Iran Polym J (2016) 25:525–537
DOI 10.1007/s13726-016-0444-6

ORIGINAL PAPER

Effect of electrospinning on the ionic conductivity of polyacrylonitrile/polymethyl methacrylate nanofibrous membranes: optimization based on the response surface method

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Received: 5 December 2015 / Accepted: 24 May 2016 / Published online: 7 June 2016

Abstract A novel fibrous polymer electrolyte membrane was produced based on polymethyl methacrylate/polyacrylonitrile (PMMA/PAN) blend. This was achieved through optimization in the loadings of the two polymers and electrospinning method. Consequently, the effect of PMMA on the ionic conductivity was assessed. A quantitative relationship between ionic conductivity and the important parameters including voltage, solution concentration, and PMMA content was determined. The response surface method (RSM) was employed to obtain the quantitative relationship and to determine the ion conductivity of PAN/PMMA electrospun membrane. Analysis of variance technique was used to study the importance of parameters and their interactions. A regression model was applied to determine the most influential factors on the ionic conductivity and to find the maximum ionic conductivity of the electrolyte membrane as an optimal result. The average fiber diameter was in the range of 206–367 nm, and the membranes were associated with high porosities between 50 and 91 %, and the electrolyte uptakes were in the range of 285–460 %. For all samples, the ionic conductivity of gel polymer electrolytes at 25 °C was above the 1 mS/cm. The ionic conductivity changed with the voltage directly and with the solution concentration inversely. According to the results, the ionic conductivity showed its dependency with the PMMA content, increasing with the PMMA content up to 50 % and smoothly decreasing with PMMA further increases. Some important interactions between the parameters were also detected.

Keywords Ionic conductivity · Electrospinning · Polyacrylonitrile · Polymethyl methacrylate · Response surface method

Introduction

Conducting polymers (CPs) are a unique class of materials that exhibit electrical and optical properties of metals or semiconductors [1–3]. CPs are suitable for applications as chemical and biological sensors, electrochromic devices, and secondary battery electrodes [4–6]. On the other hand, gel polymer electrolytes (GPEs) need to be insulators of high performance with a capability of conducting ions by intrinsic ionic conductivity or by soaking electrolyte [7]. For more than five decades, liquid electrolytes have been used in various energy-related devices, such as super capacitors [8], electrochromic devices [9], dye-sensitized solar cells [10], lithium ion batteries [11, 12], and low-temperature fuel cells [13]. Leakage and volatility are the major disadvantages of liquid electrolytes, resulting in their low durability and short device lifetime. Hence, they have been almost replaced by polymer electrolytes, which are not associated with the common drawbacks of liquid electrolytes, such as evaporation, corrosion, volatility, and less flexibility. However, such solid polymer electrolytes suffer from poor conductivity at room temperature [14]. Among the numerous researches on enhancing the ionic conductivity of polymer electrolytes, gel polymer electrolytes were

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