Assessing Performance and Degradation Mechanisms in Proton Exchange Membrane Fuel Cells

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Fuel cells, considered the next generation of power sources, exhibit high generation efficiency and low environmental impact. From the different type of fuel cells available, the Proton Exchange Membrane Fuel Cell, PEMFC, has shown rapid development in the last decade, with a great increase in the power density to specific power ratio.
Portable and mobile as well as stationary applications of fuel cells have been demonstrated. Furthermore, a variety of energy conversion applications, in association with renewable sources for fuel and oxidant supply, have been put forward and are seen as viable options in future highly distributed power generation.

A considerable research effort in Materials Science and Electrochemistry is needed in order to increase the knowledge about fuel cells lifetime and reliability. In this work, the modular character of a PEM fuel cell will serve to examine the factors affecting performance, focussing on electrode kinetics and operating conditions together with the issues of thermal and water managements. A comparison will be done for PEM fuel cells fed by gas and liquid fuels emphasizing the effect on efficiency of the electrode kinetics, arising from multi-step fuel oxidation reactions and fuel crossover.

The mechanism of ageing and degradation in fuel cells are not well understood. PEM fuel cell operates under very aggressive conditions in both anode and cathode. Increases in cell voltage leading to higher efficiencies may lead to surface oxidation of the supported catalyst, decreasing reaction activity and accelerating electrode degradation. In the case of fuel starvation, the anode potential may rise to levels compatible with the oxidization of water and if water is not available, oxidation of the carbon support will accelerate catalyst sintering. These issues will be addressed, in order to better categorize irreversible changes in the kinetic and/or transport properties of the cell, demonstrating the use of non-destructive electrochemical as well as ex-situ approaches.

The contribution of mathematical modeling in PEM fuel cells will be also emphasized, focusing the prediction of conditions for a better thermal and water management and in aiding design and operating strategies.