Effect of Multi-Walled Carbon Nanotubes on Fuel Cell Membrane Performance

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Abstract : The most promising clean energy source is the fuel cell, since it does not generate toxic gases and other hazardous compounds. Again the direct methanol fuel cell (DMFC) is more user-friendly as it is easy to be miniaturized and suited as energy source for automobiles as well as domestic applications and portable devices. And unlike the hydrogen used for some fuel cells, methanol is a liquid that is easy to store and transport in conventional tanks. The most important part of a fuel cell is its membrane. Till now, an overall efficiency for a methanol fuel cell is reported to be about 20 ~ 25%. The lower efficiency of the cell may be due to the critical factors, e.g. slow reaction kinetics at the anode and methanol crossover. The oxidation of methanol is composed of a series of successive reactions creating formaldehyde and formic acid as intermediates that contribute to slow reaction rates and decreased cell voltage. Currently, the investigation of new anode catalysts to improve oxidation reaction rates is an active area of research as it applies to the methanol fuel cell. Surprisingly, there are very limited reports on nanostructured membranes, which are rather simple to manufacture with different tuneable compositions and are expected to allow only the proton permeation but not the methanol due to their molecular sizing effects and affinity to the membrane surface. We have developed a nanostructured fuel cell membrane from polydimethyl siloxane rubber (PDMS), ethylene methyl co-acrylate (EMA) and multi-walled carbon nanotubes (MWNTs). The effect of incorporating different proportions of f-MWNTs in polymer membrane has been studied. The introduction of f-MWNTs in polymer matrix modified the polymer structure, and therefore the properties of the device. The proton conductivity, measured by an AC impedance technique using open-frame and two-electrode cell and methanol permeability of the membranes was found to be dependent on the f-MWNTs loading. The proton conductivity of the membranes increases with increase in concentration of f-MWNTs concentration due to increased content of conductive materials. Measured methanol permeabilities at 60oC were found to be dependant on loading of f-MWNTs. The methanol permeability decreased from 1.5 x 10-6 cm^2/s for pure film to 0.8 x 10-7 cm^2/s for a membrane containing 0.5wt % f-MWNTs. This is due to increasing proportion of f-MWNTs, the matrix becomes more compact. From DSC melting curves it is clear that the polymer matrix with f-MWNTs is thermally stable. FT-IR studies show good interaction between EMA and f-MWNTs. XRD analysis shows good crystalline behavior of the prepared membranes. Significant cost savings can be achieved when using the blended films which contain less expensive polymers.

Keywords : fuel cell membrane, polydimethyl siloxane rubber, carbon nanotubes, proton conductivity, methanol permeability
Conference Title : ICEMA 2015 : International Conference on Engineering Materials and Applications
Conference Location : London, United Kingdom
Conference Dates : July 25-26, 2015