

# Electric field poling TiO<sub>2</sub> and polymer complex electrolytes achieve high conductivity in lithium ion battery application

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Lithium-ion battery is an important energy storage device, widely used in electronic products. In order to improve the durability and safety, solvent free polymer electrolyte becomes one of the critical components to meet the growing challenge[1]. Although with many promising material advantages, solid polymer electrolyte is far inferior to the liquid electrolyte in ion conductivity. A second drawback is the huge interface resistance between the electrolyte and the electrodes, due to the voids created by incomplete adhesion of the two solids.

In this paper, we report a novel solid polymer electrolytes where ionic liquid [EMIM]<sup>+</sup> [FSI]<sup>-</sup> and TiO<sub>2</sub> nanoparticles[2] were impregnate with polymer blend of PVDF-HFP and PMMA. Under electric field poling, the oval shape TiO<sub>2</sub> nano-particles is re-oriented with preferentially ordered arrangement in non-crystalline regions of the polymer blends which served to facilitate fluent ion migration induced in more straight forward manner. Furthermore, high dielectric constant of TiO<sub>2</sub> nanoparticles weakens the ionic force within ionic liquid which liberates lithium ion for better transport. Both factors contributes to appreciable increase of ionic conductivity to more than  $10^{-3}$  S / cm at room temperature. In the composite electrolyte samples, ion conductivity of  $4.52 \times 10^{-3}$  S / cm at 80 °C can be achieved with addition of 3% TiO<sub>2</sub> nanoparticles.

Although the mobility of the polymer is still not high at room temperature, the ordered arrangement created by E-F poling, and the high dielectric constants originated from the nano particles establishes favorable ionic liquid conduction mechanism. In combination with the super PvDF/PMMA adhesion properties with the electrodes, the interface resistance is substantially reduced. Lithium battery half cells using the solid polymer electrolytes containing ionic liquids and TiO<sub>2</sub> particles, with lithium iron phosphate as cathode, excellent and stable cyclic capacity is found to be maintain at 140 mAh / g at 0.2 C, after 100 charged and discharge cycle.

## References:

- [1] S.V. Shalu, R.K. Singh, Development of ion conducting polymer gel electrolyte membranes based on polymer PVdF-HFP, BMIMTFSI ionic liquid and the Li-salt with improved electrical, thermal and structural properties, *J Mater Chem C* 3(28) (2015) 7305-7318.
- [2] D. Song, C. Xu, Y. Chen, J. He, Y. Zhao, P. Li, W. Lin, F. Fu, Enhanced thermal and electrochemical properties of PVDF-HFP/PMMA polymer electrolyte by TiO<sub>2</sub> nanoparticles, *Solid State Ionics* 282 (2015) 31-36.