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Water transport through a PEM Fuel Cell: a one-dimensional model with heat transfer effects

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Abstract: (Your abstract must use **Normal style** and must fit in this box. Your abstract should be no longer than 300 words. The box will 'expand' over 2 pages as you add text/diagrams into it.)

One of the critical problems and design issues of PEM fuel cells is the water management because the membrane's hydration determines the performance and durability of the cell. In this work, a steady state, one-dimensional model accounting for coupled heat and mass transfer in a single PEM fuel cell is presented. Two-phase flow effects are neglected. The anode and cathode flow channels are treated using the continuous stirred tank reactor (CSTR) approach. The cell voltage expression incorporates the anodic and cathodic overpotentials as well as the ohmic losses across the membrane. The reactions in the catalyst layers are considered as homogeneous. The kinetics of the cathodic oxygen reduction is modelled using the Tafel equation while a modified Tafel expression is used to describe the anode losses. 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. It is assumed that the membrane proton conductivity and water diffusivity are a function of λ, the number of water molecules per ionic group. 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 computed.

Particular attention is paid to the water distribution across the membrane. The influence of different parameters (such as the current density and the level of humidification of inlet gases) over the water transport and on the cell performance is studied. The model is validated with recent published data and with experimental results obtained with an in-house designed PEMFC ($25cm^2$ of active area). This easily implemented simplified model is suitable to define the optimal hydration conditions of the membrane.