ANALYSIS OF ELECTROCHEMICAL IMPEDANCE DATA FOR IRON IN BORATE BUFFER SOLUTIONS

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Carbon steel is used extensively for the fabrication of tanks for the storage of High Level Nuclear Waste (HLNW) in the Hanford Reservation in the State of Washington. Carbon steel generally displays good corrosion resistance in alkaline environments, particularly if the pH does not exceed 13 and if the temperature is lower than about 200 ^oC. Although carbon steel does not exhibit as great a corrosion resistance as does nickel in alkaline environments, its lower cost made it the material of choice for storage of liquid HLNW. The corrosion resistance can be attributed to the high stability of the passive film that forms on the alloy surface. The barrier layer of the passive film is generally recognized as being defective magnetite ($Fe_{3+x}O_{4-y}$), where the principal defect is probably the metal interstitial ($x > y$), although a significant contribution to the defect structure may be made by oxygen vacancies. Both defects give rise to the observed n-type electronic character of the barrier layer, such that their differentiation has proven to be very difficult. In any event, the passive film is such that general corrosion rates corresponding to a few tenths of $\mu A/cm^2$ 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 iron in alkaline environments, and to make available critical data for modeling the corrosion behavior of HLNW storage tanks over the design life of 100 years, we have measured electrochemical impedance data on iron in borate buffer solutions at 25 ^oC and as a function of potential across the passive range. We report here optimization of the Point Defect Model (PDM)[1] on the data, including the extraction of values for various parameters contained within the PDM. The parameter values are now being used to model the steady state and transient behavior of carbon steel in alkaline HLNW environments, in order to predict the accumulation of general corrosion damage over the 100-year design life of the storage tanks.

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