PhD project

Synthesis and characterisation of COF (Covalent Organic Framework) based composite electrolyte for all-solid-state sodium-ion batteries

Context and objective of the project

The development of future generations of batteries, which will be safer and more efficient, involves replacing the liquid electrolyte with a solid, solvent-free matrix.[1] This objective is the focus of a worldwide effort to find new materials capable of meeting all the performance, stability and cost requirements. To date, there is no miracle material capable of achieving this. On the one hand, there are ceramic materials that offer high conductivity and satisfactory electrochemical stability, but for which flexibility, shaping, the use of critical elements and the difficulty of recycling are the main constraints, slowing down their integration into high-performance complete systems.[2] Conversely, organic compounds, particularly polymers, have good mechanical properties and are flexible, but lag behind in terms of performance (solvent-free) and electrochemical stability.[3]

Among the various possible chemical systems, Covalent Organic Frameworks (COFs) are attracting particular attention because of their exceptional textural properties (very high specific surface area, very low density, high porosity, etc.).[4] In recent years, two approaches have been proposed for their use as electrolytes in lithium-ion batteries:[5] the first involves impregnating a lithium salt into the porous structure,[6] while the second is based on the direct incorporation or grafting of a permanent charge (ionic COF) or an ion-chelating moiety.[7]

To date, most studies have focused on the mobility of lithium ions. Very few studies have explored the mobility of sodium ions, but these show that this type of material has very strong potential for dendrite suppression, high sodium ion mobility, a high transport number and good stability with respect to sodium metal.[8]

[1] J. Janek *et al.*, *Nature Energy, 1, 16141,* **2016**.

[2] T. Yu *et al.*, *Journal of Alloys and Compounds*, 885, 161013, **2021**.

[3] S. Xiao *et al.*, *Energy Storage Materials*, 63, 102970, **2023**.

[4] A. Côté *et al.*, *Science*, 310, 5751, 1166, **2005**.

[5] Y. Xu *et al.*, *Nanoscale*, 16, 11429, **2024**.

[6] a) A. Vazquez-Molina *et al.*, *J. Am. Chem. Soc.*, 138, 9767, **2016**. b) B. Irié-Bi *et al.*, patent WO/2024/100209.

[7] a) K. Jeong *et al.*, *J. Am. Chem. Soc.*, 141, 5880, **2019**. b) Z. Gao *et al.*, *J. Mater. Chem. A*, 10, 7497, **2022**.

[8] a) J. Guo *et al.*, *Adv. Funct. Mater.*, *34*, 2313496, **2024**. b) Y. Yan *et al.*, *Nat. Comm.,* 14, 3066, **2023**. C) T. Kang *et al.*, *Adv. Energy Mater.*, *13*, 2204083, **2023**.

Project description

As part of a bilateral European project dedicated to the construction of all-solid-state sodium-ion batteries, this PhD project aims to design new COF-based composite electrolytes for sodium ion mobility. More specifically, the subject focuses on the design (synthesis and characterisation) and modification (post-functionalisation) of porous organic

compounds of the COF (Covalent Organic Framework) type. These materials will serve as the basis for the manufacture of composite electrolytes for integration into a all-solid-state sodium-ion battery.

Profile required

For this project, we are looking for a motivated and dynamic scientist who would like to complete his/her PhD in an international environment. To do this, you must have a Master's degree, ideally in materials chemistry, and a sound knowledge of organic materials chemistry (polymers and/or molecules), the synthesis and characterisation of porous materials and, ideally, electrochemistry applied to batteries (ionic conductivity, cyclic voltammetry, etc.). Previous experience in the synthesis and characterisation of porous materials is strongly recommended. Skills in electrochemistry and/or chemistry would be highly advantageous. Fluency in English, both orally and in writing, is essential. Ability to write scientific reports and articles and to communicate (exchanges with supervisors, oral presentations at meetings/congresses, etc.) is highly recommended.

Targeted starting date : November 2024

How to apply ?

Send your *curriculum vitae*, covering letter and letters of recommendation to the following address: matthieu.becuwe@u-picardie.fr (LRCS)

For more information about the hosting lab: https://www.lrcs.u-picardie.fr/