Unravelling the effect of a magnetic field on the electrochemical properties of composite electrode materials

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Nowadays, the increasing demand for energy promotes the research in sustainable and efficient energy storage systems. Electrochemical energy storage devices (EESD), in particular supercapacitors (SCs) are widely developed, due to their high reversibility and storage efficiency, compact structure and zero operation emission. The performance of SCs strongly depends on the device design and properties of electrode materials, and progress is always needed in these fields. Very recently, it has been demonstrated that the electrochemical properties of transition metal oxide (TMO) nanoparticles can be significantly improved by the application of moderate external magnetic field. These findings gave rise to an emerging interdisciplinary field of research, namely *magnetoelectrochemistry* [1,2], which has been very scarcely studied up to now. In that context, this PhD project aims at studying the electrochemical properties of EESD electrode materials under an applied magnetic field.

The PhD project will be focused on two types of promising composite electrode materials. First, conventional composites based on graphene and TMO nanoparticles, in particular iron oxide/ternary metal (Fe, Ni, Mn) oxide nanoparticles (such as Mn_3O_4, $Fe_{3-x}Mn_xO_4$…) will be studied. Also, graphene-based composites with hybrid perovskites (HPs), in particular lead-free HPs with Cu, Sn and Ni such as MA_2CuBr_4 doped by magnetic ions ((Cr, Dy)2+), will be investigated. The latter emerging class of materials showed promising properties for EESD application, but remains very barely explored.

The materials will be synthesized by chemical [3, 4] and mechanochemical [5] synthesis methods mastered at ICPEES. The composition and structure of synthesized materials, and their electrochemical properties as SC electrodes, will be characterized in details. The effect of fixed and time-varying applied magnetic field and of applying a magnetic field in different positions around the electrochemical cell on its performance will be analyzed to gain a clearer understanding of the underlying mechanisms of charge storage under the magnetic field, and determine the optimal device configuration. This PhD project aims to advance the development of new performant magneto electro chemical energy storage devices.

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[4] G. E. Fenoy et al., Electrochimica Acta, 2018, 283, 1178–1187.

[5] PhD report, Yihui Cai, 13/12/2024, Mechanosynthesis of 3D, 2D and Quasi-2D Hybrid Perovskites and MAPbI3@graphite Composites: Mechanisms and Potential Applications