Investigation of Sodium Dodecyl Sulfate and Hostacor® IT as Flash Rust Inhibitors for Rinsing Archaeological Iron

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Introduction

Lepidocrocite, known as flash rust, is a type of corrosion that can appear suddenly when iron is exposed to high moisture levels. It is a common problem for conservators rinsing wet archaeological iron. Corrosion inhibitors could be an effective addition to the treatment procedure.

Hostacor® IT has been tested and used in the conservation of composite wood and iron objects. The surfactant sodium dodecyl sulfate (SDS) has been used as a corrosion inhibitor for copper in acidic solutions. It was investigated as an alternative because it has more desirable properties than Hostacor® IT (Table 1). The aim of this experiment was to determine if SDS is as effective as Hostacor® IT as a corrosion inhibitor for iron with the goal of finding a suitable product that will improve rinse procedures for archaeological iron artifacts.

Corrosion inhibitors	Advantages	Disadvantages
Hostacor® IT	- Known to be effective - Tested industrial product	- Expensive - Difficult to obtain - Needs environmentally safe disposal
Sodium dodecyl sulfate	- Inexpensive - Easily obtained as Orvus® WA paste - No disposal concerns	- Unknown efficacy as a corrosion inhibitor for iron

Table 1. The two potential corrosion inhibitors chosen for testing.

Experimental Design

Samples: 54 cold rolled steel 2x2 inch coupons were used. The coupons were degreased with ethanol. 1/3 of the coupons were left as bare metal, 1/3 were scratched with sandpaper, and, 1/3 were corroded for 3 months with daily spritzes of water.

Solutions: 4 concentrations of SDS were tested against a control (tap water) and a 1% solution of Hostacor® IT. Two SDS solutions were below the critical micelle concentration (CMC), and two were above (Table 2). The formation of micelles is a factor in the effectiveness of surfactant corrosion inhibitors. The CMC of SDS is 2.34 g/L.

Coupon type	Tap water	SDS 0.1% (w/v)*	SDS 0.2% (w/v)*	SDS 0.5% (w/v)	SDS 1% (w/v)	Hostacor 1% (v/v)
Corroded Metal	3	3	3	3	3	3
Scratched Metal	3	3	3	3	3	3
Bare Metal	3	3	3	3	3	3

Table 2. Number of samples by coupon type and by solution. Solutions with asterisks indicate those below the CMC. This table corresponds to the layout used for the experiment seen in figure 2.

Procedure: Each steel coupons was placed into one of the solutions for a 12-hour period. Samples were evaluated visually and photographed every hour to assess the development of flash rusting. The coupons were visually divided into 9 sections and each section was evaluated using a scale between 0 and 5 (Fig.1).

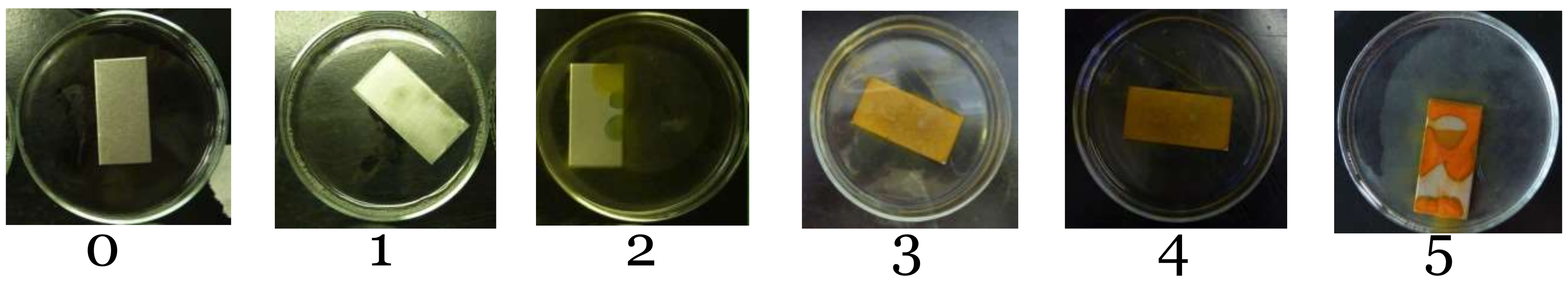

Figure 1. Visual scale for rating the intensity of flash rusting. 0= no rust. 1= rust had initiated. 2= rust was translucent, and orange or grey. 3= rust was thicker but still translucent, and orange-brown. 4= rust was thicker, opaque, and orange-brown. 5= rust was thicker, opaque, and bright orange. The scale indicates that a given level of rust intensity was present in a section, although it did not necessarily cover the entire section's surface.

