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Effect of Soaking in Hot Saline Solutions and Humid Atmospheres on the Passive Film Behavior of a Ni-Cr-Mo Alloy

Pallavi Pharkya, Joe H. Payer
Department of Materials Science and Engineering,
Case Western Reserve University
10900 Euclid Avenue, Cleveland OH 44106

Alloy 22, a Ni-Cr-Mo alloy, is the candidate material for fabrication of canisters for disposal of high-level and spent nuclear fuel waste in the proposed Yucca Mountain repository in Nevada. This paper investigated the passive film behavior and corrosion properties on Alloy 22 as a function of soaking in hot, saline environments and in hot, humid atmospheres. Environmental parameters include potential, temperature, pH in chloride and multi-species solutions. Hot, humid exposures are planned for temperatures up to 300 °C. Soaking times are planned to extend for up to 1000 hours. This work is part of a multi-investigator study to determine the durability of passive films and localized corrosion processes in metal exposed to moist particulate and deposits[1].

Of particular interest are the long-term stability of the passive film and the effects of soaking in aqueous solutions or hot, humid atmospheres. A combination of electrochemical methods measure changes in passive film properties, and a combination of surface analysis techniques are used to characterize the film composition and structure. Electrochemical methods include Potentiodynamic Polarization tests for the general corrosion behavior; along with Electrochemical Impedance Spectroscopy (EIS) and Mott-Schottky (M-S) analysis for electronic properties of the passive films. Alterations in the chemical composition and structure of the passive film are characterized using X-ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES) and Transmission Electron Microscopy (TEM).

Results for freshly formed films are shown in figure 1. The EIS results show that the interfacial impedance increased with increasing potential to maximum within the passive range and then decreased as the potential was increased further. Interfacial impedance was found to decrease with increasing temperature. Mott-Schottky analysis indicated that the oxide film which is n-type in the passive region changes to p-type in the transpassive region. Figure 2 shows the representative chemical soaking results at 90°C for up to 240 hours; the interfacial impedance increased with soaking time.

Results from this work are combined with those from collaborative studies to correlate the passive film properties with the resistance to localized corrosion using multi-crevice assemblies and micro-corrosion cells. The passive film growth and dissolution are interpreted with reference to processes based on the point defect model.

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Reference
1. DOE OST&I Annual Report 2005, Office of Civilian Radioactive Waste Management (OCRWM), 2006

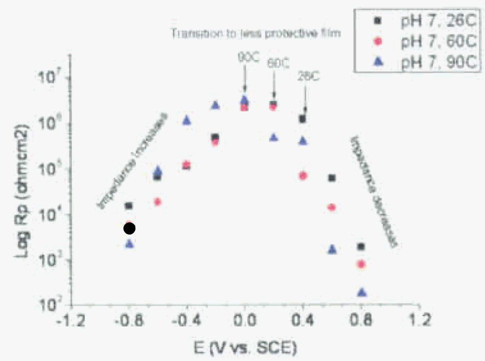

Figure 1. Interfacial impedance of the passive film on alloy 22 as a function of applied potential and temperature in 5M NaCl (pH = 7). The potential applied was from open circuit potential to just below transpassive potential and the temperatures investigated were 26 °C, 60 °C and 90 °C.

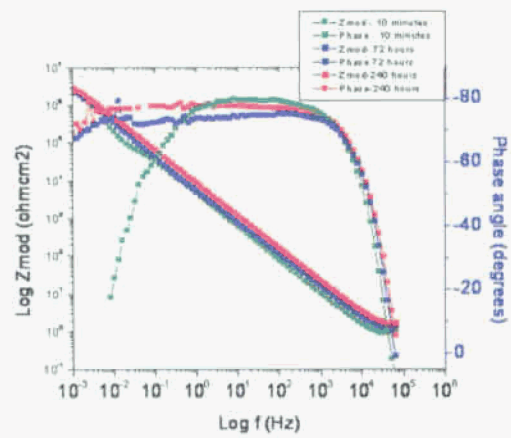

Figure 2. EIS behavior as function of chemical soaking of the passive film on Alloy 22 with time in 5M NaCl (pH = 7) at a constant potential, 0.15Vsce and temperature, 90 °C.