



Contents lists available at ScienceDirect

Journal of Industrial and Engineering Chemistry

journal homepage: www.elsevier.com/locate/jiec

Improved electrochemical, mechanical and transport properties of novel lithium bisnonafluoro-1-butanefluorimidate (LiBNFSI) based solid polymer electrolytes for rechargeable lithium ion batteries

K. Karuppasamy^{a,b,*}, Dongkyu Kim^a, Yong Hee Kang^a, K. Prasanna^c, Hee Woo Rhee^{a,**}^a Polymer Materials Lab, Department of Chemical and Biomolecular Engineering, Sogang University, Mapo-gu, Seoul, South Korea^b Division of Electronics and Electrical Engineering, Dongguk University-Seoul, Seoul 04620, South Korea^c Electrochemical Energy Storage and Conversion Lab (EESC), Kyung Hee University, 1732, Deogyong-daero, Giheung-gu, Yongin, Gyeonggi 17104, South Korea

ARTICLE INFO

Article history:

Received 26 January 2017

Received in revised form 21 March 2017

Accepted 25 March 2017

Available online 4 April 2017

Keywords:

Ionic conductivity
Transference number
Electrochemical stability
Lithium ion batteries
Laviron's theory

ABSTRACT

In the present work, a new methodology for improving the ionic conductivity and cation transport properties of polymer electrolytes have been synthesized by adding bulky anion based novel lithium bisnonafluoro-1-butanefluorimidate salt and characterized for its applications in lithium ion batteries. The self-standing solid polymer electrolyte films exhibit excellent mechanical, thermal, and electrochemical stability. The ion–polymer interactions are examined thoroughly by ATR Fourier Transform-Infrared Spectroscopy. The solid polymer electrolyte prepared with EO/Li ratio 14 exhibits a highest ionic conductivity of $10^{-4} \text{ S cm}^{-1}$ at 333 K. Also, it achieves a maximum lithium transference number of 0.31 and it is electrochemically stable in the scanned electrochemical window. This new type of polymer electrolytes with high ion conductivity and improved mechanical properties paves way to be a potential candidate along with lithium anode and LiCoO_2 cathode in the lithium ion batteries.

© 2017 The Korean Society of Industrial and Engineering Chemistry. Published by Elsevier B.V. All rights reserved.

Introduction

Over two decades, research and development of ion conducting solid polymer electrolytes (SPEs) has been intensively investigated for applications in tremendous promising technologies such as rechargeable lithium ion batteries (LIBs), fuel cells, supercapacitors and dye sensitized solar cells etc. [1–5]. In recent years, most of the efforts have been focused towards the direction to develop solid polymer electrolytes having fast ionic conductivity with long term stability and to miniaturize device sizes [6,7]. These particular focuses on SPEs leading to lithium ion battery applications are due to its outstanding benefits which include greater safety than liquid electrolytes, flexibility, light weight, toxicity, and so forth associated with liquid electrolytes [8–11].

Various polymer hosts had been employed for SPE's preparation in past few decades. Amongst, poly (ethylene oxide) PEO is one of the most promising candidates due to its inimitable electrical,

electrochemical and optical properties, along with its ease of preparation and excellent environmental stability [12–15]. Unfortunately, the conductivity of typical PEO-based electrolytes is very low (10^{-6} – $10^{-5} \text{ S cm}^{-1}$) at room temperature. Besides, its lithium transference number is exceedingly low at room temperature [16]. Henceforth to overcome the aforementioned issues, various efforts have been made by the way of employing plasticizers, blending with other polymers, nanofillers along with lithium salt to suppress PEO crystallinity and thereby increase ionic conductivity as a result of higher polymer chain mobility and the resultant faster cation diffusion [1,2,6,13,14,17]. The effect of TiO_2 nanofiller on electrochemical and structural properties of PEO host matrix have been deeply investigated and reported elsewhere [17]. But, the incorporation of additives or blending in PEO host matrix not only suppresses the polymer crystallinity but also has some adverse effect on electrochemical performance and lithium ion transference number [18]. According to Mandal et al., [18] during incorporation of additives in PEO-host matrix, the lithium ion transport in PEO matrix does not occur solely as free lithium cations but in aggregates of ions of various sizes owing to reduce the lithium ion transference numbers which in turn requires more energy, time and electrochemical potential while recharge the battery. These similar disadvantages were observed by Johansson

* Corresponding author at: Polymer Materials Lab, Department of Chemical and Biomolecular Engineering, Sogang University, Mapo-gu, Seoul, South Korea.

** Corresponding author.

E-mail addresses: karuppasamyiitb@gmail.com (K. Karuppasamy), hwrhee@sogang.ac.kr (H.W. Rhee).