High Performance Lithium-ion Polymer Cells assembled Using In-Situ Chemical Cross-Linking without a Free Radical Initiator

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Due to their high energy density and long cycle life, lithium-ion batteries have rapidly become the dominant power sources for portable electronic devices, electric vehicles and energy storage systems. However, safety issues still prevent full utilization of these batteries. High flammability of the organic solvents used in common liquid electrolytes can lead to fires and explosions when short circuits or local overheating accidently occurs. The quest for safer and more reliable electrolyte systems is therefore urgent, and gel polymer electrolytes are promising candidates in this regard. Most efforts to increase the ionic conductivity by incorporating larger numbers of liquid electrolytes are detrimental to their mechanical properties. In order to overcome this problem, an in-situ chemical cross-linking reaction with a multi-functional acrylate has been reported [1,2]. In this process, an electrolyte solution containing cross-linking agents is injected into a lithium-ion cell, and gelation is carried out by heating the cell, which resolves the leakage problem while maintaining good thermal and dimensional stability as well as high ionic conductivity. However, this method has inherent disadvantages that the thermal curing should be performed with free radical initiators at an elevated temperature higher than 80 ^{o}C, which may induce a thermal decomposition of the salt and other undesirable side reactions. These factors can ultimately degrade the battery performance. Moreover, these problems pose serious impediments for increasing the size of the battery for large-scale applications, such as electric vehicles and electrical energy storage systems. Hence, searching for an in-situ cross-linking of an electrolyte solution without any thermal initiators at mild temperatures is of great interest.

With the goal of developing high performance lithium-ion polymer batteries, a cross-linked gel polymer electrolyte was synthesized without any initiators at 65 ^{o}C, which allowed the production of lithium-ion polymer batteries via in-situ chemical cross-linking at a low cost. As cross-linking agents, we used fluoroethylene carbonate (FEC), polyethyleneimine (PEI) with amine groups, and poly(ethylene glycol) diglycidyl ether (PEGDE) with epoxy groups. In this paper, the cycling performances of lithium-ion polymer batteries assembled by in-situ chemical cross-linking are investigated and compared with those of liquid electrolyte-based lithium-ion batteries. The results reported in this work confirm the superior performance of our gel polymer electrolyte compared to that of liquid electrolyte.

References

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