290q Chemical and Mechanical Stability of Membranes Modified by Ion Beam Irradiation

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The effect of modifying membranes by irradiation with hydrogen ions on membrane performance is being studied here. The objective of the project is to "firm up" the membrane infrastructure since under pressure, membrane pores bend and temporarily change shape to allow large, normally rejected particles to pass through. As the ions penetrate the membrane surface, they lose energy to the membrane polymer and transfer energy to the membrane structure. This energy increase causes the membrane infrastructure to break existing bonds, cross-link internal pores, and form volatile molecules that change the microstructure of the membrane. This increase in internal rigidness of the membrane allows for a more predictable membrane permselectivity. In order to determine the stability of modifications, defined as the prevention of any deterioration incurred over time, induced by modification, modified and unmodified membranes were stored in different solutions for prolonged periods of time, and, then, they were characterized to evaluate changes. Modified membrane samples were stored in parallel with virgin membrane samples for prolonged periods of time (i.e., from 1 week up to 2 months) in dry storage (membrane samples only) as well as wet storage (i.e., solutions of pH = 3, 5, 7 and 10, of low ionic strength (DI) and high ionic strength, and of 0, 0.1 and 0.5 M chlorine) to determine if any structural and/or morphological changes occurred, as well as if the modification has been absorbed by the polymer. ATR-FTIR, AFM, SEM, contact angle and mechanical strength measurements will be performed to determine the effects of time on the modifications. Figure 1 shows a typical infrared spectrum for the virgin sulfonated polysulfone membrane obtained at the room temperature. The infrared spectrum (Fig.1) was consistent with the spectrum of the sulfonated polysulfone reported in the literature, which confirms that the membrane was made of sulfonated polysulfone. Peaks at 1041 cm-1, 1103 cm-1, 1149 cm-1, 1238 cm-1, 1485 cm-1, 2950 cm-1, 3110 cm-1,and 3380 cm-1 correspond to the presence of SO3 (sulphonic), C-O (ether), R-(SO2)-R (sulfone), C-O (ether), C=C (aromatic), CH (aliphatic), CH (aromatic) and OH stretching bonds respectively. Figure 1 also compares the infrared spectrum of the virgin and irradiated membranes membranes, which shows that peak height at 1041 cm-1 was decreased by 19% after irradiation. This decrease was due to the breakage of some of the sulphonic – benzene ring bonds due to the irradiation of the membrane, and cross liking occurs at the free sites. Changes occur only on the surface of the polymer, since ion beam irradiation was only used to modify the surface. When sulphonic bonds are broken, after ion beam irradiation, a positive radical on the benzene ring is formed and H2SO4 is released. The free radical on the benzene ring is hypothesized to bind to a unbroken free sulphonic site to increase cross linking. Thus, due to irradiation, the surface morphology of the polymer was changed and the charge of the membrane was decreased. Before testing was initiated, it was determined that the roughness values of the virgin and irradiated membranes were 3.73 nm and 4.55 nm, respectively. The roughness of the membrane remained virtually unchanged since its original roughness was low. AFM analyses for the virgin and irradiated membranes, after approximately 14 hours of testing, are shown in Figures 2 and 3. The AFM analyses show that the roughness of the virgin membrane was approximately 195.39 nm, while that of irradiated membrane was approximately 3.49 nm. Thus, cake accumulation on the virgin membrane occurred faster than and was significantly greater than on the irradiated membrane. These two analysis along with the others mentioned earlier provide a more concrete picture on what characteristic changes occurred on the membrane surface, and can determine whether these characteristic changes are any more likely to result on a post modified sulfonated polysulfone membrane than a virgin sulfonated polysulfone membrane.

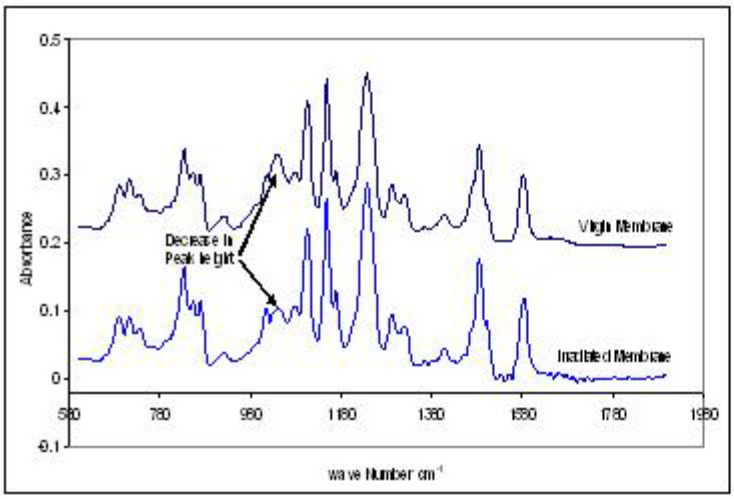

Figure 1. FTIR analyses comparing the virgin and irradiated membrane.