; Begley, M.; Gahan, C. G. M.; Hill, C. *Microbiology* **2012**, *158*, 1389–1401.
(2) Campos, N.; Rodríguez-Concepción, M.; Seemann, M.; Rohmer, M.; Boronat, A. *FEBS Lett.* **2001**, *488*, 170–173.
(3) Seemann, M.; Bui, B. T. S.; Wolff, M.; Tritsch, D.; Campos, N.; Boronat, A.; Marquet, A.; Rohmer, M. *Angew. Chem. Int. Ed.* **2002**, *41*, 4337–4339.
(4) Seemann, M.; Wegner, P.; Schünemann, V.; Bui, B. T. S.; Wolff, M.; Marquet, A.; Trautwein, A. X.; Rohmer, M. *J. Biol. Inorg. Chem.* **2005**, *10*, 131–137.
(5) Rekittke, I.; Nonaka, T.; Wiesner, J.; Demmer, U.; Warkentin, E.; Jomaa, H.; Ermler, U. *FEBS Lett.* **2011**, *585*, 447–451.
(6) Lee, M.; Gräwert, T.; Quitterer, F.; Rohdich, F.; Eppinger, J.; Eisenreich, W.; Bacher, A.; Groll, M. *J. Mol. Biol.* **2010**, *404*, 600–610.

EPR characterization of atypical molybdenum-containing Formate Dehydrogenases

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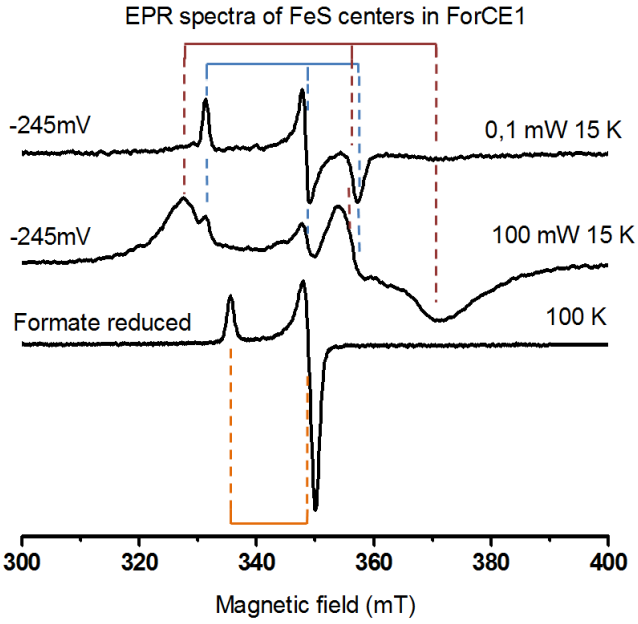
Nowadays one of the biggest environmental challenge is the bioremediation of atmospheric CO_2. Biocatalytic reduction of CO_2 into formate by microbial formate dehydrogenases (FDHs) is very promising [1]. In this work, we present our latest results aimed at characterizing by EPR spectroscopy two similar FDHs, named ForCE1 and ForCE2, from the soil bacterium *Bacillus subtilis*. These enzymes belong to the Mo/W-*bis*PGD (i.e. pyranopterin guanosine dinucleotide) superfamily, previously referred as the DMSOR family, widespread among prokaryotes [2a].

These two FDHs appear to be of great scientific interest for the following reasons. First, sequence analyses reveal that they belong to a still uncharacterized family of FDHs. Secondly, they display a high oxygen tolerance, an auspicious feature for potential biotechnological purposes. Finally, how these enzymes are integrated in the metabolism of this aerobic organism remains to be established, leaving an open door for new biological discoveries.



The catalytic core of ForCE1 and ForCE2 is composed of two subunits. From sequence analysis, the largest one (ForC) is predicted to coordinate four to five iron-sulfur clusters and a Mo-*bis*PGD whereas ForE does not appear to house any cofactor. By combining redox potentiometry and EPR spectroscopy, we were able to characterize the EPR signatures and the redox properties of several paramagnetic cofactors in the purified enzymes. These are clearly assigned to three [4Fe-4S] clusters, one [2Fe-2S] and a Mo(V) species. In addition, an unexpectedly intense radical signal (g = 2.0027) is also detected. Associated to the ForC subunit, its origin remains to be established.

To conclude, two representatives of an uncharacterized FDH subfamily display astonishing properties supporting further EPR and electrochemical investigations.

[1] D. Niks, R. Hille, *Protein Science*, 28, **2019**, 111-122.
[2] a) S. Grimaldi, B. Schoepp-Cothenet, P. Ceccaldi, B. Guigliarelli, A. Magalon; *Biochimica et Biophysica Acta*, 1827, **2013**, 1048-1085. b) L. B. Maia, J. J. G. Moura, I. Moura, *J. Biol. Inorg. Chem.*, **2015**, 20, 287-309. C) S. Grimaldi, F. Biaso, B. Burlat, B. Guigliarelli, *Molybdenum and Tungsten Enzymes, chapter 3, RCS Metallobiology*, Serie N°7, **2017**, 68-120.

