Electrochemical Investigations in the Ionic Liquid 1-Butyl-3-Methylimidazolium Hexafluorophosphate

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We have been investigating the electrochemical properties of alkali metals in the ionic liquid 1-butyl-3-methylimidazolium hexafluorophosphate (bmimPF$_6$) for possible battery applications. In addition to a wide potential window (ca. 4.5 V) and good chemical stability, bmimPF$_6$ is also hydrophobic, which should impart additional long-term stability to a battery system.

While it is possible to deposit lithium and sodium metal from bmimPF$_6$ solutions of the ions at a platinum electrode, determination of the formal potential is complicated by the onset of solvent reduction. Utilizing an HMDE as the working electrode circumvents this problem, since the favorable free energy of formation of the alkali metal amalgams shifts the reduction potential of the alkali metal ions to more positive values. An additional advantage to using an HMDE is that the electrochemical properties of potassium can also be examined even though the reduction of K$^+$ normally occurs past the cathodic limit for bmimPF$_6$ (See Figure 1).

The formal potentials and diffusion coefficients of lithium, sodium and potassium were obtained from bmimPF$_6$ solutions of the hexafluorophosphate salts of these metals using an HMDE and two silver wires as pseudo-reference and counter electrodes. The ferrocenium/ferrocene couple was used to establish the reference potential. A representative staircase cyclic voltammogram for an 8 mM ferrocene/bmimPF$_6$ solution at an HMDE is shown in Figure 2.

Another area of interest related to the development of high-energy density batteries is the incorporation of conductive polymers. While it is possible to use chemical oxidants to prepare conductive polymers, electrochemical polymerization would seemingly promote the formation of a more intimate contact between anode material and polymer. We have initiated investigations into the electropolymerization of conductive polymers such as polypyrrole, polyaniline and polythiophene in bmimPF$_6$, and will report on some of our results.

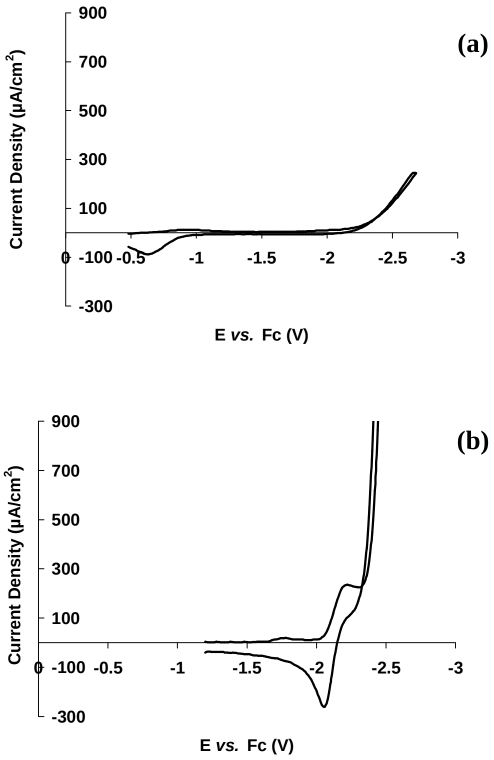

Figure 1: Current density *vs.* potential for a 25 mM KPF$_6$ solution in [bmim]PF$_6$, 500 mV/s at a) Pt and (b) hanging mercury drop electrode.

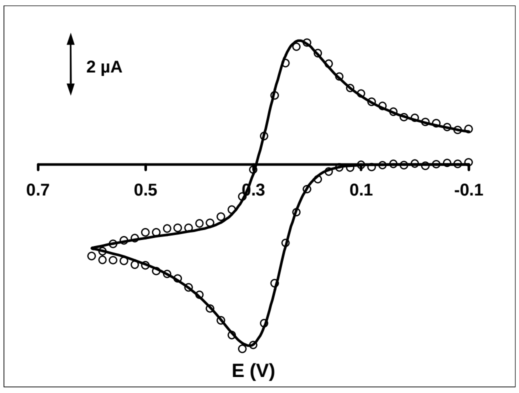

Figure 2: Staircase cyclic voltammogram of 8 mM ferrocene/bmimPF$_6$ solution used to establish reference potential (average of 10 scans, 500 mV/s scan rate). The experimental data (circles) was fit using non-linear regression analysis assuming a reversible, 1-electron process (solid line).

ACKNOWLEDGMENT

This work was supported in part by the Air Force Office of Scientific Research and the Office of Naval Research.