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Development of Rechargeable Aluminium Batteries.

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The high cost, the scarcity and the high reactivity of metallic lithium to ambient condition such as humidity and oxygen are some drawbacks for lithium-based batteries such as lithium-ion and more recently, lithium-air. Aluminium, in contrast, is the third most abundant metal in the crust earth, presents low flammability and its cost is forty times lower than lithium. Moreover, it presents promising theoretical gravimetric and volumetric energy densities comparable to lithium-based batteries. Still, one of the major research challenges for the development of rechargeable aluminium batteries is the electrodeposition of metallic aluminium that should occur in the anode during battery re-charging. This electrochemical process is very challenging due to the high reduction potential of aluminium that makes necessary the use of non-aqueous electrolytes. Among them, chloroaluminate ionic liquids are considered as of the most promising electrolytes for aluminium electrodeposition and they have been used very recently to develop the first examples of aluminium batteries [1,2]. *The aim of this PhD is to develop a rechargeable and high energy density battery based on cheap, abundant and non-reactive aluminium.* The specific objectives associated with this project are:

(1) to investigate different electrolytes which allow the reversible Al^{3+}/Al^{0} reaction in the anode of the battery including ionic liquids, (2) to optimize the Al^{3+}/Al^{0} half-cell reaction by adjusting the composition of the electrolyte; different solvents, salts and additives will be investigated, (3) to study how properties of aluminium-based anode materials such as composition and geometry affect to the reversibility of Al^{3+}/Al^{0} reaction; Al alloys and 3D structures will be investigated, (4) To investigate cathodic materials compatible with the selected anode and electrolyte. Air cathodes containing catalyst towards ORR/OER reaction will be investigated to evaluate the potential of aluminium-air batteries. Moreover, intercalation cathodes similar to the ones used in lithium-ion batteries will be also investigated to develop Aluminium-ion batteries.

During the first months of the PhD I have been working on the reversible electrodeposition of aluminium using one ionic liquid electrolyte and different anodes in half-cell experiments. Preliminary results are very promising and show the high potential of aluminium as anodic material for future batteries.

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