Laboratoire Chimie de la Matière Condensée de Paris
Sorbonne Université – Case Courrier 174
4, Place Jussieu - 75252 PARIS Cedex 05

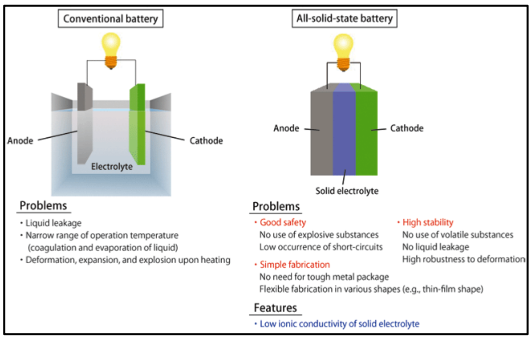
MASTER INTERNSHIP

Title: New multivalent ion conductors for all-solid-state batteries

Keywords: All-solid-state batteries, multivalent ion inorganic conductors

Scientific description:
Currently, the demand for energy is growing considerably, whether for nomad or stationary applications. In this context, it is necessary to develop efficient systems that are safe for users. In addition to these criteria, the questions of the management of resources and recyclability of materials are now at the heart of concerns.
Li-ion batteries with liquid electrolyte currently have the best performance and are used for smartphone, camera or electric or hybrid vehicles applications. The disadvantages of these systems reside mainly in the flammable nature of some electrolytes used and the uncertainty surrounding the availability and cost of lithium or other constitutive elements in the near future.

Inorganic all-solid-state batteries, in which both electrodes and electrolytes are solid, become an interesting alternative of existing systems (numerous companies start to be strongly interested in this technology: Toyota, Panasonic, Volkswagen, Fisker, Dyson…), thanks to several advantages [1,2]:



From http://www.spring8.or.jp/en/news_publications/research_highlights/no_49/

- Absence of flammable organic liquid electrolytes,
- Dead weight in all-solid-state battery packaging can be largely reduced, resulting in increased energy density,
- Compared with organic liquid electrolytes and polymer electrolytes, inorganic solid electrolytes have much better electrochemical stability and are compatible with higher potential cathode materials to increase energy density
- Design flexibility (micro-systems, 3D manufacturing…)
- All-solid-state batteries have excellent mechanical properties.

In that context, multivalent-ions (*i.e.* Mg, Ca, Al) batteries would bring a breakthrough in terms of energy density since they would be based on the use of metal anodes [2,3]. Nevertheless, numerous issues still have to be solved to increase performance of multivalent all-solid-state-batteries: management of electrolyte/electrode interfaces, increase of the ionic conductivity of electrolytes...

The objective of this project is to develop new solid electrolytes conductive of multivalent ions (Mg^{2+}, Zn^{2+}, Al^{3+}). The first step is to identify the most promising systems, considering the toxicity and availability of resources. Different synthesis routes can be implemented, depending on the chosen systems (solid route, sol-gel route, co-precipitation, etc.). The crystal structure of the synthesized compounds will be characterized by XRD and TEM. Powders will be then sintered by Spark Plasma Sintering (SPS) in order to obtain samples of controlled density and microstructure. Ion conductivity and conduction mechanisms will then be characterized by impedance spectroscopy, according to the composition and microstructure of the samples.

More information about RMES team at LCMCP: https://lcmcp.upmc.fr/site/rmes-2/

How to apply: Please send your CV and motivation letters to Dr Damien Bregiroux (damien.bregiroux@sorbonne-universite.fr)

[1] Famprikis et al., Fundamentals of inorganic solid-state electrolytes for batteries, Nature Materials, (2019) 10.1038/s41563-019-0431-3
[2] https://www.ee.co.za/article/solid-state-batteries-future-storage-standard.html
[3] Leisegang et al., The aluminum-ion battery: a sustainable and seminal concept? Frontiers in Chemistry, 7 (2019) 268