Water Electrolysis with a Homogeneous Catalyst in an Electrochemical Cell

Christopher A. Bonino,[1] Javier J. Concepcion,[2] Andrew Miller,[1] Paul G. Hoertz,[1] James A. Trainham,[1] Thomas J. Meyer,[2] and John Newman[1]

[1] RTI International
3040 Cornwallis Rd, Research Triangle Park, NC 27709
[2] The University of North Carolina at Chapel Hill
Chapel Hill, NC 27599

Renewable-powered electrolysis is a near-term technology for liquid solar fuels. Alkaline electrolyzers use heterogeneous catalysts (e.g., Raney nickel) and corrosive electrolytes (e.g., KOH), which can have drawbacks. Specifically, replacement of spent catalyst requires shutdown of the electrolyzers. Furthermore, electrolyzer components that withstand the harsh operating conditions are costly. A homogeneous catalyst that functions at near-neutral pH has the potential to overcome these shortcomings, since it can be replenished without unit disassembly and operated with low-cost electrolyzer materials.

In this study we examine $[Ru(Mebimpy)(bpy)OH_2]^{2+}$ [Mebimpy=2,6-bis (1-methylbenzimidazol-2-yl)pyridine; bpy =2,2'-bipyridine], a homogeneous catalyst for water oxidation, using an electrochemical flow cell. The catalyst is soluble in aqueous electrolytes, including phosphate buffer solution (PBS, pH 7.8). The electrochemical cell includes a zero-gap configuration to minimize ohmic losses. The catalyst kinetics is elucidated by electrochemical methods, including polarization and Tafel plots. Current efficiencies are measured from the evolved gases. We discuss the effects of catalyst concentration on the cell performance. (Figure 1.) We also compare the catalyst performance with different electrode materials, including carbon and nickel. The development of pH gradients across the electrochemical cell from electrolysis is also discussed.

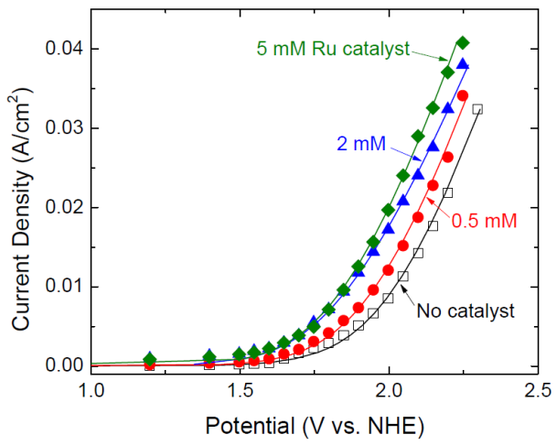

Figure 1. Half-cell (oxygen evolution reaction) polarization curves for 0 (□), 0.5 (●), 2 (▲), and 5 mM (♦) concentrations of $[Ru(Mebimpy)(bpy)OH_2]^{2+}$ homogeneous catalyst in pH 7.8, 0.2 M PBS. The carbon electrodes are separated by an anion exchange membrane.