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ORIGINAL PAPER

Preparation and characterization of proton exchange membrane by UV photografting technique

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Abstract

Ultraviolet (UV)-induced graft copolymerization of glycidyl methacrylate GMA onto poly(ethylene terephthalate) (PET) films and the subsequent sulfonation on the monomer units in the grafting chain using sulfuric acid were carried out to prepare proton exchange membranes (PEMs) for fuel cells. A maximum grafting value of 23.5% was found for 15 vol% GMA after 4-h radiation time. Optimum concentration of sulfuric acid was selected for the sulfonation reaction to be 1 mol/L based on the degree of sulfonation and the tensile strength studies of the membrane. The radiation grafting and the sulfonation have been confirmed by titrimetric and gravimetric analysis as well as FTIR spectroscopy. The maximum ion exchange capacity (IEC) of 2.085 meq g^{-1} was found at 46.99% degree of sulfonation and the maximum proton conductivity was found to be 60.35 mS cm^{-1} at 30 °C and relative humidity of 100%. The various physical and chemical properties of the PEMs such as water uptake, mechanical strength, thermal durability, free-volume content, and methanol permeability were also studied as function of sulfuric acid concentration. To investigate the suitability of the prepared membrane for fuel cell applications, its properties were compared with those of Nafion 112 as standard membrane.

Keywords Polymer electrolyte membrane · Glycidyl methacrylate GMA · Fuel cell · UV radiation grafting · Sulfonation

Introduction

Due to the increasing demand for energy because of the huge world economic growth, there have been extensive efforts to find new energy resources. Nowadays, the fossil fuel is one of the most abundant energy sources. Although it is cheap and having high energy density, its supply is limited and will be depleted. Moreover, combustion of fossil fuel emits carbon dioxide (CO_2) which has severe impacts on the environment [1], leading to a temperature increase of the earth's near surface of 0.8 °C over the past century [2]. The way to mitigate climate change and satisfy growing energy demand is to deploy renewable energy technology on a large scale [3].

Recently, the polymer exchange membrane fuel cell (PEMFC) has been the most promising and important candidate for power applications ranging from micro-power and transportation to large-scale stationary power systems for buildings and distributed generation. PEMFCs have many advantages such as low operating temperature, sustained operation at a high current density, light weight, compactness, the potential for low cost and volume, long stack life, fast start-ups, and suitability for discontinuous operation [4–12]. In a PEMFC, the electrolyte is a polymeric membrane having some special properties such as high proton conduction at the fuel cell operating temperature, low permeability to the fuel (hydrogen) and the oxidant (oxygen), enough hydration to allow good operations, and good chemical and mechanical stability for long-term operations. From the different proton exchange membranes (PEMs), perfluorosulfonated membranes like Nafion are the most used and extensively studied. But they have some drawbacks such as low stability at higher

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