The design of a new electrochemical cell for studying highly active metalloenzymes

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Protein Film Electrochemistry is a technique consisting in immobilizing enzymes on a rotating disc electrode in a configuration where the electron transfer is direct, and the enzymatic activity is monitored as an electrical current [fig 1]. This technique has proved extremely useful to study various aspects of the activity of metalloenzymes [1]. Generally, the consumption of the substrate at the surface of the electrode is compensated by a flow of a fresh buffer imposed by the rotation of the electrode. However, this wasn't the case for CO dehydrogenase (CODH), which is an enzyme that catalyzes the reversible reduction of CO_2 into CO following this equation:

$$CO_2 + 2e^- + 2H^+ \leftrightarrows CO + H_2O$$

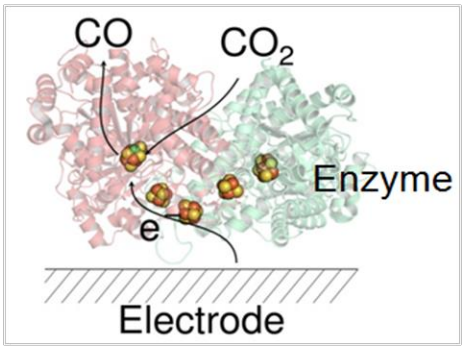

Figure 1 . schematic representation of protein film electrochemistry

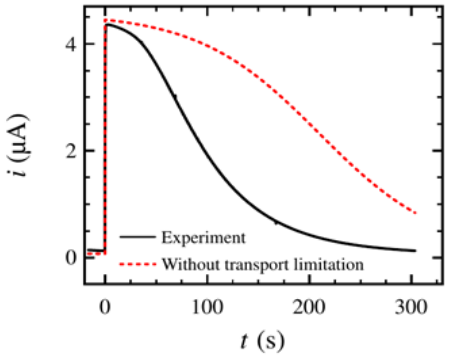

Figure 2 . experiment in which the CODH is exposed to a transient injection of CO

This enzyme is so fast that the catalysis is mostly limited by the transport of the substrate (CO) towards the electrode, and not by the catalyzed chemical reaction, even at a high rotation rate. This limitation hides information about the catalysis in the electrochemical response [2] [fig 2]. As this problem couldn't be overcome by the rotating disc electrode, we chose to design a completely different type of electrochemical cells (called jet flow cell) in which the buffer is pumped towards a static electrode [3].

We screened different jet flow cell geometries by means of numerical simulation. Then, we selected and built one with promising transport properties (a high and homogenous mass transport coefficient, and a low shear stress at the surface of the electrode) [4]. In this work, we optimize the current design by simulation, and we further test the performance of the new setup experimentally by using simple redox couples such as Fe $(CN_6)^{3}$/ Fe $(CN_6)^{3-}$ or adsorbed nitrite reductase which is an enzyme that catalyzes the reduction of nitrite to ammonium. This new cell should provide a much greater flexibility for changing the concentration of the species that the enzyme is exposed to. Therefore, it will be useful for studying other metalloenzymes that don't even require high mass transport.

1. C. Léger, P. Bertrand, Chem. Rev.2008,108,7,2379-2438.
2. M. Merrouch, J. Hadj-Saïd, C. Léger, S. Dementin, V. Fourmond. Electrochimica Acta, 2017, 245, 1059-1064.
3. M. Fadel, J-V. Daurelle, V. Fourmond, J. Vicente, 23ème Congrès Français de Mécanique, 2017.
4. M. Fadel, J-V Daurelle, V.Fourmond, J.Vicente. Phys.Chem.Chem.Phy, 2019, 21, 12360.

Electrochemical detection of environmental contaminants based on Laccase/nanomaterial-based sensor

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The development of biosensors based on redox enzymes has intensified in recent years with the aim to achieve low-cost and easy-to-use sensing devices (1). In this respect, laccases have been employed in biosensors, owing to their enzymatic activity towards oxidation of phenolic compounds (Phs) and polycyclic aromatic hydrocarbons (PAHs). These classes of compounds are ubiquitous in several ecosystems and are considered major environmental pollutants because of their toxicity, potential mutagenicity and carcinogenicity (2). POXA1b laccase enzyme from *Pleurotus ostreatus* displays a high redox potential and is endowed with a remarkable stability at high temperature and at alkaline pH, thus it can be used to detect several aromatic compounds in different matrices (3). Herein two recombinant laccases, POXA1b (Lac) (3) and chimera POXA1bVmh2 (Lac-Vmh2) (4) are exploited to develop novel nanomaterial-based biosensors. These novel biosensing platforms were assembled either by depositing a dispersion a bio-functionalized few layer graphene (FLG) with Lac and Lac-Vmh2 or by modification of Multi-walled carbon nanotube (MWCNT) electrodes by the recombinant enzymes. Then, these bioelectrodes were characterized and used as working electrode to detect contaminants, such as Phs andPAHs (figure 1).

