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Title:

HEAT AND MASS TRANSFER EFFECTS IN A PASSIVE DIRECT METHANOL FUEL CELL: A 1D MODEL

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One of the critical problems and design issues of passive direct methanol fuel cells is the water management because the presence of large amounts of water floods the cathode and reduces the cell performance. Another obstacle for DMFC development is the methanol crossover, where methanol diffuses through the membrane generating heat but no power. This problem can be limited if the cell operates with low methanol concentration on the anode. However, this significantly reduces the energy density of the system since water will produce no power. In this work, a steady state, one-dimensional model accounting for coupled heat and mass transfer in a passive DMFC is presented. Two-phase flow effects are neglected. The cell voltage expression incorporates the anodic and cathodic overpotentials as well as the ohmic losses across the membrane. The mixed potential of the cathode due to methanol crossover is also included. The reactions in the catalyst layers are considered as homogeneous. The model accounts for the kinetics of the multi-step methanol oxidation at the anode while the kinetics of the cathodic oxygen reduction is modelled using the Tafel equation. Pressure gradients across the layers are assumed as negligible. Mass transport in the diffusion layers and membrane is described using effective Fick models. Local equilibrium at interfaces is represented by partition functions. Water transport through the membrane is assumed to be a combined effect of diffusion and electro-osmotic drag. The heat transport through the gas diffusion layers is assumed as a conduction-dominated process. The thermal conductivity for all the materials is assumed as constant. Heat generation or consumption is considered in the catalyst layers. The analytical solutions for concentration and temperature across the cell are

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computed.
In this work, special attention is devoted to the effects of the methanol concentrations and the current density on the methanol and water crossover toward the cathode side. The model predicts the correct trends of the transport phenomena's in the passive DMFC and is in accordance with the experimental results and with published data. This easily implemented simplified model is suitable for use in real-time DMFC simulations in order to define the optimal operating conditions.