Pioneering Use of Ionic Liquid-Based Aqueous Biphasic Systems as Membrane--Free Batteries

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Conventional batteries (Li-ion, Na-ion, NiMH, etc.) have solids as active materials attached to metallic current collectors, usually scarce and expensive. To store large quantities of energy in static systems flow batteries have been proposed, which are based on two fluid phases separated by a membrane. Recently, an innovative concept of membrane-free batteries based on the immiscibility of two redox electrolytes in biphasic systems was proposed, formed by an aqueous and a non-aqueous phase. In this concept, the use of the membrane is redundant due to the immiscibility of electrolytes that are phase-separated by their intrinsic thermodynamic nature, avoiding the use of scarce and expensive metallic active compounds such as vanadium salts. Organic molecules such as quinones, which can be easily prepared at low cost and are environmentally friendly, were used to successfully replace those metallic compounds. In order to improve this concept while avoiding the use of a volatile organic phase, membrane-free batteries based on two aqueous immiscible phases were developed. Aqueous biphasic systems (ABS) formed by water, ionic liquids and salts were proposed as the basis for the creation of aqueous-rich membrane-free batteries. This concept was shown to be feasible due to the selective enrichment of redox organic molecules in each aqueous phase of the ABS. The required separation of electrolytes in the battery is not driven by an expensive membrane that hampers mass transfer, but instead by the intrinsic immiscibility of the two phases. The results gathered show that some redox ABS can be used as Total Aqueous Membrane-Free Batteries with theoretical battery voltages as high as 1.6 V.

FIGURE 1
Scheme of a battery formed by two immisicible aqueous phases.