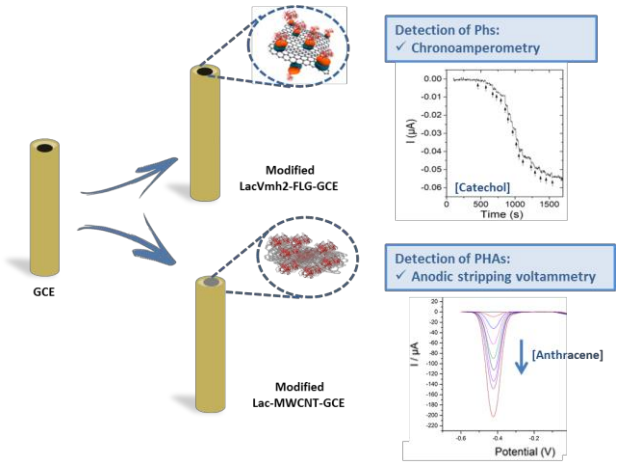

Figure 1. Biosensor Development

Acknowledgements
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1. C. Dincer, *et al*., *Adv*. *Mater*., **2019,***1806739*.
2. K. Fujikawa, *et al*., Mutat Res., **1993**, *290,175*–182
3. C. Pezzella, *et al*., *J*. *jbiotec*., **2017**, *72, 175*–181.
4. I. Sorrentino, *et al*., *Appl Microbiol Biotechnol*., **2019**, *103,3061*–3071

Design and study of anti-oxidant inorganic complexes mimicking the superoxide dismutase (SOD)

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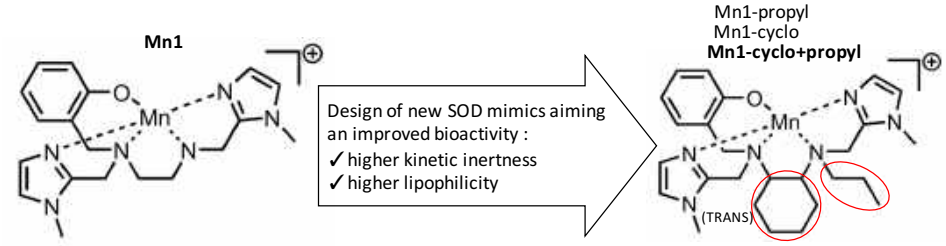
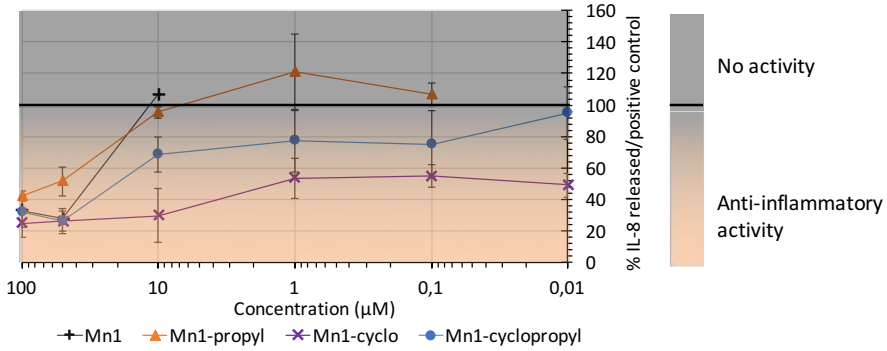
Superoxide Dismutases (SODs) are metalloenzymes involved in the cellular antioxidant defenses. They regulate the concentration of the superoxide anion, a reactive oxygen species (ROS)[1]. It has been shown that SOD defenses are weakened in intestinal epithelial cells of patients suffering from inflammatory bowel diseases (IBDs)[2]. The resulting increase in ROS amount, leading to oxidative stress, may contribute to the pathogenesis in IBDs. Low-molecular weight complexes, mimicking SOD activity may be promising antioxidant metallodrugs for the treatment of IBDs. The research conducted in Policar's group has led to the development of the manganese complex Mn1 that has shown anti-oxidant and anti-inflammatory activities in intestinal LPS-stressed epithelial cells, an inflammation model mediated by oxidative stress[3]. However, Mn1 is very flexible compared to the native SOD and is prone to metal-assisted dissociation in cells. Indeed, metal exchanges might occur between the manganese center and metal ions present in the biological environment. Aiming at improving the bioactivity of this SOD mimic, three new MnSOD mimics derived from Mn1 have been designed. Their structure includes additional cyclohexyl and propyl groups. In one hand, by rigidifying the ligand structure, the cyclohexyl group may provide a compact and preorganized coordination cavity to encapsulate the manganese ion and thus may improve the kinetic inertness of the complexes[4]. In the other hand, the lipophilic propyl group may favor the cell penetration of the complexes and hence enhance their bioavailability.



Anti-inflammatory activity in a cellular model of IBD: release of inflammatory cytokine IL-8



We have assessed the potential of new SOD mimics derived from Mn1 to demonstrate higher intrinsic SOD activity, higher lipophilicity and improved kinetic inertness in the cellular environment. Very interestingly, the new Mn1 derivatives were shown to provide anti-inflammatory effects in intestinal LPS- stressed epithelial cells at lower doses than Mn1 and are hence more efficient SOD mimics.