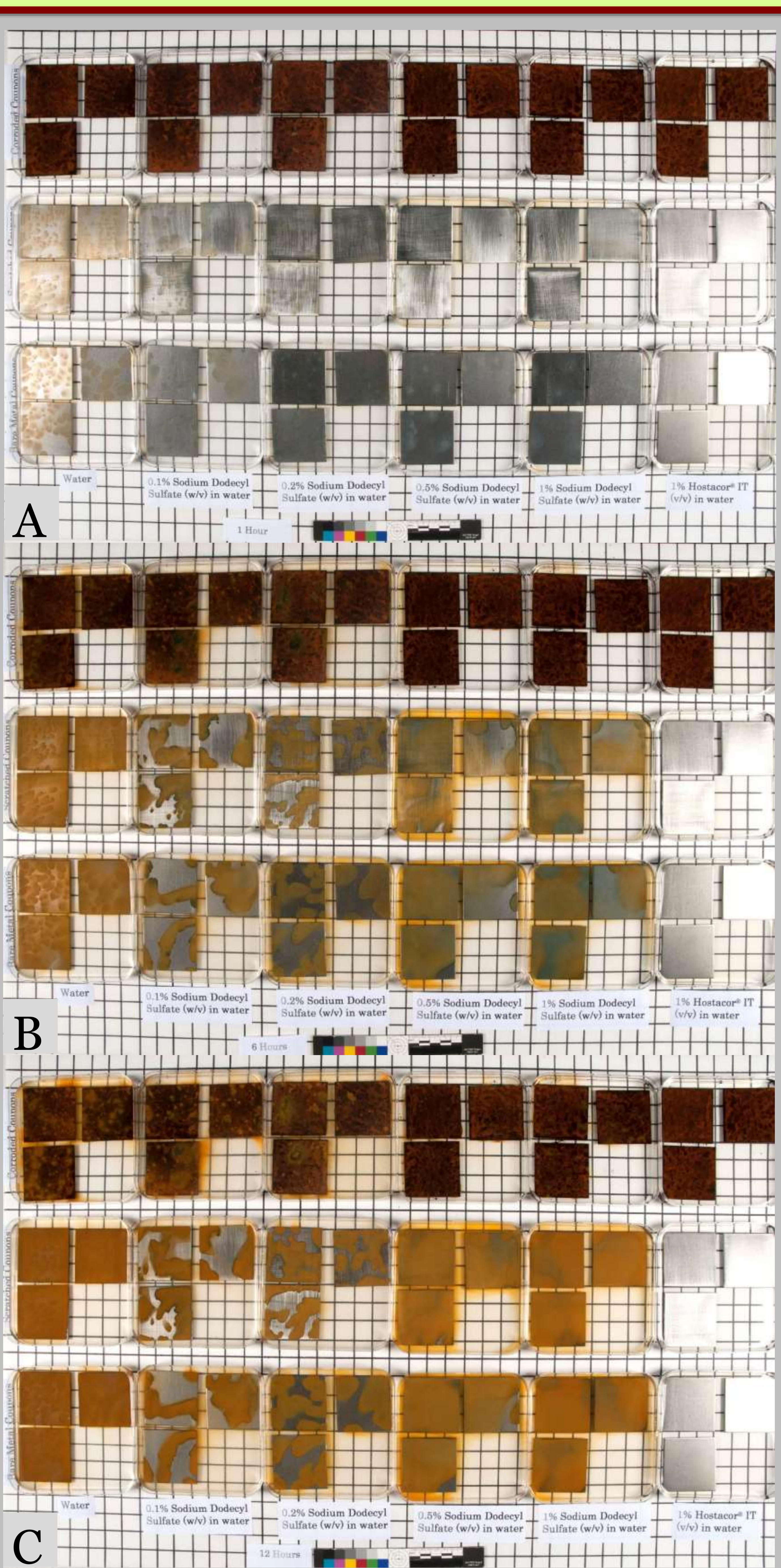

Figure 2. Photographs of experiment progress at (A) hour 1, (B) hour 6, and (C) hour 12. Solutions and samples were arranged in the same layout as shown in Table 2. At hour 1 (A), no initiation of rust was visible on the corroded coupons. At hour 6 (B), rust development on the corroded coupons in water and in the lower concentrations of SDS was comparable, while rust had just initiated on the corroded coupons in the higher concentrations of SDS. At hour 12 (C), rust was thicker and more developed on the corroded coupons in water and the lower concentrations of SDS, while it had not progressed much further on the corroded coupons in the higher concentrations of SDS.

Results and Discussion

Flash rust developed on all three types of coupons over time (Fig. 2). As expected, the coupons in tap water began to rust immediately while coupons in 1% Hostacor did not rust.

