Impact of NaOH (aq) short-term washing of βFeOOH on its ability to corrode iron

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Upon excavation archaeological iron normally contains soluble chloride, making it highly unstable in its post-excavation environment. Long-term treatments aimed at controlling archaeological iron corrosion include aqueous washing methods designed to remove soluble chloride. Most often these involve using either NaOH or $NaOH/Na_2SO_3$ to create alkaline conditions that aid the removal of chloride ions. Chloride occurs within objects in a number of forms: as counter ions in solution to balance Fe^{2+} produced at anodes on the metal surface when sufficient moisture is present in the object; as highly soluble $FeCl_2.4H_2O$ when conditions are sufficiently dry; adsorbed onto insoluble βFeOOH and occluded in its crystal structure; adsorbed onto αFeOOH in small amounts (0.2% maximum).

While soluble chloride bearing compounds can cause corrosion in high relative humidity (RH), hygroscopic compounds such as $FeCl_2.4H_2O$ and βFeOOH are problematic at low humidity. Mobile surface adsorbed chloride on hygroscopic βFeOOH allows it to corrode iron at humidities as low as 15% RH and $FeCl_2.4H_2O$ corrodes iron to 20% RH. While $FeCl_2.4H_2O$ readily solvates in water or NaOH (aq), washing βFeOOH in deionised water for a few hours has been shown to remove most of its soluble surface adsorbed chloride and greatly reduces its ability to corrode iron.[1] The work here explores how short term washing βFeOOH in NaOH solutions of differing molarities impacts upon its ability to corrode iron at high RH.

A range of NaOH molarities were used to provide differing hydroxyl ion concentrations in the wash solutions, which were standardised to run for 24 hours per sample. The corrosion rate, at 80% RH, of iron powder mixed with washed βFeOOH samples was recorded by measuring oxygen consumption of samples in reaction vessels, using a remote sensing technique. Unwashed βFeOOH samples and βFeOOH washed in deionised water were used as controls and comparators. The amount of chloride removed in each 24 hour wash was measured and related to the corrosion rates of iron mixed with the washed βFeOOH samples. The dataset was used to identify relationships between removal of chloride from βFeOOH as a function of NaOH molarity and subsequent changes to its ability to corrode iron.

A complex set of variables, which include morphology and composition of the corrosion product layers, chloride location and form and concentration, mean optimum removal of chloride from archaeological iron by alkaline wash treatments can take months. This study adds to understanding of such treatments by offering clear guidance on how short-term washes of archaeological objects in NaOH impact on the ability of insoluble βFeOOH to corrode iron.

Watkinson, D. and Emmerson, N. (2016) The impact of aqueous washing on the ability of βFeOOH to corrode iron. Journal Environmental Science and Pollution Research. https://link.springer.com/content/pdf/10.1007%2Fs11356-016-6749-3.pdf