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Development of Advanced In-Situ Techniques for Chemistry Monitoring and Corrosion Mitigation in SCWO Environments

Digby D. Macdonald
Pennsylvania State University
517 Deike Building
University Park, Pennsylvania 16802
Phone: 814-863-7772
E-mail: ddm2@psuvm.psu.edu

Karen M. Garcia
Idaho National Engineering and Environmental Laboratory
MS 3765
P.O. Box 1625
Idaho Falls, Idaho 83415
Phone: 208-526-8852
E-mail: gia@inel.gov

George Engelhardt
Pennsylvania State University
517 Deike Building
University Park, Pennsylvania 16802
Phone: 814-865-2332
E-mail: engel@essc.psu.edu

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Digby D. Macdonald, Pennsylvania State University

Karen M. Garcia, Idaho National Engineering and Environmental Laboratory
George Engelhardt, Pennsylvania State University

Research Objective

This report evaluates the two years results of our research on the development of advanced electrochemical techniques for use in supercritical water oxidation (SCWO) environments.

Research Progress and Implications

The SCWO technology was found to be a promising approach to treat a variety of hazardous wastes. However, the corrosion processes in the SCWO reactors is still a problem for further development of this technology. We have developed a flow-through electrochemical cell (FTEC) which allows us to monitor the corrosion process in real time at temperatures up to 500°C and pressures up to 400 bar. The FTEC consists of a flow-through Ag|AgCl external pressure-balanced reference electrode, a flow-through platinum hydrogen electrode, an yttria-stabilized zirconia pH sensor and an electrochemical noise sensor. The new FTEC has been designed to serve as a measurement vessel for our high temperature and high pressure circulation once-through flow loop and titanium alloy was chosen as the construction material. The FTEC, shown schematically in Figure 1, is used for our experiments. Two HPLC pumps are employed in the system, one for pumping the reaction solution through the loop and the other for pumping the reference solution through the reference electrode. The system pressure is sustained as a constant via a back pressure regulator. The temperature was measured using a thermocouple installed at the center of the FTEC.

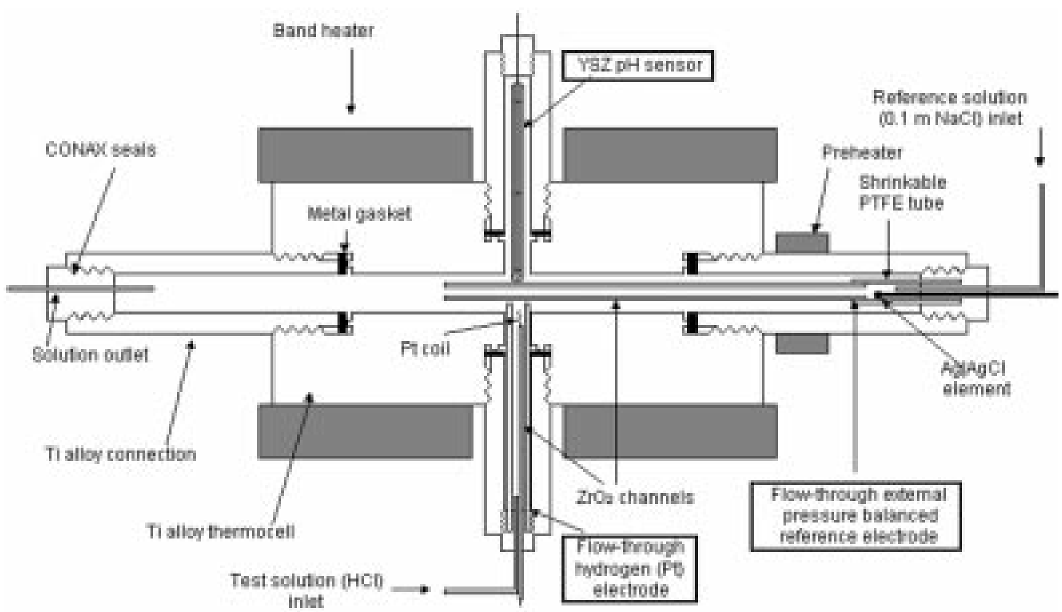

Figure 1. Diagram of the flow-through electrochemical cell (FTEC).

Because many physico-chemical processes, including corrosion, are sensitive to the pH, the measurement and control of pH is very important for the high temperature SCWO environment. We have measured [1] the potentials of the FTEC for several HCl(aq) + NaCl(aq) solutions of different concentrations of HCl(aq) and derived the corresponding pH differences (ΔpH) over a wide range of temperatures at pressure around 350 bar. Comparison of the experimentally derived and theoretically calculated ΔpH values presented in Figure 2 clearly demonstrates the ability to measure pH with a high accuracy (better than ±0.05 pH units). This result also shows the viability of the developed FTEC as a versatile potentiometric system for use at supercritical temperatures. During the next year of the project we will address the problem of electrochemical noise measurements and monitoring corrosion processes that occur on metallic materials exposed to super critical water.

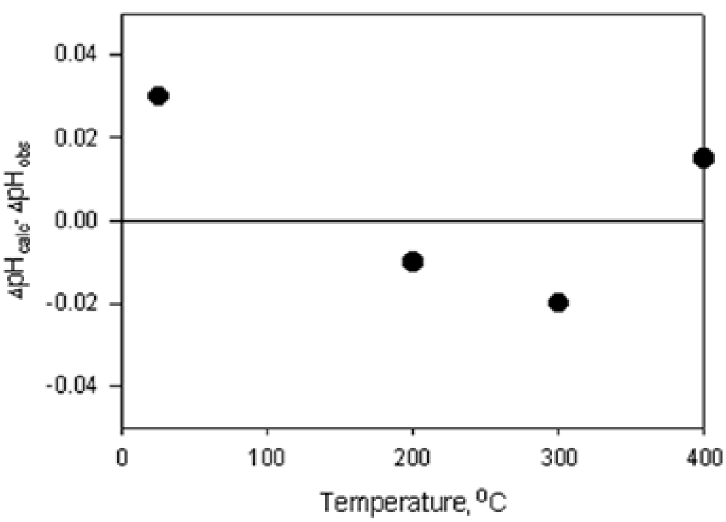

Figure 2. Comparison between theoretically calculated and experimentally measured differences in pH (ΔpH): ΔpH= pH(0.01mHCl+0.1mNaCl)-pH(0.001mHCl+0.1mNaCl).

[1] S.N. Lvov, X.Y. Zhou, and D.D. Macdonald, Potentimetrioc pH Measurements in Supercritical Aqueous Solutions, In: Proc. of the 193rd Meeting of the Electrochemical Society, San Diego, 1998, Abstr. No. 1016.

Planned Activities

During the next year of the project, we will address the problem of electrochemical noise measurements and monitoring corrosion processes that occur on metallic materials exposed to super critical water.