Mesoporous silica with different surface area used as electrolyte's fillers for ethanol fuel cells application

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Abstract – Mesoporous silica (MPS) with different surface area have been prepared using pluronic F127 and pluronic F068 as surfactantants. The surface area of calcined Silica powder synthesized using pluronic F127 and pluronic F068 were about 400 and 800 m^2/g, respectively. The synthesized MPS was then used as filler for a commercial Nafion polymer. To test the effect of the specific area, the composite was characterized by thermogravimitry, DSC and impedance spectroscopy. The composite materials with low surface area show higher conductivity value.I

Many work was conducted to enhance the water retention of Nafion® and related membranes by incorporating transition metal oxide particles, such as SiO$_2$, obtaining promising results. Antonucci et al. [1] studied a silica composite membrane for direct methanol fuel cell application and they attributed the enhanced performance of the composite membrane to the hygroscopic properties of silica. Watanabe et al. [2] investigated silica and titania impregnated Nafion® composite membranes They reported that the silica particles were superior to titania particles in terms of water-retention qualities within the Nafion® membrane and attributed this effect to the higher water sorption properties of silica. Nishiyama et al [3] studied the possibility of the use of mesoporous materials for fuel cells application, they reported that the ordered structure of pores seem to contributed to the high proton conductivity of the system.

In this first part of the work, a mesoporous silica (MPS) with different surface area (SA) was synthesized and characterized, then used as a filler for commercial Nafion polymer with the aim to study the effect of the SA on conductivity behaviors in a controlled ambient (temperature and relative humidity) of the composite. Later the composite will be tested in ethanol fuel cells, to study also the effect of morphology of the filler on the ethanol cross over through the membrane.

The mesoporous silica, with medium SA and high SA were prepared using two different triblock copolymers with the trade name Pluronic F127 and Pluronic F68 (BASF Corp., USA), and TEOS as silica source in an acidic ambient. The obtained powder was then calcinated at 600 °C

The N2 adsoprtion-desorption isotherms of the two samples exhibit type IV-like isotherms, typical of ordered mesoporous materials with a sharp inflection at ,as shown in Figure.1. The surface area was analyzed by the BET (Braunauer, Emmet and Teller) method. The BET surface area data of the silica samples after the removal of the templates was about 428 m^2 g^{-1} for the silica synthesized using the Pluronic F127 and about 800. m^2 g^{-1} for the silica synthesized using the Pluronic F68.

To evaluate the influence of physico-chemical properties of the inorganic filler on the electrochemical behavior, composite recast Nafion membranes containing 5 wt.% of MPS powder was prepared and characterized by impedance spectroscopy in a controlled ambient ,as a first tool to investigate the influence of the morphology of the filler on the conductivity of the composite. In fact the conductivity behaviors is clearly affected by the morphology type of the silica (figure2). Composite material with silica with low SA show higher conductivity particularly at low relative humidity.
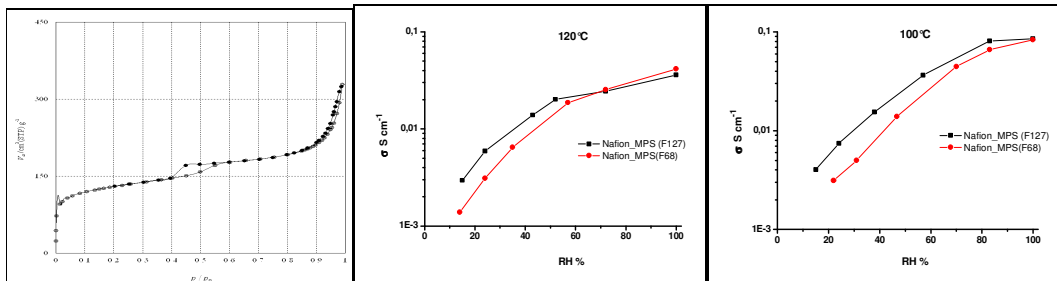
Figure 1: Nitrogen adsoprtion-desorption isotherms of MPS (Pluronic F127).

Figure 2: Conductivity dependence of the composite membrane as function of relative humidity at different temperature (at 120 °C in the left and at 100°C in the right)

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