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Self-assembling sulfonated graphene oxide membranes for PEM fuel cells

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Novel sulfonated graphene oxide membranes to be used as potential alternative electrolytes for proton exchange membrane fuel cells (PEMFCs) have been developed. Currently, Nafion is the most common and used membrane in PEMFC systems due to its high proton conductivity, good mechanical behavior and adequate durability. However, it also exhibits drawbacks such as easy shrinkage and swelling upon even slight water content change and a dramatic conductivity decrease upon dehydration. Therefore, it would be desirable to find a feasible alternative for operations at high temperature and low humidity and for such purpose extensive research has been devoted for many years. Among the possible approaches which have investigated many polymers, graphene oxide (GO) seems to be a superb candidate as a novel electrolyte due to its self-assembling and mechanical properties together with the presence of oxygen-containing hydrophilic functional groups which might improve water retention. In order to show satisfying conduction and mechanical properties, GO needs to be functionalized with different acid groups tightly bound to its layers. In this work we introduced -SO_3H groups into the GO structure and identified an optimal sulfuric acid to GO ratio in the preparation route. The membranes were characterized by FTIR spectroscopy, TG-DTG analysis, XRD, SEM and EDX spectroscopy. Then, ion exchange capacity (IEC) and water uptake were measured as a function of both temperature and relative humidity. Impedance spectroscopy was also performed in order to assess proton conductivity. Such techniques evidenced that sulfonation process successfully occurred and an optimal amount of sulfuric acid for such process was identified accordingly. For the best sulfonated membrane an IEC value higher than 1 and a maximum water uptake close to 50 % were obtained; moreover a better behavior compared to Nafion was observed in terms of proton conductivity especially at low relative humidity.

Keywords: graphene oxide, sulfonation, fuel cells, electrolytes