Performance evaluation of sulfonated polysulfone/graphene oxide nanocomposite membranes as cost-effective PEMs for fuel cell application

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The environmental and performance limitations of conventional Nafion-based proton exchange membranes have provoked the search for alternative materials, which can function as electrolytes in low-cost, ecofriendly and high-performing PEM fuel cells [1]. Sulfonated polysulfone (sPSU) ionomer has recently gained great consideration since it can effectively combine large availability on the market, excellent film-forming ability and remarkable thermo-mechanical resistance with interesting proton conductive properties [2]. Despite the great potential, however, the use of sPSU as PEMs in high-temperature fuel cells is still hampered by inadequate dimensional stability and poor proton conductivity in comparison with the state-of-the-art Nafion.

Here, the dispersion of 2D platelike nanolayers in the sPSU matrix has been exploited to enhance the proton conductivity and the dimensional stability of the resulting polymer electrolyte. Taking into account the presence of a large number of hydrophilic acid groups, the addition and the homogenous dispersion of layered materials within the polymer matrix is expected to dramatically enhance the conductivity performance of the electrolytes promoting an efficient proton transport via a Grotthuss-type mechanism. At the same time, benefical electrostatic interaction between sGO platelets and the acid groups of the polymer should significantly increase the dimensional resistance [3]. Accordingly, in this work a detailed characterizzation of sulfonated polysulfone nanocomposite membranes containing sulfonated graphene oxide (sGO) is presented in terms of electrolytes morphoplogy, dimensional and hydrolitic stability, water transport properties and electrochemical behavior. In particular, molecular dynamics and proton transport mechanism were deeply studied by NMR spectroscopy through direct measurements of self-diffusion coefficients (D) and relaxation times (T_1 and T_2). The effects of dimensionality and organization of sGO nanofillers on the physico-chemical, mechanical and dimensional properties of the nanocomposite membranes were assessed by DSC, TGA, DMA and swelling tests, respectively, while the proton conductivity was determined by electrochemical impedance spectroscopy (EIS). The ion diffusivity studies, together with electrochemical characterizations, as a function of T and RH, may allow to comprehend the relationship between architecture, dimensionality, chemical structure of ionomers and nanofillers and the physicochemical properties of the resulting electrolytes.

References

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