A study of osmosis rate in several proton conducting polymer composite membranes

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Global warming and its effects are a major threat to well-being of humanity, and require urgent solutions. Reducing emissions of the main contributor to warming of the planet - atmospheric CO_2 - are likely to not be sufficient. Developing technologies for removing CO_2 from the atmosphere and reducing it to useful chemical compounds using renewable energy sources could be of major assistance in averting the climate crisis [1].

Project CO2EXIDE [2] aims to develops methods and materials for production of ethylene from CO_2, water and renewable energy. This conversion is done in an electrochemical cell, which requires several key components, one of which is a proton conducting membrane [3]. Nafion membranes are known to be the standard choice for such a task, however, alternatives are being explored as well. Sulfonated polyetheretherketone (SPEEK) is a cheaper material with many suitable properties [4].

For optimal operation of the CO_2 electrochemical reduction cell, different concentrations of electrolyte, typically $KHCO_3$, are used in cathode and anode sides. This poses a problem since osmosis is expected to occur due to concentration gradient present, which can make the membrane undergo sizeable stresses.

In this work, we aimed to quantify the rate of osmosis in SPEEK and reference Nafion membranes as well as several SPEEK/zirconium oxide composites, to evaluate possible effects of additives on the rate of osmosis. A simple two chamber cell was used, with the membranes as separators, and 1 mol/L and 2,5 mol/L $KHCO_3$ solutions as electrolytes. Concentration changes were determined indirectly, by measuring electric conductivity of electrolytes. Obtained results show a clear correlation between the zirconium dioxide content of the composite membranes and the rate of osmosis through them.

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