



### PhD offer

Collaborative supervision between « Institut de Chimie de la Matière Condensée de Bordeaux » and « Laboratoire de Chimie Appliquée des Matériaux » de Rabat

## Polyanionic framework for specially engineered smart materials

### Context

Complementary to crystallographic study, most of the physical properties of solids need to be collected either on large single crystal or on a high-density pellet prepared from powder sample. The growth of large single-crystal or the densification of pellets are often difficult to achieve. The PhD offer is based on the single crystal growth expertise of the «*Laboratoire de Chimie Appliquée des Matériaux (LCAM)*» in Rabat (Université Mohammed V, Morocco) and physical characterization expertise of «*Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB)*» (Université de Bordeaux / CNRS / Bordeaux INP, France).

Interestingly all the exciting recent development are related either to low temperature single crystal flux growth or to low temperature sintering approaches leading to promising and sustainable perspectives in terms of both characterization & optimization of multi-functional materials.

Our main research goal is the stabilization of multifunctional solids for which external stimuli such as temperature, pressure, electrical and/or magnetic field allow to switch the dedicated material from ground state to an excited state leading to control physical / chemical properties change.

### PhD Objective

Up to now, our common polyanionic frameworks approaches allowed us to stabilize promising powder samples exhibiting exciting magnetic properties with space group of interest for ferroelectric and/or ferroelastic properties. However, their expected bulk dielectric and/or elastic properties could not be characterized yet due to a lack of single crystal and/or bulk pellets.

As a first step, powder growth phases by intermediate and/or low temperature solution growth in molten salts are planned in LCAM. Then, if the single crystal growth failed, low temperature sintering approaches will be carried out to improve the densification as Spark plasma sintering (SPS), also known as field assisted sintering technique (FAST) at ICMCB. Finally, complementary state of the art microscopy, scattering and spectroscopic techniques will be available both at LCAM & ICMCB and/or in the Multiphos consortium or using large facilities (Synchrotron and Neutrons). Especially single crystal diffractometer is planned at LCAM, temperature dependent powder X-Ray diffraction is planned in collaboration with PanAnalytical Company and, thanks to a single device in France, magnetic properties using Diamond Anvil Cell in the [5K ; 350K] temperature range up to 7 T will be studied.

"Smart" materials are expected in which physical properties such as optical, electrical, di-electrical, magnetic, mechanical or chemical characteristics respond to external stimuli.

## PhD Expectations:

- Literature review about Polyanionic framework and the available synthesis processes
- Stabilization of targeted compositions using Solid State Chemistry route
- Structural characterization ( X-Ray diffraction ; Le Bail and Rietveld refinement)
- *Stabilization of dense pellet using Ceramic engineering if single crystal growth failed*
- Physical and/or chemical characterization
- Written and Oral Report **in french and in english** of the synthesis and sintering procedures, of the experimental characterizations, scientific results and discussions with respect to the literature

**Possible networking:** In addition to the co-supervision for which a stay of 18 months in the both involved in the project institutions is mandatory, the pre-doctoral student will be able to collaborate within the Multiphos consortium (<https://anr.fr/Project-ANR-21-CE08-0051>) if necessary.

**Requirements :** Actively pursuing a Master's and/or engineering student in Solid State Chemistry; Materials Chemistry and/or Physics.

**Starting date:** Anytime between September and November 2024 knowing that the total duration of 36 months is shared into two (18 months in Rabat and 18 months in Bordeaux). Please see the following item related to university of Bordeaux <https://doctorat.u-bordeaux.fr/pendant-le-doctorat/mobilite-internationale/cotutelle-codirection-label>

**Application:** Candidates are requested to submit a **single pdf file** to [olivier.toulemonde@icmcb.cnrs.fr](mailto:olivier.toulemonde@icmcb.cnrs.fr) **and** [j.khmiyas@um5r.ac.ma](mailto:j.khmiyas@um5r.ac.ma) containing:

- A letter motivating the application
- A detailed CV
- Academic transcripts

Selection will be based on merit and potential, measured in terms of academic records and personal achievements prior to a common interview.

Motivation, proactivity and capacity for teamwork will also be taken into account