[1] Sheng Y. et al., *Chemical Reviews* **2014,** 114 (7), 3854–3918
[2] Kruidenier L. et al., *Journal of Pathology*, **2003**, 201, 7-16
[3] Mathieu, E et al., *Inorg. Chem.* **2017,** *56*, 2545-2555
[4] Laine, S. et al., *New Journal of Chemistry.* **2018**, 42 (10)

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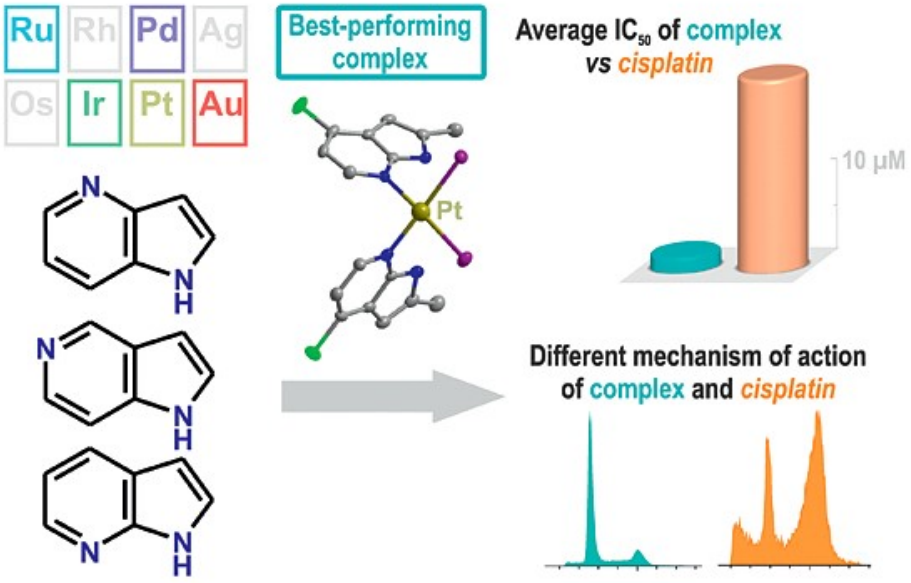

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High Spin (*main room*)

12:00-13:00	**General Assembly of the GIS FrenchBIC** (for members of the GIS network)		
13:00-13:50	**PL.3**	**Policar**	page 65
	Metal complexes in biological environments: a new frontier in inorganic chemistry		
13:50-14:20	**KL.2**	**Ortega**	page 66
	Interaction of copper and zinc with neuronal dendritic cytoskeletal proteins revealed by correlative synchrotron nano-XRF and STED super resolution microscopy		
14:20-14:50	**KL.3**	**Ilbert**	page 67
	Impact of copper stress on a redox-regulated molecular chaperone Hsp33 in *Escherichia coli*		
14:50-15:20	*Coffee break — Q&A*		
15:20-15:50	**KL.4**	**Dorlet**	page 68
	Binding of copper to the novel protein CopI from Cu resistant photosynthetic purple bacteria		
15:50-16:20	**KL.5**	**Michaud-Soret**	page 69
	Silver nanoparticles fate and safer-by-design biocide made of tri-thiol bridged silver nanoparticle assemblies		
16:20-16:50	**KL.6**	**Sorokin**	page 70
	Mono- and binuclear iron phthalocyanine-like complexes: from bio-inspired oxidation to carbene transfer reactions		
16:50-17:20	**KL.7**	**Hess**	page 71
	Earth-abundant mono- and bi-metallic Mabiq complexes for photocatalysis		
17:20-17:50	*Coffee break — Q&A*		
17:50-18:00	**Closing Remarks for FrenchBIC 2020**		

Metal complexes in biological environments: a new frontier in inorganic chemistry

Focuses on Mn-SOD mimics: design from bio-inspiration to combinatorial approach, and evaluation in cells.

Clotilde Policar
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and collaborators (quoted in the references below)

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Superoxide dismutases are redox metalloproteins that protect the cell against oxidative stress. These enzymes are highly efficient in catalysing the dismutation of superoxide, with several physico-chemical parameters that have been carved by evolution.[1] What are the main parameters for this optimized activity and how they can be mimicked in low-molecular weight complexes meant to be used as anti-oxidants? To be active in cells, these antioxidants must reach their target and cellular assays are key to characterize their bio-activity.[2,3,4,5]
In this talk, we will present a range of SOD mimics, Mn-complexes bio-inspired from SOD and with cellular evaluation, associated with imaging in cells,[2,3,4] and two generations of peptide-based Cu-complexes (de novo Cu-complex[6] and issued from a combinatorial approach[5]).

