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Copper corrosion in bentonite /saline groundwater solution- The effect of the environment and electrode geometry

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Copper is the material chosen for the fabrication of nuclear waste disposal containers in Sweden. The corrosion rate of pure copper has been followed for a period of more than three years[1] using thin electrical resistance (ER) sensors placed in a test package containing an oxic bentonite clay/saline groundwater environment at room temperature. A series of electrochemical impedance spectroscopy (EIS) measurements has also been performed on these sensors. After three years the estimated corrosion rate obtained from the ER measurements was 1.0 µm/year. Rates were also determined from EIS measurements, and fell in the range between 0.4 and 0.7 µm/year. However, an appropriate physical interpretation of the equivalent circuit used to extract these values remained unresolved.

To resolve this issue a series of laboratory studies is underway to determine the mechanism of cuprous oxide film formation, and how it varies between saline groundwaters and a system in which the transport of ions, oxidants and soluble corrosion products to and from the corroding interface is limited (e.g., in bentonite, saturated with saline groundwater). Also, different geometries of the copper electrodes (electrical resistance (ER) probes and copper discs) have been studied in order to understand the importance of geometrical effects on the impedance response.

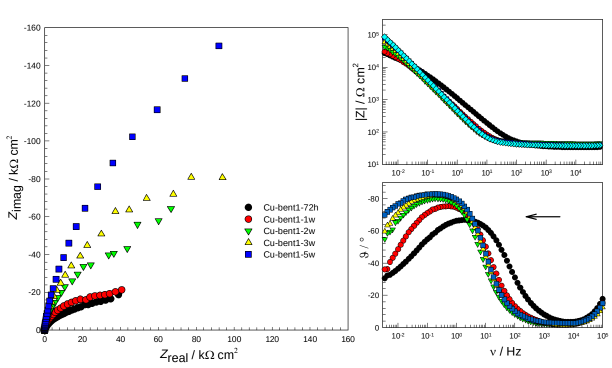

Figure: Impedance data for copper exposed to bentonite/saturated with saline groundwater for 6 weeks

Different electrochemical techniques, including EIS, have been applied to determine the initial mechanism of copper corrosion in oxic saline environments with and without the addition of bentonite. The composition and physical properties of the surface film on the copper electrodes was determined by Raman spectroscopy, X-Ray photoelectron spectroscopy and FIB/SEM analyses after a 6-week exposure period. These results will aid in the interpretation of the impedance spectra observed on the ER sensors exposed to compacted bentonite for more than 3 years.

Keywords: Copper, Electrical resistance sensors, bentonite, saline groundwater, electrochemical impedance spectroscopy

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References:

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