Reversible Fuel Cells with Mixed Proton, Oxygen Ion and Electron (Hole) Conductors for Power Generation and Fuel Synthesis

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Much of the experimental work on solid oxide fuel cells (SOFC) and solid oxide electrolyzer cells (SOEC) has been based on oxygen ion conducting solid electrolytes. The same cells can in principle be used for fuel production with a feed gas containing CO₂. Reaction equilibria at the two electrodes contain various gaseous species such as H₂, H₂O, CO, CO₂, and O₂, although membrane transport is governed by O²⁻ ions. Electrode effects are expected to be governed by various electrode reactions in which the actual charge transfer involves O²⁻ ions.

With the use of high temperature mixed proton, oxygen ion, and electron (hole) conductors such as many doped perovskites, two ionic species transport through the membrane, O^{2-} and H^+ . Thus, electrode effects are expected to be governed by various electrode reactions in which the actual charge transfer can involve two ions, O^{2-} and H^+ . The overall electrocatalysis at the two electrodes thus involves two sets of polarization resistances (and two sets of exchange current densities).

The objective of this work is to present a simple, equivalent circuit-based analysis of two modes of operation – fuel cell (power generation) and fuel production. Possible experimental approaches for the measurement of electrocatalytic effects at the two electrodes will be discussed.

Acknowledgements: This work was supported by the US Department of Energy under Grant No. DE-FG02-06ER46086.