References:

1-Policar C., "Mimicking SODs, Why and How: Bio-Inspired Manganese Complexes as SOD Mimics" in: Reboucas J. S., Batinic-Haberle I., Spasojevic I., Warner D. S., St. Clair D., Redox Active Therapeutics, Mimicking SODs, Why and How: Bio-Inspired Manganese Complexes as SOD Mimics, Springer, Switzerland, 2016, pp. 125-164 doi: http://dx.doi.org/10.1021/acs.inorgchem.6b02695

2-Mathieu E., Bernard A.-S., Delsuc N., Quévrain E., Gazzah G., Lai B., Chain F., Langella P., Bachelet M., Masliah J., Seksik P., Policar C., "A cell-penetrant manganese superoxide dismutase (MnSOD) mimic is able to complement MnSOD and exerts an antiinflamatory effect on cellular and animal models of inflammatory bowel diseases", Inorg. Chem. 56 (2017) 2545-255

3-Mathieu, E.; Bernard, A.-S. ; Ching V.H-.Y. ; Somogyi, A. ; Medjoubi, K. ; Rodon-Fores, J. ; Bertrand, H. C. Vincent, A. ; Trépout, S. ; Guercquin-Kern, J.-L. ; Scheitler, A. ; Ivanovic-Burmazovic, I. ; Seksik, P. ; Delsuc, N. ; Policar, C., *Dalton trans,* 2020, 2323-2330, doi: 10.1039/c9dt04619d
doi: http://dx.doi.org/10.1021/acs.inorgchem.6b0269

4- Mathieu, E.; Bernard, A.-S.; Quévrain, E.; Zoumpoulaki, M.; Iriart, S.; Lung-Soong, C.; Lai, B.; Medjoubi, K.; Henry, L.; Nagarajan, S.; Poyer, F.; Scheitler, A.; Ivanović-Burmazović, I.; Marco, S.; Somogyi, A.; Seksik, P.; Delsuc, N.; Policar, C. Intracellular Location Matters: Rationalization of the Anti-Inflammatory Activity of a Manganese(Ii) Superoxide Dismutase Mimic Complex. *Chem. Commun.* **2020**, *56* (57), 7885–7888. https://doi.org/10.1039/D0CC03398G.

5-Vincent, A. ; Rodon-Fores, J. ; Tauziet, E. ; Quévrain, E. ; Dancs, A. ; Conte-Daban, A. ; Bernard, A.-S, Pelupessy, P. ; Coulibaly, K. ; Seksik, P. ; Hureau, C. ; Selmeczi, K. ; Policar, C. ; Delsuc, N. ; Chem. Commun., 2020, 56, 399-402, IF(2018-19) 6.164, doi : 10.1039/C9CC07920C

6-Mathieu, E.; Tolbert, A.; Koebke, K.J.; Tard, C.; Iranzo, O.; Penner-Hahn, J.E.; Policar, C., and Pecoraro, V. *Chem. Eur. J.,* 2020, 26, 249-258, IF(2018-19) 5.16, https://doi.org/10.1002/chem.201903808

Interaction of copper and zinc with neuronal dendritic cytoskeletal proteins revealed by correlative synchrotron nano-XRF and STED super resolution microscopy

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Zinc and copper are involved in neuronal differentiation and synaptic plasticity but the molecular mechanisms behind these processes are still elusive due in part to the difficulty of imaging trace metals at the synapse level [1]. We have previously reported a correlative microscopy approach consisting in labeling organelles or proteins with specific fluorophores for live-cell imaging prior to synchrotron X-ray fluorescence (SXRF) imaging [2]. This correlative approach was limited by the spatial resolution of optical fluorescence microscopy, above 200 nm, which is larger than the spatial resolution achieved today with nano-SXRF and insufficient to resolve synaptic sub-structures. To overcome this limitation we present a method to correlate nano-SXRF with STED (STimulated Emission Depletion microscopy) performed both at 40 nm resolution [3]. We correlate STED microscopy of cytoskeleton proteins and SXRF imaging of trace metals on primary rat hippocampal neurons. We achieve a detection limit for trace metals in the zeptogram level per pixel using ID16A beamline at ESRF. We reveal the co-localization at the nanoscale of zinc and tubulin in dendrites with a molecular ratio of about one zinc atom per tubulin-αβ dimer. We observe the co-segregation of copper and F-actin within the nano-architecture of dendritic spines. Overall, the combination of STED super-resolution microscopy and SXRF nano-imaging indicates new functions for zinc and copper in the regulation of the synaptic cytoskeleton, a mechanism involved in memory formation [3].

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1. Perrin L.; Roudeau S.; Carmona A.; Domart F.; Petersen J.D.; Bohic S.; Yang Y.; Cloetens P.; Ortega R. *ACS Chem. Neurosci*. **2017**, *8*, 1490-1499.
2. Roudeau S.; Carmona A.; Perrin L.; Ortega R. *Anal. Bioanal. Chem.* **2014,** *406*, 6979–6991.
3. Domart F.; Cloetens P.; Roudeau S.; Carmona A.; Verdier E.; Choquet D. ; Ortega R. *BioRxiv* **2019**, 810754.

Impact of copper stress on a redox-regulated molecular chaperone Hsp33 in *Escherichia coli*.

