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Title

New materials with high volumetric capacitance for electrochemical capacitors with aqeous electrolytes

Keywords

Oxides, energy storage, electrochemical capacitors, electrochemistry, materials

Supervisors

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Description

The search for new materials with improved storage properties (in terms of energy and power density) is necessary to meet the needs of efficient stationary storage systems, and electrochemical capacitors are devices that are particularly adapted to this problem.

The main objective of the thesis is to work on the formulation and synthesis methods of new electrode materials for electrochemical capacitors operating in aqueous media. It will be based on elaborating oxides associating heavy elements (W, Bi, ...) with electrochemically active transition metal cations (Mn, Fe, ...), by using synthesis techniques in order to obtain nanometric powders with a high specific surface area. The structures envisaged are Ruddlesden-Popper, Aurivillius and perovskite. The compositions will be close to those of materials used as electrodes (anode or cathode) for SOFC. The proposed methods go through solution steps, such as sol-gel, auto-combustion, co-precipitation and are already widely used in the ST2E team. Numerous characterization methods (including XRD by the Rietveld method, with the skills of Eric Quarez, XAS, in situ and operando methods, ...) will be used to precisely determine the key factors influencing the electrochemical properties (presence of vacancies, evolution of the oxidation state, ...).

The thesis will be based on the recent results obtained in the team (Nicolas Goubard's thesis, defended in November 2016) on MWO_4 materials with volumetric capacities four times higher than the values of commercial supercapacitors [1]. This work served as a basis for the work carried out by Elodie Grange (assistant engineer) for 6 months in the ST2E team (September 2017 - February 2018), which is currently being pursued since March 2018 by an Erasmus Mundus trainee. Several polycationic oxides, in particular those based on iron, have been identified, for which the pseudo-capacitive behavior is strongly linked to the morphology, the structure and the composition of the different materials, thus opening up many prospects for increasing the energy density of supercapacitors.

Profile

The candidate must have a solid formation on synthesis methods (low temperature, by soft chemistry), characterization techniques (chemical analysis, X-ray diffraction, spectroscopies and / or microscopy), and of electrochemical analysis (cyclic voltammetry, galvanostatic studies, electrochemical impedance, ...).

References

[1] N. Goubard-Bretesché et al., Electrochim. Acta 206 (2016) 458-463