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Development of Solid Electrolytes Based on Networked Cellulose

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Abstract : Three different kinds of solid polymer electrolytes were prepared using polyethylene oxide (PEO) as a base polymer, networked cellulose (NC) as a physical support and LiClO4 as a conductive salt for the electrolytes. Networked cellulose, a modified form of cellulose, is a biodegradable and environmentally friendly additive which provides a strong fibrous networked support for structural stability of the electrolytes. Although the PEO/NC/LiClO4 electrolyte retains its structural integrity and mechanical properties at 100oC as compared to pristine PEO-based polymer electrolytes, it suffers from poor ionic conductivity. To improve the room temperature conductivity of the electrolyte, PEO is replaced by the polyethylene glycol (PEG) which is a liquid phase that provides high mobility for Li+ ions transport in the electrolyte. PEG/NC/LiClO4 shows improvement in ionic conductivity compared to PEO/NC/LiClO4 at room temperature, but it is brittle and tends to form cracks during processing. An advanced solid polymer electrolyte with optimum ionic conductivity and mechanical properties is developed by using a ternary system: TEGDME/PEO/NC+LiClO4. At room temperature, this electrolyte exhibits an ionic conductivity to the order of 10-5 S/cm, which is very high compared to that of the PEO/LiClO4 electrolyte. Pristine PEO electrolytes start melting at 65 °C and completely lose its mechanical strength. Dynamic mechanical analysis of TEGDME: PEO: NC (70:20:10 wt%) showed an improvement of storage modulus as compared to the pristine PEO in the 60–120 °C temperature range. Also, with an addition of NC, the electrolyte retains its mechanical integrity at 100 oC which is beneficial for Li-ion battery operation at high temperatures. Differential scanning calorimetry (DSC) and thermal gravimetry analysis (TGA) studies revealed that the ternary polymer electrolyte is thermally stable in the lithium ion battery operational temperature range. As-prepared polymer electrolyte was used to assemble LiFePO4/ TEGDME/PEO/NC+LiClO4/Li half cells and their electrochemical performance was studied via cyclic voltammetry and charge-discharge cycling.

Keywords : solid polymer electrolyte, ionic conductivity, mechanical properties, lithium ion batteries, cyclic voltammetry
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