Towards quantitatively assessing the success of dodecanoic acid as an inhibitor for the treatment of archaeological iron nails

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Controlling the post-excavation corrosion of archaeological iron nails infused with chloride ions from their burial environment is a longstanding problem. While desiccation is proven to prevent corrosion, it requires significant outlay and ongoing management for its continued success[1]. Desalination enhances stability but treatment effectiveness is unpredictable[2]. Inhibitors potentially offer a labour saving cheap solution for long-term storage of archaeological iron objects, with the ideal treatment being immersion in the inhibitor to deliver an object that is stable in aggressive relative humidity (RH). Unfortunately, inhibitors may change object aesthetics, pose health risks and there is limited quantitative evidence-based assessment of their effectiveness on archaeological iron. Recently, attention has turned to low toxicity natural inhibitors.

Linear sodium carboxylates have shown effectiveness on modern steel analogues and archaeological surfaces when tested by electrochemical immersion techniques[3]. This study determined quantitatively the impact of a standardised dodecanoic acid treatment on the corrosion rate of 20 archaeological nails from the Roman site at Caerleon (South Wales). Prior to treatment, individual corrosion rates were determined by sealing each nail in its own reaction vessel with the interior controlled to 80% RH, then remotely recording oxygen depletion inside the vessel via light striking an oxygen sensor within it. Treatment of each nail involved an aqueous 0.1M dodecanoic acid solution, with pH adjustment to manipulate solubility and prevent gelling. Each nail was immersed in its own 100ml dodecanoic acid solution for 24 hours followed by controlled 12 hour desiccation prior to re-measuring oxygen consumption rates at 80% RH.

No object ceased to consume oxygen. Seventeen nails (85%) returned lower oxygen consumption rates but with no discernible pattern, as both major and minor rate reductions occurred. Three nails (15%) had increased corrosion rate. The nature, form and location of chloride in archaeological iron and corrosion layer composition and morphology introduce a wide range of sample variables that are considered when discussing outcomes. Although reproducibility limitations exist, this methodology offers an evidence based route for predicting the success of an inhibitive system in its working context.

1. **Watkinson D. and Lewis M. 2005** Desiccated storage of chloride contaminated archaeological iron objects. *Studies in Conservation*, **50** 241-252
2. **Rimmer M., Watkinson D. and Wang Q. 2013** The impact of chloride desalination on the corrosion rate of archaeological iron. *Studies in Conservation*, **58** 326-337
3. **Brantes L. and Melato A. 2013** Coatings including carboxylates for the preservation of metallic heritage artifacts. In Dillmann P., Watkinson D., Angelini E., Adriaens A. (eds), *Corrosion and Conservation of Cultural Heritage Metallic Artifacts*. EFC Series No. 65, 518-539, Woodhead