

Lithium/Seawater Battery with High Anodic Efficiency

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A novel lithium/seawater battery utilizing a hydrophobic, low temperature molten salt membrane/lithium anode has been developed in an attempt to minimize lithium-water parasitic reactions and hence to greatly increase lithium anodic efficiency. Almost 100% anodic efficiency was achieved with hydrophobic molten salt $\text{BMI}^+\text{PF}_6^-$ (1-butyl-3-methylimidazole (BMI^+)-based ionic liquids with hexafluorophosphate-- PF_6^-) and the membrane VLZ (VLZ-105 μm is manufactured by Nippon Kodoshi Corporation (NKK)) in artificial seawater (3% NaCl solution). The anodic current density remained stable at 0.2 mA/cm² for about 10 hours under potentiostatic discharge at +0.5V vs OCP, but thereafter, the current density quickly decreased (Figure 1). Due to the great kinetic stability of lithium in contact with $\text{BMI}^+\text{PF}_6^-$, the lithium/ $\text{BMI}^+\text{PF}_6^-$ interface could remain viable for many hours, but eventually traces of water penetrate the hydrophobic molten salt and reach the lithium surface, resulting in the formation of LiOH at the lithium/salt interface and in hydrogen evolution at the same location. The sudden increase in the interfacial impedance due to the formation of the LiOH corrosion product is postulated to be the reason for the sharp decrease of the current density (Figures 2 and 3). Impedance spectra measured before and after the potentiostatic discharge of the lithium anode system were compared and analyzed to explain the interface change in the lithium anode system. A theoretical model of the lithium/molten salt interface has been proposed to help explain the experimental results.

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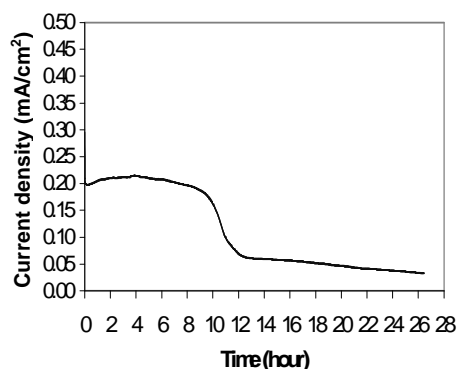


Figure 1. Polarization current density of

lithium/ $\text{BMI}^+\text{PF}_6^-$ /4-VLZ anode system with polarization potential -2.33V , SCE (before polarization, OCP= -2.83V , SCE)

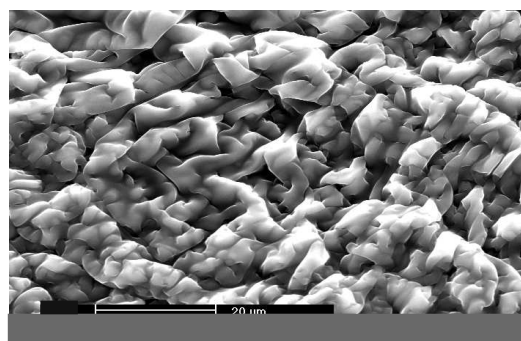


Figure 2. Li covered by $\text{BMI}^+\text{PF}_6^-$ has a “silvery” looking surface. The patterns are more separated because after “water” contaminated the sample and LiOH formed.

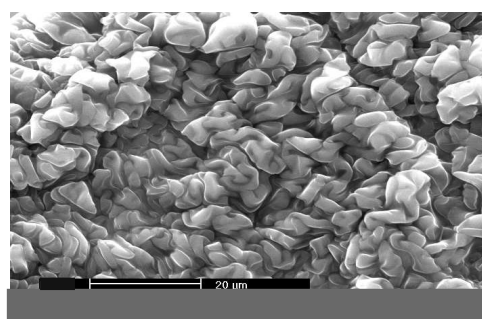


Figure 3. Pt surface covered by $\text{BMI}^+\text{PF}_6^-$ has a “silvery” looking surface.

