

Comparison of Two Ionic Liquids as the Supporting Electrolytes of Non-aqueous Redox Flow Battery
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Introduction

Redox flow batteries (RFBs) are a kind of promising large scale energy storage devices. Differ from the conventional batteries, they store chemical energy in two liquid electrolytes, rather than in solid electrodes. The operating potential of traditional aqueous RFB system is constrained by the limit of the potential of water electrolysis, so the low energy density is obtained. Recently, non-aqueous RFBs have got some attention [1-3]. These non-aqueous electrolytes promise wider stable potential windows, wider operating temperature ranges, higher energy and power densities than aqueous electrolytes. However, the conductivity for organic solvent is much lower than water, there is a large ohmic voltage drop exists. To solve this problem, ionic liquids was applied to the non-aqueous systems.

In this work, Two ionic liquids- 1-ethyl-3-methyl imidazolium hexafluorophosphate (EMIPF₆) and tetrabutylammonium hexafluorophosphate (TEAPF₆) are synthesized and used in a non-aqueous vanadium(III) acetylacetonate [V(acac)₃] redox flow battery as supporting electrolytes.

Experimental

Two ionic liquids EMIPF₆ and TEAPF₆ were synthesized [4], and then dissolved in acetonitrile with V(acac)₃ to get the electrolyte for RFBs.

The conductivity and of the electrolytes with different concentration of ionic liquids was examined with electrochemical impedance spectroscopy (EIS). The charge-discharge characteristics of this system are evaluated in an H-type glass cell with galvanostatic method.

Results and discussion

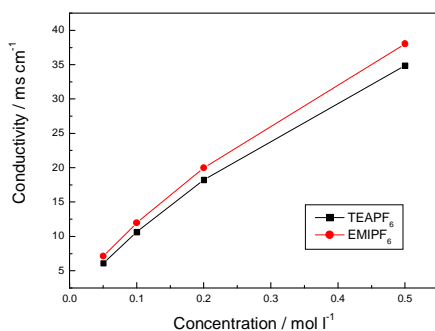


Fig.1. Conductivity of electrolytes with 0.01 mol l⁻¹ V(acac)₃ and the different concentrations of ionic liquids.

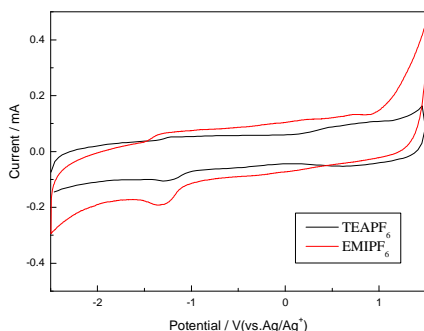


Fig.2. Cyclic voltammograms in 0.2M two different ionic liquids in CH₃CN as the scan rate is 0.2 V s⁻¹

With increased concentration of the ionic liquids, the conductivity of the electrolytes increased obviously and reached to a reasonable value. It's also can be seen that the conductivities of TEAPF₆ were lower than EMIPF₆ in the same concentration. The cyclic voltammograms of two electrolytes without the active species show no important peaks existed in the examined potential window, so these two ionic liquids can be regarded as electrochemically inert, moreover, TEAPF₆ is more stable than EMIPF₆.

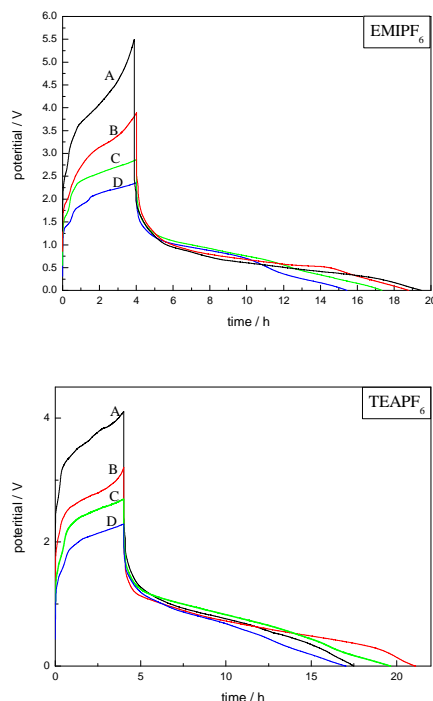


Fig.3. Charge-discharge curves of 0.01M V(acac)₃ with different ionic liquids concentration and I_c=1 mA, I_d=0.1 mA. (A) 0.05 (B) 0.10 (C) 0.20 (D) 0.50 M.

In the H-type cell, the charge voltages are much higher than discharge voltages in the low concentration of ionic liquids and decrease with the concentration increase of the supporting electrolyte. Although the conductivities of EMIPF₆ were much higher, TEAPF₆ exhibits a better energy efficiency than EMIPF₆. It may be due to a higher stability and a lower viscosity for the TEAPF₆ system.

Conclusions

EMIPF₆ and TEAPF₆ have been synthesized and used in a non-aqueous vanadium redox flow battery. The ionic liquids can improve the conductivity of the organic electrolytes obviously, with which, a higher voltage efficiency is obtained. Energy efficiency of the electrolyte containing TEAPF₆ is much higher than the electrolyte containing EMIPF₆, so TEAPF₆ are more suitable for used as the supporting electrolyte.

References

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