Lisa Zuily, Nora Larach, Olivier Seneque, Olivier Genest, Peter Faller, Ursula Jakob, Marie-Thérèse Giudici-Orticoni and Marianne Ilbert*

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In the cellular environment, protein homeostasis is maintained by a highly dynamic network of molecular chaperones. While their activity and substrate specificity has been extensively studied under a variety of stress conditions, little is known about how chaperones protect proteins during copper stress. Copper is known to generate reactive oxygen species (ROS) via the Fenton reaction, it can also induce protein unfolding. In this study, we focus on the role of the redox-regulated molecular chaperone Hsp33, from *Escherichia coli*, in protecting proteins against copper-induced unfolding. Hsp33 has been shown to sense and respond to protein aggregation triggered by oxidative heat stress[(2)] using a sophisticated mechanism: with a C-terminal redox switch domain and an adjacent metastable linker region[(3)]. Here, we show that even under anaerobic conditions and non-stress temperature, copper converts Hsp33 into a highly active chaperone holdase, thus serving as a potent physiological activator of Hsp33. Once activated, Hsp33 effectively prevents copper-induced protein aggregation. These results provide first insights into the role of molecular chaperones during copper stress, and demonstrate how stress-activated chaperones regulate their conversion into effective molecular chaperones.

References

[2] W. Voth, U. Jakob, Stress-Activated Chaperones. A first line of Defense. **2017,** Trends Biochem Sci. Nove, *42(11)*:899-913.

[3] M. Ilbert, J. Horst, S. Ahrens, J. Winter, P.C. Graf, H. Lilie, U. Jakob. The redox-switch domain of Hsp33 functions as dual stress sensor. **2007,** Nat. Struct. Mol. Biol. *Jun;14(6):*556-63

Binding of copper to the novel protein CopI from Cu-resistant photosynthetic purple bacteria

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CopI is a novel periplasmic protein of 15 kDa, recently discovered while investigating the copper tolerance in the environmental bacterium *Rubrivivax gelatinosus*[1]. It is also present in pathogenic bacteria such as *Vibrio cholerae*[2]. The enzyme was produced both from *R. gelatinosus* and by heterologous expression in *E. coli*. We have studied the binding of copper ions to the protein by various biophysical techniques including EPR and NMR. The purified protein binds at least two Cu(II) ions in a specific way. One of the sites exhibits the characteristics of green copper cupredoxins, a still poorly described protein family.[3] The other site, partially emptied during the purification process, has a square planar geometry and parameters suggesting a 3 nitrogen 1 oxygen coordination sphere. Studies using mutations show that the latter site is located in the N-terminus portion of the protein. Studies of a potential Cu(I) specific binding site as well as electron transfer are underway in the laboratory. Possible roles for the metal ions will be discussed.

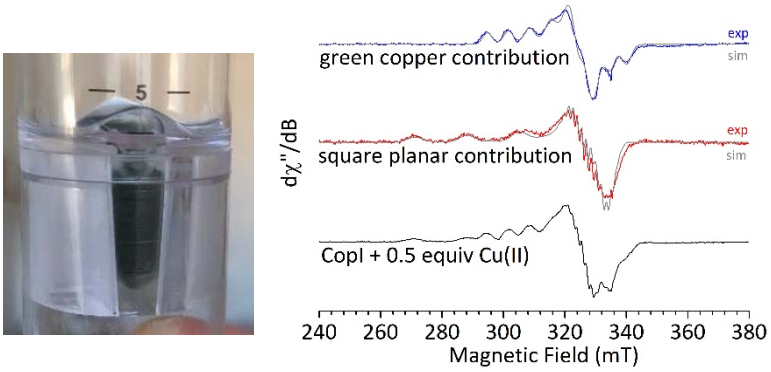

Figure 1. Left: purified soluble fraction containing CopI. Right: EPR spectrum of CopI and deconvolution into both contributions with their respective simulations.

1. Durand, A.; Azzouzi, A.; Bourbon, M. L.; Steunou, A. S.; Liotenberg, S.; Maeshima, A.; Astier, C.; Argentini, M.; Saito, S.; Ouchane, S. *mBio* **2015**, *6 (5)*, e01007-15.
2. Marrero K.; Sánchez A.; González LJ.; Ledón T.; Rodríguez-Ulloa A.; Castellanos-Serra L.; Pérez C.; Fando R. *Microbiology* **2012**, *158*, 2005-2016.
3. Roger, M.; Biaso, F.; Castelle, C. J.; Bauzan, M.; Chaspoul, F.; Lojou, E.; Sciara, G.; Caffarri, S.; Giudici-Orticoni, M. T.; Ilbert, M. *PloS one* **2014**, *9 (6)*, e98941.

Silver nanoparticles fate and Safer-by-design biocide made of tri-thiol bridged silver nanoparticle assemblies

From Mechanistic toxicology to safer by design

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Abstract

Silver nanoparticles (AgNPs) are widely used in consumer products for their biocidal activity. AgNP-containing medical devices is also a growing market with applications in dentistry, prosthesis, catheters or wound dressings. Their activity is due to their capacity to release bioavailable Ag(I) ions which is highly toxic for microorganisms inducing alterations of lipid bilayers, proteins and nucleic acids making them a long-lasting biocide. We first studied the fate of AgNPs in cellulo and in vitro and understood the dissolution process in presence of polythiol biomolecules.

