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Radiation-crosslinked nanofiber membranes with well-designed core-shell structure for high performance of gel polymer electrolytes

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Abstract: The polymer nanofiber membranes with core (polyacrylonitrile, PAN)-shell (polyethylene oxide, PEO) structure were prepared by using coaxial electrospinning under different concentration of spinning solution. The polyporous nanofiber membranes were activated in liquid electrolytes and transformed into gel polymer electrolytes (GPEs). The microstructure, crystallization behavior and mechanical properties of nanofiber membranes were studied. Based on the proper collocation of polymer materials, desirable microstructure, appropriate crystallinity and moderate radiation-crosslinking, the high saturated electrolyte uptake, conservation rate and mechanical properties of polymer membranes were obtained. The electrochemical testing of the resulting GPEs revealed high ionic conductivities, good electrochemical stability and appropriate lithium-ion transference numbers, which are realized through choosing an optimal concentration of core/shell spinning solution. Moreover, the Li/GPE/$LiCoO_2$ cells with GPEs based on the radiation-crosslinked nanofiber membranes with optimized core-shell structure showed excellent initial discharge capacities as well as remarkable cycle performance. Through the implementation of the proper collocation of two ordinary polymer materials and facile preparation techniques, comprehensive performance of the resulting GPEs was more superior to that of GPEs involved with pure PAN and commercial Celgard® 2500. The radiation-crosslinked nanofiber membranes with well-designed core-shell structure can be used as an ideal skeleton material in GPEs for lithium-ion batteries with high performance.

Keywords: Nanofiber membrane; Gel polymer electrolyte; Core-shell structure; Radiation crosslinking; Electrochemical performance

1. Introduction

Lithium ion battery has been widely used in portable electronic devices and electric vehicles because it has many advantages including high energy density, high working voltage, high efficiency, memory-effect-free and long cycle life [1,2]. In recent years, many approaches have been employed to develop polymer lithium-ion