A Membrane-Free Redox Flow Battery with Two Immiscible Redox Electrolytes

Electrochemical energy storage is one of the few options to store the energy from intermittent renewable energy sources like wind and solar. Redox flow batteries (RFBs) are such an energy storage system, which has favourable features over other battery technologies, for example, solid state batteries, due to their inherent safety and the independent scaling of energy and power content. However, because of their low energy density, low power density, and the cost of components such as redox species and membranes, commercialised RFB systems like the all-vanadium chemistry cannot make full use of the inherent advantages over other systems.

A membrane-less design has the potential to overcome aforementioned disadvantages as the elimination of the membrane, as one of the major cost component [1], reduces the overall cost and the use of non-aqueous solvents leads to an enlarged potential window and therefore to an improvement of the energy density. The use of nonconventional solvents also offers the application of new earth-abundant and inexpensive redox active materials, which can boost the performance and efficiency. This battery type has recently developed and has shown high potential [2]. To explore more options, with possible higher reaction kinetics, higher stability and lower crossover, we want to study various species/solvent combinations as new redox active species and electrolytes for redox flow batteries. A membrane-free battery based on the immiscibility of two electrolytes that spontaneously form a biphasic system whose interphase functions as a “natural” barrier will be developed and vanadium is replaced by e.g. organic molecules.

In this thesis you will investigate new electrolyte compositions for an RFB using two immiscible electrolytes forming two phases with a phase boundary. This will potentially reveal a new type of redox flow battery for stationary storage of renewable energy.

Your activities will be:
- selection of the redox active species and electrolytes;
- validation of the new electrolyte compositions by electrochemical analysis (CV, EIS);
- crossover studies of various redox active species/solvent combinations;
- investigation of a new cell-design;
- conduction of charge / discharge tests of the best candidates and comparison of the analysed data with benchmark.

[1] Zhang et al., *J. Electrochem. Soc.*, 2012, 159, A1183–A1188.
[2] Navalpotro et al. *Angew. Chem. Int. Ed.* 2017, 56, 12460 – 12465.