Polymer-ceramic Composite Electrolyte for Solid-state Li-ion Battery Systems

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Recent interest in all-solid-state Li-ion batteries for automotive applications has stimulated extensive research on solid Li-ion electrolytes. The greatest challenges to the secure establishment of the electrified automobile industry are safety and te low power density of current secondary battery systems [1-3]. Thus, development of novel electrolytes and replacing the existing organic solvent based electrolyte with all-solid-state electrolyte in future battery systems is a major objective in current solid state battery research. However, complications including low conductivity because of high interfacial resistance between the electrode and electrolyte have held back the practical use of solid-state electrolytes in rechargeable solid-state Li-ion batteries (ssLiB) [4-7]. In this study the issues of high interfacial resistance have been addressed by using a polymer composite electrolyte of polyethylne oxide (PEO) containing a dissolved Li-salt ($LiClO_4$). A composite of the polymer and lithium ion conducting ceramic, $Li_{6.5}La_{2.5}Ba_{0.5}TaZrO_{12}$ (LLBTZO), was also synthesized and investigated electrochemically. Preliminary findings show that this composite material has high ionic conductivity of 1.5×10^{-6} S cm^{-1} at 22 °C with improved adhesion to Li-metal compared to a pure garnet electrolyte. Low interfacial resistance was recorded for the as-prepared solid-state electrolyte upon Li stripping/platting experiment. The low interfacial resistance could be attributed to better adhesion and wettability between the polymer layer and the lithium electrode. In the next phase of the work, battery cycling performance will be investigated by integrating the as-developed electrolyte with suitable electrode materials.

References:

[1] V. Thangadurai, D. Pinzaru, S. Narayanan, A.K. Baral, J. Phys. Chem. Lett. 6 (2015) 292–299.
[2] Z. Zhang, Q. Zhang, C. Ren, F. Luo, Q. Ma, Y.-S. Hu, Z.-B. Zhou, H. Li, X. Huang, L. Chen, J. Mater. Chem. A. 4 (2016) 15823–15828.
[3] M.B. Berman, S.G. Greenbaum, , Membranes (Basel). 5 (2015) 915–923.
[4] W. Krawiec, L.G. Scanlon, J.P. Fellner, R. a. Vaia, S. Vasudevan, E.P. Giannelis, J. Power Sources. 54 (1995) 310–315.
[5] K. Geirhos, P. Lunkenheimer, M. Michl, D. Reuter, A. Loidl, J. Chem. Phys. 143 (2015).
[6] T. Inada, K. Takada, A. Kajiyama, M. Kouguchi, H. Sasaki, S. Kondo, M. Watanabe, M. Murayama, R. Kanno 158 (2003) 275–280.
[7] C. Wang, X.-W. Zhang, a. J. Appleby, , J. Electrochem. Soc. 152 (2005) A205.