

M2 internship, 5 months, starting ~February 2027

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Trinuclear cobalt multi-switchable and multi-stable complexes

Key words: coordination chemistry, molecular magnetism, redox, (spectro-)electrochemistry

Project's description: Our research team focuses on designing magnetic molecules that can adopt multiple stable electronic states and be reversibly switched between them in a controlled manner in response to external stimuli such as temperature, pressure, light, or redox inputs. These multi-stable and multi-switchable systems hold strong potential for the development of sensors, molecular electronics, and responsive devices. Our approach relies on trinuclear cobalt complexes incorporating redox-active dioxolene ligands, which can reversibly interconvert between Co(III)–catecholates and Co(II)–semiquinone states through valence tautomerism (VT). In the last few years, we have obtained several of such molecular systems that show particularly interesting properties (magnetic switch (VT), multi-redox behavior, solvatochromism). The next key scientific challenge is to precisely tune the interactions between the three Co–dioxolene subunits to achieve multiple successive and reversible electronic transitions. Chemically, this can be achieved by adjusting two factors: the ligand field imposed by the external ligand, and the degree of electronic communication provided by the redox-active central ligand. Thus, we are now exploring various redox-active bridging ligands able to modulate the electronic communication between active centers. Once the different molecular systems have been obtained, for which we already have preliminary results, the work will focus on elucidating the redox processes involved, in particular whether oxidation occurs at the ligands and/or at the metal centers. This is investigated using a combination of complementary experimental techniques together with theoretical studies carried out in collaboration with our partners. By combining multiple switching mechanisms within a single molecule, this project will establish the foundations for next generation molecular materials featuring reversible, multi-stimuli-controlled magnetic and electronic properties.

Objectives: This internship will consist in synthesizing and characterizing the redox-active cobalt complexes. To do so, the M2 student will first be in charge of the organic synthesis of different ligands for which basic organic chemistry knowledge is required. Then, most of the part of the internship will be devoted to coordination chemistry, as the student will synthesize the trinuclear Co(II)/Co(III) complexes, in solution and in solid state (single-crystal growth). The study of the obtained [Co₃] complexes will focus on the magnetic and electrochemical properties, as well as UV-vis spectroscopy (spectro-electrochemistry) for which the student will learn to work in autonomy. All these characterizations will be performed in the lab.

Desired qualifications: The research topic requires strong knowledge in inorganic chemistry, basic knowledge in magnetic materials would be a plus. Some syntheses will be carried out under controlled atmosphere. *This internship opportunity is available as part of a project funded by the ANR and may therefore lead to a thesis proposal on the same topic.*

Techniques: NMR, IR, XRD, (spectro-)electrochemistry, SQUID magnetometry, EPR, data simulations

