ELECTROCHEMICAL IMPEDANCE STUDY OF ALLOY C-22 IN PROTOTYPICAL HIGH LEVEL NUCLEAR WASTE ENVIRONMENTS

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Alloy C-22 has emerged as the material of choice for the fabrication of canisters for the disposal of High Level Nuclear Waste (HLNW) in the Yucca Mountain Repository in Nevada. This nickel-based alloy, which contains chromium (20.0-22.5 %), molybdenum (12.5-14.5 %), tungsten (2.5-3.5 %), and iron (2.0-6.0 %) as major alloying elements, displays excellent corrosion resistance when in contact with saturated, low pH brines and other solutions at temperatures up to at least 100 ^{o}C. The corrosion resistance can be attributed to the high stability of the Cr_2O_3 passive film that forms on the alloy surface. The passive film is such that general corrosion rates corresponding to a few tens of nA/cm^2 are commonly observed in the steady state, even under severe environmental conditions. In order to better understand the origin of the high corrosion resistance of Alloy C-22, we report here an electrochemical impedance study of this alloy in saturated NaCl solutions (6.2 m) at 80 ^{o}C under de-aerated conditions, and as a function of potential across the passive range. As expected, the polarization resistance (R_p) decreases with the increasing the bias potential. When the bias potential is increased from +498 mV to +998 mV, which is greater than the passivity breakdown voltage, the value of R_p decreased by three-fold. The sudden decrease in R_p upon entering the transpassive state is attributed, according to the predictions of the Point Defect Model (PDM)[1], to thinning of the passive film due to enhanced dissolution, in which Cr(III) in the passive film is oxidized to Cr(IV) in the solution. Of considerable interest is the pseudo-inductive loop that appears in the impedance locus at low frequencies and at high potentials for polished surfaces, because the loop is not observed for as-received surfaces. This indicates that the air-formed oxide film on the alloy surface may have substantially different structural and impedance properties than does the anodically formed film and hence it is of considerable interest to ascertain whether both types of behavior can be accounted for by a single model for the interface. Analysis of the data in terms of the Point Defect Model is described in another contribution to this symposium.

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[1] D. D. Macdonald, Pure Appl. Chem., **71**, 951 (1999).