Master's (M2) Research Internship – 6 months (March–August 2027)

Characterisation of hard carbons and evaluation of their electrochemical properties as anode materials for sodium-ion batteries

Background and objectives:

Sodium-ion batteries are a promising route to diversifying electrochemical energy-storage technologies. Among candidate anode materials, hard carbons are of particular interest because they can reversibly store sodium and can be produced from a wide range of precursors. Their performance, however, depends strongly on their structural organisation, surface chemistry and porosity, particularly on the distinction between open and closed pores.

In this context, the Institut de Chimie de Clermont-Ferrand (ICCF) is offering a research internship to establish relationships between the physicochemical characteristics of different hard carbons and their electrochemical behaviour in sodium-ion batteries. The aim is to compare representative materials, including commercial benchmarks where available, and identify the key parameters governing reversible capacity, initial Coulombic efficiency and cycling stability.

Research programme and proposed activities:

The intern will undertake multiscale characterisation of carbon powders: X-ray diffraction (XRD) to study structural order, Raman spectroscopy to assess carbon disorder, small-angle X-ray scattering (SAXS) to probe nanoscale porosity, and helium pycnometry. Depending on the samples, complementary surface and morphological analyses (gas adsorption, electron microscopy) may be carried out. Combining the results will make it possible to discuss the contribution of closed porosity without treating any single technique as a definitive measurement.

The second part will focus on electrochemical evaluation: electrode preparation using a controlled formulation, assembly of coin-type half-cells versus sodium metal, and galvanostatic testing under comparable protocols. The study will examine reversible specific capacity, initial Coulombic efficiency, cycling stability, rate capability and the relative capacity contributions of sloping and low-potential plateau regions. Cyclic voltammetry or electrochemical impedance spectroscopy may complement these tests.

The project will provide a critical analysis of structure–texture–performance relationships, accounting for measurement reproducibility and limitations of interpretation, and will identify the most promising hard carbons for further study.

Candidate profile and application:

Applicants should be second-year Master's (M2) students in chemistry, materials science, physical chemistry or electrochemistry. Prior knowledge of materials characterisation and/or battery electrochemistry would be an asset. Experimental rigour, autonomy, critical thinking, data-analysis skills and the ability to communicate results in French and English are expected.

Applications should include a CV, a cover letter and Master's academic transcripts; a reference letter from a previous internship supervisor may also be included.

Contact:

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