Composite multi-layered membranes for direct methanol fuel cells

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Abstract

Membranes to be used in Direct Methanol Fuel Cells (DMFC) require both high proton conductivity and low methanol crossover. Actual Nafion 117 membranes are conductive but leak methanol. Since methanol and hydrated proton transport occur similarly in almost all polymers, membrane selectivity improvements cannot depend only on these polymers. However, such improved selectivity can be achieved using polymer membranes loaded with selective particles. Polymer-zeolite composite membranes have been synthesized, which fulfil all requirements for DMFC operation: high selectivity, low conductance and good mechanical properties.

More specifically, a selective membrane can be synthesized using polyvinyl alcohol loaded with 50 wt% mordenite or tin-mordenite [1]. Unfortunately, such a membrane exhibits poor mechanical properties -it is noticeably prone to cracks- and has a rather low proton conductivity ($\sigma \leq 10^{-2}$ S/cm). However, sandwiching such selective membrane between two protective layers drastically improves the mechanical properties. The multi-layered membrane still exhibits interesting selectivity. The best results are obtained with a 5 10^{-5} m-thick selective central layer containing 50 wt% of tin-mordenite embedded in PVA heat-treated at 150 ^{o}C for 27 h, sandwiched between two sprayed 2 10^{-5} m-thick 10 wt% PVA in Nafion layers, heat-treated at 150 ^{o}C for 1 hour. The small concentration of PVA in the protective layer insures its satisfactory bonding with the selective layer, whereas the Nafion provides high proton conduction. The selectivity improvement over the Nafion 117 benchmark is 5.8 and 7.0 for membranes with external layers heat-treated for 1 hour under air and nitrogen respectively. These experimental selectivity results are consistent with the Maxwell theory [1].

These membranes are currently tested in direct methanol fuel cell.

***Key words*:** direct methanol fuel cell, composite membrane, polyvinyl alcohol, Nafion, tin-mordenite, selectivity

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[1] Brett Libby, Ph-D Thesis, 2001