PhD thesis
Aqueous fast rate sodium-ion batteries

With the increase of variable renewable energy being integrated in the energy mix, there is a larger need for battery energy storage systems, in order to ensure frequency stability to the consumer. Aqueous redox-flow battery systems are appealing, but still carry a too high cost. On the other hand, aqueous sodium-ion batteries (ASIBs) can be made both inexpensive, safe and eco-friendly. However, the narrow electrochemical stability windows of aqueous electrolytes limit their energy densities and result in a very limited choice of electrode materials, in order to avoid the hydrogen and/or oxygen evolution reactions (HER/OER). Additionally, the solubility of the nano-sized electrode active materials is a common problem, leading to poor cycling stability.

Recently, water-in-salt electrolytes (WiSEs) were proposed to mitigate these drawbacks, but the salts employed are both toxic and costly. WiSEs also suffer in performance; The ionic conductivity of 35 m NaFSI is typically at 8 $mS.cm^{-1}$, whereas the one of traditional aqueous electrolyte is at ca. 100 $mS.cm^{-1}$.

This PhD project will reinvestigate ASIB electrolytes to enable full cells comprising polyanionic sub-micronic active materials for both the positive and negative electrodes. The objective is to investigate the stability of different electrode active materials upon cycling and their high-rate performance combined with altered electrolyte salt concentration. Through the latter the sweet-spot of the ability to limit the HER and the optimal ionic conductivity for power performance will be sought. In practice, the polyanionic type materials will be synthesized at a sub-micronic scale by soft chemistry routes. For both anodic and cathodic electrodes, to reach good electronic conductivities, carbon coating will be applied either during the synthesis or during post-synthesis by mechanical grinding. To test the full cells, this project will focus on low cost, easy to prepare, and sustainable electrolytes. A systematic study by progressively increasing the electrolyte salt concentration will be performed evaluating the stability upon cycling and the capacity retention. Additives as well as the pH of the electrolyte will also be optimized and correlated with electrode solubility and cycling stability.

STARTING DATE: Ideally in September or October 2023

CONTEXT/QUALIFICATIONS

The thesis will be prepared in collaboration between three partners of the ALISTORE-ERI network. ALISTORE-ERI is Europe's oldest academic-industry network in the area of batteries that currently federates >30 partners performing cross-cutting high-level battery R&D. The PhD student will be registered at the Doctoral School of UPJV (Amiens, France). The first half of the thesis work will be localized at ICMCB in Bordeaux (France) and the second half at LRCS in Amiens. During the PhD duration there will also be short period spent at Chalmers University of Technology (Sweden) that will be paid by the project. The candidate must have a MASTER 2 or Engineer degree in chemistry, electrochemistry or materials sciences with high standard. Knowledge on energy storage, materials and solution chemistry will be valuable. Excellent level of English, both written and spoken.

CONTACTS

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Selection process

The candidate should first contact anyone of the three contact persons above and provide (via e-mail):
- a detailed CV
- a motivation letter emphasizing the fit between the candidate's background and the proposed position
- the names and contact details of at least 2 reference persons

In parallel, the application will go through the CNRS employment website: https://emploi.cnrs.fr/
The candidate will be selected by a panel after interviews by the end of March or beginning of April 2023.