Study of voltage cycling conditions on Pt oxidation and dissolution in polymer electrolyte fuel cells

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Our study is devoted to the electrochemical behavior of platinum (Pt) catalyst layer (CL) in a polymer electrolyte fuel cell membrane (PEM) at various operating conditions and at different voltage (electric potential difference versus a reference of 0 V) cycling applied in accelerated stress tests. The degradation of platinum is described in a spatially one-dimensional model between CL-gas diffusion layer and CL-PEM interfaces. The Holby's model for unknown Pt ion concentration, Pt particle diameter, and PtO coverage ratio is considered with respect to two electro-chemical reactions: (i) the Pt ion dissolution, and (ii) the Pt oxide coverage of catalyst, with reaction rates presented by Butler–Volmer functions of exponential type.

The theoretical study of the underlying diffusion system with the nonlinear reactions is presented by analytical methods and gives explicit solutions through a first integral of the ODE system when omitting the diffusion. Numerical tests are obtained using a second order implicit-explicit IMEX scheme. The computer simulation shows a linear decay of the mean Pt mass loss ratio. The lifetime of the catalyst depends on the voltage profile and the upper potential level. By this, the degradation phenomenon would be impossible without the diffusion.

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