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AFM studies of S-PEEK films for PEMFC electrolyte

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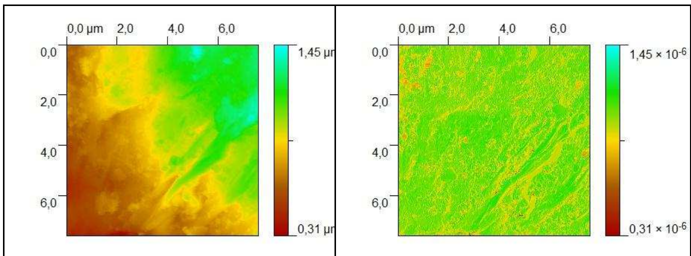
Abstract – Electrolyte membranes were made from S-PEEK prepared by sulfonation of PEEK with sulfuric acid; they were intended to be used in PEM fuel cells. The electrical conductivity of the S-PEEK membrane was measured in a home-made system, with figures as high as 1.5 Scm^{-1}. S-PEEK films analyzed by atomic force microscopy (AFM) showed very small rugosity, on the order of less than 1 μm. Furthermore, the films were apparently composed of S-PEEK of different sulfonation grades, strongly embedded in each other. The high mixture of the S-PEEK types likely provided for its high electrical conductivity.

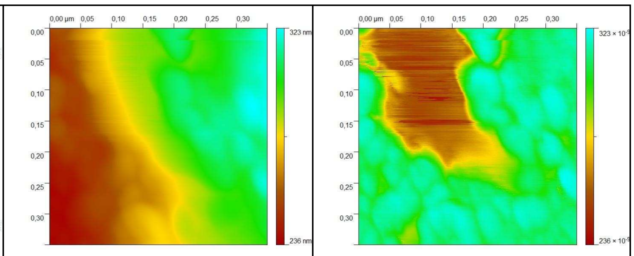
Proton exchange membrane fuel cells (PEMFC) are primarily differentiated by their electrolyte, which consists of a polymeric membrane able of transporting protons. The performance of these cells is highly dependent on the properties of the membrane, which should present good mechanical, thermal and chemical stability, all of them ensuring the cell functioning for long periods [1]. In this work membranes were synthesized from sulfonated poly-ether-ether-ketone (S-PEEK), obtained from PEEK functionalization according to Fiuza et al. [2]. PEEK was reacted with sulfuric acid, adding sulfonic groups to the polymer structure to promote proton conduction through the membrane. This electrolyte is much studied because of its good mechanical strength, high thermal stability and high electrical conductivity.

The electrical conductivity of the S-PEEK membrane was measured in a home-made system consisting of two chambers separated with the membrane. The conductivity was as high as 1.5 Scm^{-1}, measured with continuous current; it increased with increasing currency frequency, for radio frequency alternate current. The S-PEEK films were also analyzed by atomic force microscopy (AFM), using an Agilent machine, model 5500 AFM in a non-contact (AAC) mode. Figure 1 shows the AFM micrograpgy of S-PEEK surface on a large scale (8x8 μm), as Figure 2 shows the analysis for a small region (350X350 nm). The S-PEEK surface membrane was very flat, as the largest observed difference from top to valley was on the order of 1 μm (Figure 1A). The surface was likely composed of a rubber-type material well dispersed on a rigid material plane (Figure 1B), with little correlation between surface topography and composition. These same conclusions, drawn at a more striking fashion, may be seen from a small region of the S-PEEK surface (Figure 2). The almost flat surface, observed on Figure 2A, is formed of basically two types of materials, with different “tapping consistencies” (Figure 2B); the rubber-type material (brownish region) embedded in a rigid matrix (blue-green region). The two materials may be related to S-PEEK with different sulfonation grades. The S-PEEK membrane showed very little rugosity, with different types of materials strongly embedded in each other, likely providing for the high electrical conductivity of the S-PEEK membrane.



A: Topography | B: Phase

Figure 1: AFM micrography of S-PEEK surface (8x8 μm)



A: Topography | B: Phase

Figure 2: AFM micrography of S-PEEK surface (350x350 nm)

References: 1. E. G. Barreto, R. A. Fiuza, R. S. Catão, Y. Pepe, N. M. José, J. S. Boaventura, Caracterização de membranas poliméricas obtidas a partir do S-PEEK para aplicação em células combustíveis do tipo PEM, in Annals of 9° Congresso Brasileiro de Polímeros, Campina Grande, 2007. 2. R. P. Fiuza, D. Ribeiro, N. M. José, E. G. Barreto, J. S. Boaventura, PEEK based conducting polymer synthesis for application in PEM fuel cells in Annals of Fuel Cells Science and Technology - Groove Seminar, Turin, 2006.