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Development of Ionic Liquid-based Electrolytes for New Electrochemical Energy Storage Devices

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In the dawn of a new renewable energy system based on natural and intermittent sources such as solar or wind, electrochemical energy storage devices are being investigated to counteract the output fluctuations and maintain the reliability of grid operation[1]. In order to improve the performance of the devices and to achieve the new requirements for these applications, the scientific community is focused on the study of new materials for their two basic components: electrodes and electrolyte[2].

Regarding this issue, the aim of this thesis is the formulation of new ionic-liquid based electrolytes and their application in electrochemical energy storage devices such as; i) high performing supercapacitors and ii) innovative concepts of redox flow batteries. In particular, this work will be orientated to study the use of redox electrolytes based of redox-active organic molecules for hybrid supercapacitors as well as its behavior in a new concept of membrane-free flow battery[3]. Therefore, during this period a deep study of the state of the art of organic redox electrolytes and its application in hybrid supercapacitors and redox flow batteries will be carried through. Subsequently, once the new electrolytes have been formulated, its electrochemical behavior will be investigated by electrochemical techniques such as, cyclic voltammetry, galvanostatic charge-discharge and impedance spectroscopy in 3-electrode electrochemical cell (half-cell). Afterwards, this kind of redox electrolytes will be used in hybrid supercapacitors with different types of carbon electrodes and their energy storage mechanism will be elucidated in full cells. Moreover, application of these redox electrolytes in a new concept of Membrane-free battery will be investigated. This revolutionary concept relies on the immiscibility of redox electrolytes, having a biphasic system which behaves as a reversible battery without any membrane or separator. For the development of this totally new technology, thermodynamic and engineering aspects will be discussed. Finally, a lab scale prototype will be designed and assembled to demonstrate the feasibility of this ground-breaking battery. As a result, this thesis will contribute to expand the knowledge about electrochemical energy storage devices and open up new opportunities for these technologies.

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