Abstract #483, 224th ECS Meeting, © 2013 The Electrochemical Society

PEO_{18}LiTFSI- Pyr_{14}TFSI Ternary Polymer as an Interlayer for Lithium Protected Electrode in Li-air battery

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Lithium-air battery is economical and eco-friendly because oxygen used as an active material exists infinitely and the battery has a high theoretical energy density of 11,140 $Wh{\cdot}kg^{-1}$, which is comparable with that of gasoline. In recent years, research on Li-air battery has been actively progressed. However, its performance is still limited due to problems such as the stability of lithium metal. In practical applications for electric vehicles, air containing moisture should be used. The exclusion of water from air is difficult when using a conventional filter. Lithium metal can react vigorously with the water from moisture and degrade the safety of the battery. Thus, the protection of Li metal from water is the critical problem for rechargeable Li-air batteries. The other prominent problem for rechargeable lithium-air batteries is the formation of lithium dendrite during repeated charge and discharge cycles; the dendritic Li-metal causes an internal short circuit. To overcome this problem, water stable LISICON type solid electrolyte can be employed in Li-air cell. However, the LISICON type solid electrolytes are not stable in contact with Li-metal. Thus, interlayers are needed between the solid electrolyte and Li-metal, which must be chemically stable in contact with Li-metal during operation and should have high lithium ion conductivity. PEO-based polymer electrolytes are best candidates as an interlayer. However, the conductivity of PEO-based electrolytes is lower compared to that of liquid and solid electrolytes. The PEO-LiTFSI electrolyte has the ionic conductivity of the order 10^{-6} $S{\cdot}cm^{-1}$ at room temperature. In order to use PEO-LiTFSI as an interlayer, its ionic conductivity needs to be further improved.

In the present study, N-methyl-N-butyl-pyrrolidinium bis(trifluoromethane-sulfonyl)imide (Pyr14TFSI) ionic liquid has been added to PEO-LiTFSI polymer electrolyte to increase its ionic conductivity.

The ionically conducting polymer membrane of PEO_{18}-LiTFSI- Pyr_{14}TFSI was prepared by casting technique as previously reported method [1]. Microstructure and morphology of surface were obtained by FE-SEM and optical microscope. PEO_{18}LiTFSI-Pyr_{14}TFSI was obtained by optimizing the ratio of PEO, LiTFSI and Pyr_{14}TFSI ionic liquid. The ac impedance of symmetric cell of Ag/PEO_{18}LiTFSI/Ag, Li/ PEO_{18}LiTFSI/Li, Ag/PEO_{18}LiTFSI-Pyr_{14}TFSI/Ag, Li/PEO_{18}LiTFSI-Pyr_{14}TFSI/Li, and Li/ PEO_{18}LiTFSI-Pyr_{14}TFSI/B_2O_3-LAGP/PEO_{18}LiTFSI-Pyr_{14}TFSI/Li were measured by using the ZIVE SP2 instrument in frequency range of 1 Hz ~ 1 MHz.

The stability test indicates that the PEO_{18}LiTFSI-Pyr_{14}TFSI polymer electrolyte improves the stability between the Li-metal and solid electrolyte with improved conductivity. The ac impedance and charge discharge performance measurements for Li-O_2 cell (Li/ PEO_{18}LiTFSI-Pyr_{14}TFSI/B_2O_3-LAGP/LiTFSI-TEFDME/O_2) were also carried out by using WON-A-TECH potentiostat/Galvanostat. The Li-O_2 full cell with PEO_{18}LiTFSI-Pyr_{14}TFSI polymer electrolyte exhibited a favorable discharge-charge performance.

[1] Y. Liu, Y.Takeda, T.Matsumura et.al, J.Electrochem.Soc. 153(2006) A437.