AgNPs themselves are usually easily released from the product. Besides, AgNPs are highly sensitive to various chemical environment that triggers their transformation, decreasing their activity. Altogether, AgNPs widespread use leads to bacterial resistance and safety concerns for Human and the environment. There is thus a crucial need for improvements. We secondly developped a proof of concept for a novel biocide based on AgNP assemblies bridged together by tri-thiol bioinspired ligand will be presented. The final nanomaterial is stable and less sensitive to chemical environment with AgNPs completely covered by organic molecules tightly bound *via* their thiol functions. Therefore, these AgNP assemblies can be considered as safer-by-design and innovative biocides, since they deliver sufficient Ag(I) amount for biocidal activity with no release of AgNPs.

Recent Publications

- Marchioni, M., Giulia Veronesi, G. Worms, I., Ling, WL. Gallon, T., Leonard, D., Gateau,C., Chevallet, M. Jouneau, P-H., Carlini, L., Battocchio, C. Delangle, D. Deniaud, A.* and Michaud-Soret,I.* (2019) Safer-by-design biocide made of tri-thiol bridged silver nanoparticle assemblies. *Nanoscale Horizons,* accepted.
- Marchioni *et al* (2018) Insights into polythiol-assisted AgNP dissolution induced by bio-relevant molecules. *Environmental science.Nano*, 5, 1911.
- Marchioni, M., Jouneau, P.-H., Chevallet, M., Michaud-Soret, I. and Deniaud, A. (2018) Ag-NP fate in mammals: Bridging in vitro and in vivo studies. Coordination Chemistry Reviews, 364, 118.

Mono- and binuclear iron phthalocyanine-like complexes: from bio-inspired oxidation to carbene transfer reactions

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Metal phthalocyanine complexes are efficient catalysts for a variety of reactions [1]. Although phthalocyanines have been often considered as porphyrin analogues, their catalytic properties do differ from those of porphyrin counterparts. Moreover, increasing number of examples unambiguously shows that phthalocyanine complexes are superior in many reactions. Recent extensive studies showed that metallophthalocyanine complexes are efficient catalysts, in particular for biomimetic oxidation. In contrast to the porphyrin counterparts, phthalocyanine complexes are cheap and readily available on a very large scale (~100 000 t annual production) which makes these robust complexes viable for potential industrial applications. Our groups demonstrated that along with mononuclear complexes, binuclear diiron phthalocyanine complexes exhibit remarkable catalytic properties in the oxidation of alkanes including methane and ethane, C-C bond formation, oxidative defluorination and other reactions [2].

Carbene transfer reactions to X-H bonds (X = N, C, O, S, Si, B) and olefins have emerged as a powerful strategy for the construction of elaborated molecules with potential biological activity. These reactions are believed to involve carbene metal complexes. Among metal complexes, metalloporphyrins as well as engineered hemoproteins have been extensively studied as catalysts for carbene transfer reactions [3]. In contrast, phthalocyanine-like complexes have been rarely used. Given the similarity of oxidizing oxo species with isoelectronic carbene and nitrene putative intermediates which might perform carbene and nitrene transfer reactions (Fig. 1), the high catalytic efficiency phthalocyanine-like complexes in oxidation suggests that they deserve a more careful evaluation in the carbene transfer reactions.

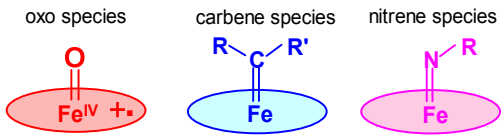

Figure 1

Herein, we explore catalytic properties of iron and diiron phthalocyanine and related porphyrazine complexes (Fig. 2) in cyclopropanation and carbene transfer to N-H bonds of amines using ethyl diazoacetate carbene precursor.

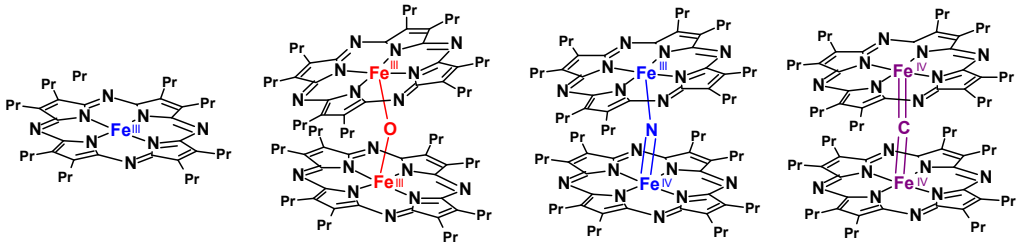

Figure 2. Structures of mono- and binuclear complexes evaluated in the carbene transfer reactions.

The electronic structure of these complexes and their putative carbene species was investigated by DFT calculations showing significant influence of the iron oxidation state and the nature of bridging atom [4]. The relationship between electronic structure of the complex and their catalytic activity in carbene transfer reactions will be discussed.

