Phosphoric Acid Doped Poly(2,5-benzimidazole) (ABPBI) and Sulfonated ABPBI Membranes for Polymer Electrolyte Fuel Cells

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The current technology in polymer electrolyte membrane fuel cells (PEMFC) is based on proton conducting membranes made of perfluorosulfonated polymers, ie. Nafion®. These membranes have two limitations. First, Nafion® and the other perfluorinated membranes are very expensive. This high cost makes difficult the commercialization of PEMFC. On the other hand, perfluorosulfonated membranes need a high humidification to keep their good proton conductivity, therefore this conductivity decay sharply above 100 ºC, and water management is very important in PEMFC. Furthermore, working over 150 - 200 ºC would benefit PEMFC because over these temperatures CO present as impurities in H_2, is not absorbed on Pt poisoning the Pt/C catalyst. These reasons have focused research to high temperature proton conductors.

When doping a membrane of commercially available PBI, it becomes a proton conducing electrolyte with good thermal and chemical stability and high proton conductivity at 80 - 200 ºC. These properties make phosphoric acid doped PBI useful for PEMFC at temperatures up to 200 ºC.(1, 2) In addition, conduction mechanism do not implies water, so water management in PBI· x H_3PO_4 PEMFC is much easier.(3)

As PBI is the only commercially available, it is the most widely studied polybenzimidazole membrane. Only phosphoric acid doped poly(2,5-benzimidazole) (ABPBI) have been studied by Savinell and Litt.(4) This second benzimidazole polymer is also a very promising proton conductor showing good thermal stability and proton conductivity at the desired temperatures of 150-200 ºC.

In this work, we report the synthesis (figure 1), membrane preparation, physico-chemical characterization (figures 2 and 3) and H_2/O_2 PEMFC test of phosphoric acid doped ABPBI and PBI (figure 4), as well as sulfonation,(5) phosphoric acid doping and characterization of previously cast ABPBI membranes. Both benzimidazole type polymers, ABPBI and sulfonated ABPBI, when doped with phosphoric acid, are as good or even better proton conductors as commercially available PBI. For this reason, ABPBI and sulfonated ABPBI are very good candidates for use in PEMFC at high temperatures, up to 200 ºC.

Aknowledgements :
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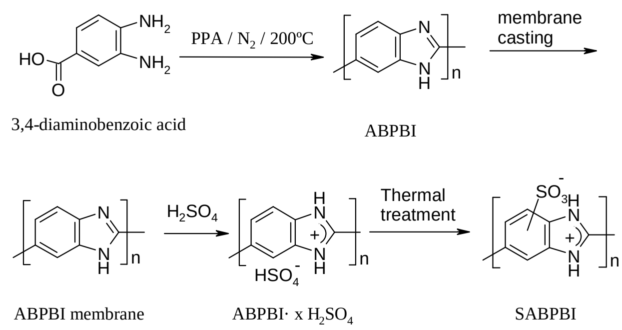

Figure 1.- Synthesis and sulfonation of ABPBI by heat treatment of H_2SO_4 doped membranes.

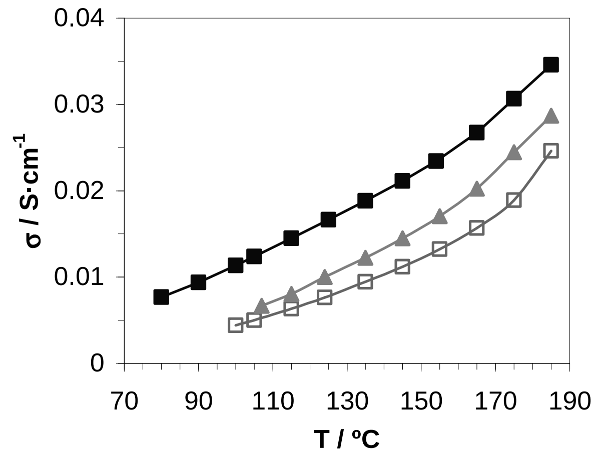

Figure 2.- Conductivity of sulfonated S-ABPBI (41 % -SO_3H)· 4.6 H_3PO_4 (■), S-ABPBI (28 % -SO_3H)· 3.4 H_3PO_4 (▲), and non sulfonated ABPBI · 2.7 H_3PO_4 (□). The three membrane were doped in the same H_3PO_4 85 % / H_2O bath for 3 days. Measures were made on the dry membranes.

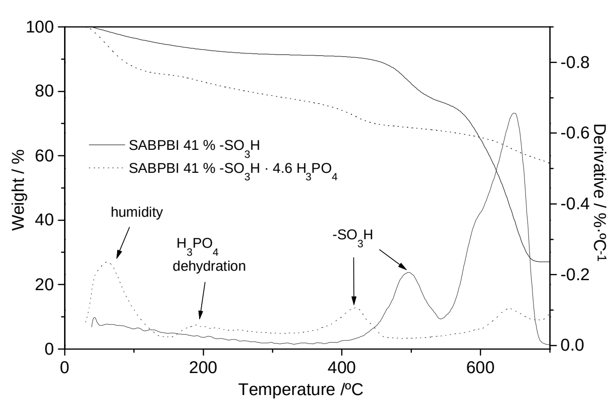

Figure 3.- TGA of SABPBI (41 % -SO_3H) and SABPBI (41 % -SO_3H) · 4.6 H_3PO_4 in air at 10 ºC·min^{-1}.

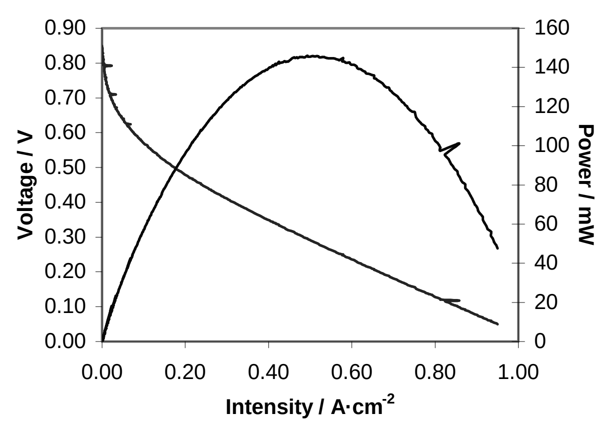

Figure 4.- ABPBI · 2.8 H_3PO_4 120 μm at 180 ºC, H_2 / O_2 humidified at room temperature. E-TEK electrodes 0.35 mg Pt·cm^{-2}.