Sulfonimide-Functionalized Polyphosphazene Blended with PVDF Membranes for PEMFCs

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Objectives

Proton conducting polymers such as Nafion™ have been extensively studied to be used in proton exchange membrane fuel cells (PEMFCs). However, Nafion is limited to operating temperatures below 100°C due to tendency of the membrane to dehydrate, resulting in decreased proton conductivity and reduced mechanical stability. To overcome these problems a number of approaches have been used to improve the Nafion-based PEMFCs. We are developing polyphosphazene-based PEMFC which was proved to be a promising fuel cell [1]. We explore polyphosphazenes because of the thermo-oxidative and reductive stability of the phosphorus-nitrogen backbone, and because of the ability of this system to permit large or subtle changes to be made in the side group structure in order to optimize membrane properties. Here we report our results to make a suitable for PEMFC applications proton conducting membrane based on sulfonimide-functionalized polyphosphazene blended with PVDF [poly(vinylidene fluoride)].

Results

Synthesis of the sulfonimide-functionalized polyphosphazene is described elsewhere [2]. In order to further improve mechanical properties and decrease the membrane swelling, the sulfonimide-functionalized polyphosphazene was blended with a non-conductive polymer such as PVDF. Blends were formed through dissolution in a common solvent, which was then solution cast and vacuum dried. Additionally, samples were exposed to various gamma radiation (cobalt 60 source) doses up to 40 Mrad. The produced membrane samples were characterized measuring the ion exchange capacity (IEC), the proton conductivity, and water swelling. Some of the results of our measurements are presented in Figures 1 and 2.

Conclusions

We have found that (1) Sulfonimide-functionalized blended with PVDF polyphosphazene is a promising proton conducting material for PEMFC applications; (2) Variations in the PVDF concentration and gamma radiation doses can significantly affect the properties of the blended proton conducting membranes; (3) A rise of acidic functionality of sulfonimide polyphosphazene (IEC) can significantly increase membrane conductivity while swelling rate of the polymer can be controlled by irradiation; (4) Blending PVDF into sulfonimide polyphosphazene can significantly reduce the water swelling and increase the mechanical strength of the membranes, while retaining the high proton conductivity of the membranes; (5) Sulfonimide polyphosphazene with IEC=1.2 meq/g blended with 20% of PVDF and irradiated at 40 Mrad showed low water swelling (30%), and high conductivity (0.052 S/cm). This material is now used for making a polyphosphazene-based PEMFC.

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References

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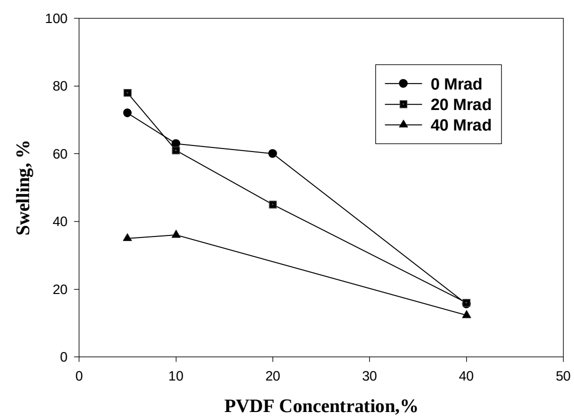

Figure 1. Swelling of sulfonimide-functionalized polyphosphazene (IEC =0.92 meq/g) blended with PVDF.

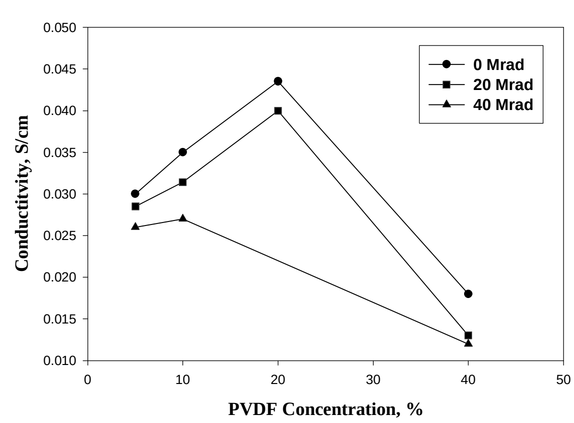

Figure 2. Conductivity of sulfonimide-functionalized polyphosphazene (IEC =0.92 meq/g) blended with PVDF.