SYSTEM ANALYSIS AS A GUIDE IN OPTIMIZING DMFC MEMBRANE PROPERTIES

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The membrane-based direct-methanol fuel cell (DMFC) currently attracts substantial R&D efforts worldwide. This paper demonstrates that membrane materials property optimization guided by system analysis is far superior to optimization efforts based on cell V-I measurements – the most common technique currently practiced to guide membrane optimization R&D.

A major focus of current worldwide DMFC R&D is to reduce the methanol permeability of the DMFC membrane -- to thereby reduce methanol "crossover" and achieve increased cell fuel efficiency. However, a combined theoretical and experimental cell efficiency analysis (by one of the present authors) in 1998 established that the DMFC fuel efficiency loss, due to methanol "crossover", is essentially eliminated by systematically controlling the methanol concentration in the methanol-water fuel mixture, as well as the fuel flow rate [1]. That analysis illustrated that the DMFC fuel efficiency can be maintained in the range of 75-95 % over a broad range of cell current density by using a system control strategy without any improvement in membrane methanol permeability properties.

This paper extends the validity of the earlier analysis by considering the energy conversion efficiency of a complete DMFC system, using a recently developed DMFC system simulation model [2] and companion DMFC cell model [3, 4]. This analysis further validates the 1998 conclusion regarding the efficacy of a fuel mixture control strategy at the system level.

In addition, it is shown that far greater system energy conversion efficiency gains will be achieved by reducing the electro-osmotic drag coefficient of the DMFC membrane -- as contrasted to reducing the methanol permeability by an equal factor.

The relative impact of these two membrane properties on DMFC system efficiency is dramatically different – with the electro-osmotic coefficient having a dominant effect on the DMFC system energy conversion efficiency, while the impact of reducing the methanol permeability is a minor change in system efficiency. This demonstrates that membrane materials property optimization guided by system analysis is far superior to the more commonly practiced optimization efforts based on cell V-I measurements.

References:

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