1. Sorokin, A. B. *Chem. Rev.* **2013,** *113*, 8152-8191.
2. (a) Afanasiev, P.; Sorokin, A.B. *Acc. Chem. Res*. **2016**, *49*, 583-593. (b) . Colomban, C.; Kudrik, E.V.; Afanasiev, P.; Sorokin, A.B. *J. Am. Chem. Soc.* **2014**, *136*, 11321-11330. (c) Kudrik, E.V.; Afanasiev, P.; Alvarez, L.X.; Dubourdeaux, P.; Clémancey, M.; Latour, J.-M.; Blondin, G.; Bouchu, D.; Albrieux, F.; Nefedov, S.E.; Sorokin, A.B. *Nat. Chem.* **2012**, *4*, 1024-1029.
3. (a) Coelho, P.S.; Brustad, E.M.; Kannan, A.; Arnold, F.H. *Science*, **2013**, *339*, 307-310. (b) Brandenberg, O.F.; Fasan, R.; Arnold, F.H. *Curr. Opin. Biotechnol.* **2017**, *47*, 102-111.
4. Cailler, L. P.; Clémancey, M.; Barilone, J.; Maldivi, P.; Latour, J.-M.; Sorokin, A. B. *Inorg. Chem.* **2020**, doi: 10.1021/acs.inorgchem.

Earth-abundant mono- and bi-metallic Mabiq complexes for photocatalysis

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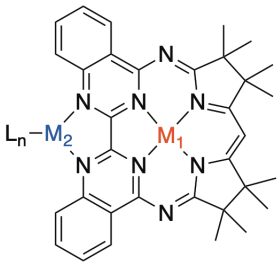
The redox cascades and water splitting reaction of Photosystem II are instigated via light absorption by chlorophylls. Artificial photosystems that catalyze H_2O splitting and solar fuel production (e.g. H_2 evolution), similarly rely on molecular photosensitizers to initiate the electron transfer processes. However, noble metal complexes based on Ru or Ir are commonly employed as the photoactive molecules in such systems. An important aim in the field of photocatalysis is to replace these noble metal complexes with earth-abundant alternatives. Our own work focuses on studies with a series of late, first-row transition metal complexes coordinated by a macrocyclic ligand, Mabiq. The ligand shares features with the biologically relevant porphyrins and corrins. The series of mono- and bimetallic Mabiq complexes are photoactive, and the M^{II}-Mabiq complexes can be photoreduced to the formally M^{I} forms. The Ni^{II}-Mabiq was successfully employed in the photoredox catalyzed cyclization of a bromoalkyl-substituted indole. The binuclear complexes offer a potential route for bifunctional photocatalysis. The photochemical properties and reactivity of the M_n-Mabiq compounds will be presented.



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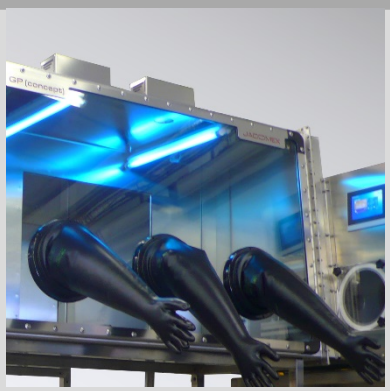

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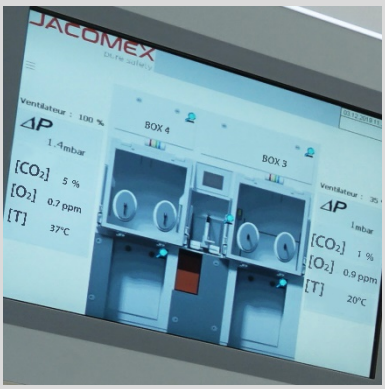

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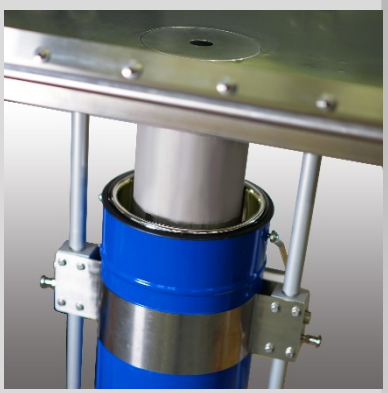

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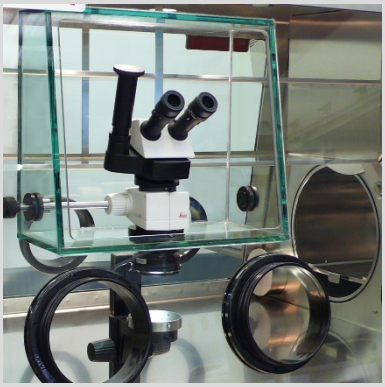

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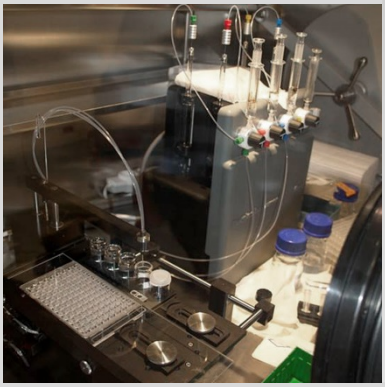

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