CEA Saclay –Service de Physique de l'Etat Condensé (SPEC)
Laboratoire *SPHYNX* (http://iramis.cea.fr/spec/SPHYNX/)

PROPOSITION DE STAGE 2022/2023

THERMOELECTRIC ENERGY CONVERSION IN COMPLEX FLUIDS (INTERNSHIP 2/2) THERMOGALVANIC ENERGY CONVERSION IMPROVEMENT IN IONIC LIQUIDS VIA BY REDOX SOLVATION AND COORDINATION CHEMISTRY

Thermoelectricity, a materials' capability to convert heat in to electric energy has been known to exist in liquids for many decades. Unlike in solids, this conversion process liquids take several forms including the ***thermogalvanic*** reactions between the redox ions and the electrodes, the ***thermodiffusion*** of charged species and the temperature dependent formation of electrical double layer at the electrodes. The observed values of Seebeck coefficient ($Se = -\Delta V/\Delta T$, the ratio between the induced voltage (ΔV) and the applied temperature difference (ΔT)) are generally above 1 mV/K, an order of magnitude higher than those found in the solid counterpart.

At SPHYNX, we have two on-going research projects to understand and exploit the heat-to-electricity conversion mechanisms in such complex fluids. (**Please consult Internship 1/2 for the other proposition**)

2) Thermogalvanic energy conversion improvement in ionic liquids via by redox solvation and coordination chemistry. Room temperature ionic liquids (RTILs) are molten salts that are liquid below 100 °C and up to 200 – 400°C. Compared to classical liquids, they exhibit many favorable features such as high boiling points, low vapour pressure, high ionic conductivity and low thermal conductivity accompanied by higher Se values. The latter is believed to stem from a complex and strong ionic environment in the solvation/complexation layer surrounding the redox species unique to ionic liquids[1,2]. A clear understanding and the precise control of the speciation of metal ions and their impact on the structural entropy change of the solvation layer is a key to the rational design of future TEC liquids. The proposed internship is experimental, exploring first the relationship between the ionic constituents of the liquid (various RTILs and RTIL/solvent mixtures) the thermogalvanic effect of commercially available redox salts via Seebeck coefficient (voltage), impedance and power measurements. In the subsequent PhD period (funding available), the study will be extended to tackle the coordination chemistry of transition metal redox ions made with commonly available metals (Fe, Cu, etc), involving), involving metal complexation studies, electrolysis, and spectral & electrochemical characterization methodologies (collaboration with IJCLab, UPSaclay).

Our long-term goal is to deepen the understanding of the bespoke compound thermoelectric phenomena in liquid media, and to demonstrate the application potential of complex thermoelectric liquids based on affordable, abundant and safe materials for thermal energy harvesting as an energy efficiency tool.

The ideal candidate will have strong background in Physics (thermodynamics) with some theoretical/practical notion of Chemistry (CPGE in MP/PC/BCPST or Undergraduate double-major in Physics & Chemistry and Energy/Electrochemistry/Chemistry courses in Master 1&2). **No numerical skills are necessary for these positions, however, basic data analysis skills are required. Hands on experience in the laboratory environment (glovebox handling, electronic hardware manipulation, etc.) is a plus.**

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REFERENCES:
[1] T. Salez "Effets thermoélectriques dans des liquides complexes: liquides ioniques et ferrofluides" Thèse de Doctorat, PSL Research University (2018)
[2] M. Beaughon « Thermoélectricité dans les solvants, liquides ioniques et ferrofluides » thèse de doctorat, l'université Paris-Saclay (2022)