Polymeric Membranes for Carbon-dioxide Separation in Alkaline Fuel Cells.

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Alkaline fuel cell (AFC) is of importance as an alternative source of energy in future, for low temperature applications. But the development of AFC, commercially, when used with H_2/air is greatly impeded by the problem of carbon-dioxide poisoning which renders a fuel cell ineffective after a certain period of operation. Several strategies have been proposed to rectify this problem, e.g., removal of CO_2 from the alkaline electrolyte using soda lime, using molecular sieves for reducing the CO_2 concentration, electrochemical removal of carbonate from the electrolyte e.t.c., but none of these paved a way for the commercialization of AFCs.

In this paper a novel method is presented for the removal of carbon dioxide from air. Oxygen selective membranes are fabricated for the purpose of filtering out CO_2 from the air that is fed to the cathode of AFCs. The main component of these membranes is a cobalt porphyrine (CoP) complex which is known to selectively attach and detach oxygen molecules to it, as shown in figure 1. These cobalt porphyrine molecules are dispersed in, Poly vinyl-pyridine, a polymer which gives structural stability to the membranes. Many such membranes are cast and then incorporated with the cathodes of fuel cells. These fuel cells are then electrochemically tested for the effectiveness of the polymer-porphyrine membranes in terms of CO_2 removal from cathode air stream.

All the electrochemical tests are carried out in a controlled atmosphere chamber. With the help of a gas proportioner a 50%O_2-50%CO_2 atmosphere is created for these tests. High CO_2 concentration is chosen in order to accelerate the process of carbon-dioxide poisoning, so that it can be monitored in a measurable time frame. Figure 2 shows the changes in the cell current density with time, for three different fuel cells. Preliminary results show that, the cell current densities decrease with time because of CO_2 poisoning, but this decrease is very prominent in the fuel cell without polymer-porphyrine membrane (refer figure 2). The current decay is less severe in the fuel cell with pure polymer membrane and even lesser in polymer membrane with porphyrine. This clearly shows the oxygen selective nature of polymer-porphyrine membranes. In this study, methanol is used as a fuel instead of H_2, accordingly the current densities shown are much lower than that the current densities given by H_2 fuel cells. Figure 3, shows the dependence of current decay rate on time. The bottom most point, in these curves, signifies maximum current decay rate. This point comes after 1.5 hours of the start of experiment in the cell without membrane and after 4 hours in the cell with polymer-porphyrine membrane. It means, if this point is taken as the reference point, we can say that carbon-dioxide poisoning is delayed by 2.5 hours in the membrane cell as compared to the membrane-less cell. For the fuel cell with the pure membrane, the point of maximum current decay rate lies in between 1.5 and 4 hours, establishing the oxygen selective nature of CoP complex.

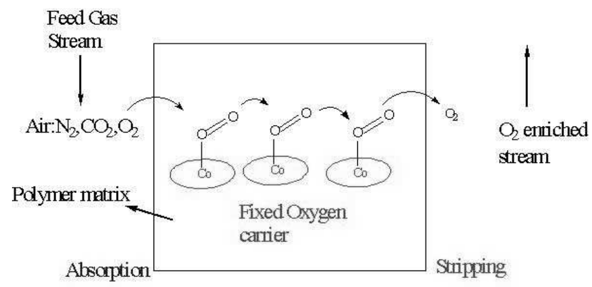

Figure 1 Schematic of oxygen transport through Fixed Carrier Polymer Membrane

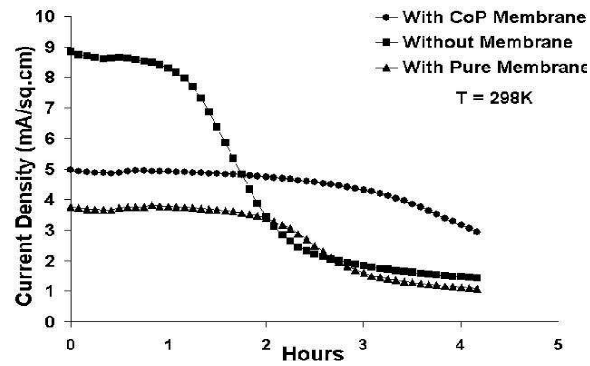

Figure 2 Current density versus time for a system with and without an external membrane/s in a 50% O_2-50%CO_2 atmosphere

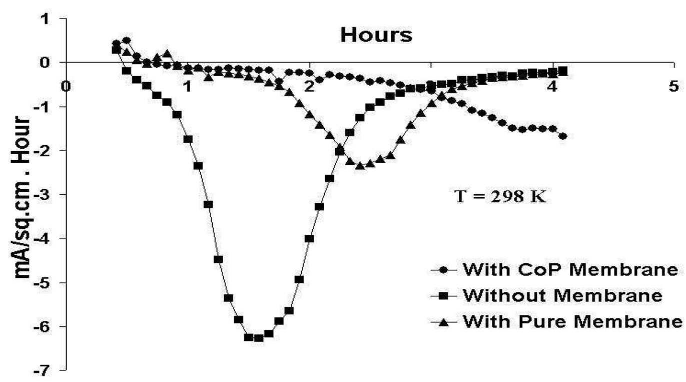

Figure 3 Degradation behaviors of alkaline fuel cells in 50%O_2-50%CO_2 atmosphere