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Formation of Nanochannels by Heavy Ions in Graphene Oxide Reinforced Carboxymethylcellulose Membranes for Proton Exchange Membrane Fuel Cells Applications

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Abstract : Proton exchange membranes (PEMs) operating at high temperatures above 100 °C with the excellent mechanical, chemical and thermochemical stability have been received much attention, because of their practical application of proton exchange membrane fuel cells (PEMFCs). Nowadays, a huge number of polymers and polymer-mixed various membranes have been investigated for this application, all of which offer both pros and cons. However, PEMFCs are still lack of ideal membranes with unique properties. In this work, carboxymethylcellulose (CMC) based membranes with dispersive graphene oxide (GO) sheets were fabricated and investigated for PEMFCs application. These membranes and pristine GO were studied by a combination of XRD, XPS, Raman, Brillouin, FTIR, thermo-mechanical analysis (TGA and Dynamic Mechanical Analysis) and SEM microscopy, while substantial studies on the proton transport properties were provided by Electrochemical Impedance Spectroscopy (EIS) measurements. It was revealed that the addition of CMC to the GO boosts proton conductivity of the whole membrane, while GO provides good mechanical and thermomechanical stability to the membrane. Further, the continuous and ordered nanochannels with well-tailored chemical structures were obtained by irradiation of heavy ions Kr^{+17} with an energy of 1.75 MeV/nucleon on the heavy ion accelerator. The formation of these nanochannels led to the significant increase of proton conductivity at 50% Relative Humidity. Also, FTIR and XPS measurement results show that ion irradiation eliminated the GO's surface oxygen chemical bonds (C=O, C-O), and led to the formation of C = C, C – C bonds, whereas these changes connected with an increase in conductivity.

Keywords : proton exchange membranes, graphene oxide, fuel cells, carboxymethylcellulose, ion irradiation
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