The coupons in the lower concentrations of SDS (0.1% and 0.2%) behaved differently than those in the higher concentrations (0.5% and 1%). On the bare and scratched coupons, the samples in water and low concentration SDS initiated rust more quickly, however by hour 12 it was the coupons in the higher concentration SDS that most closely resembled those in water (Fig. 2).

The corroded coupons, which most closely resemble archaeological iron artifacts, did not follow the same trend as the bare and scratched metal coupons (Fig. 2). The CMC of SDS is relevant to the observed results. The corroded coupons in SDS solutions under the CMC (0.1% and 0.2%) rusted at a rate similar to those in water. The corroded coupons in SDS above the CMC (0.5% and 1%) rusted at 1/3 the rate of those in water (Fig.3).

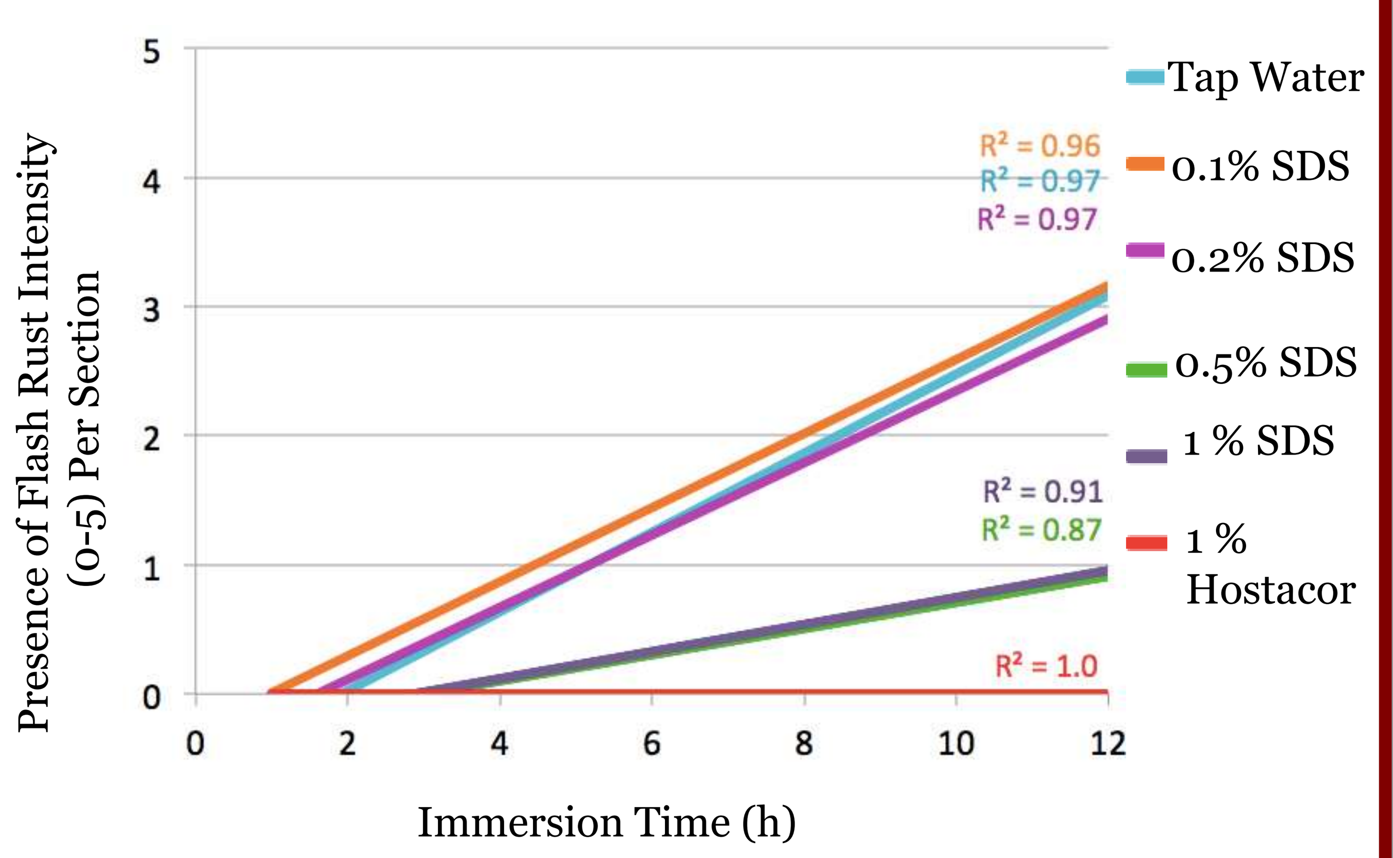

Figure 3. Observed flash rust on corroded coupons over time.

Conclusions

Although SDS is not as effective as Hostacor® IT at inhibiting flash rust, the results of this study show it has potential as a corrosion inhibitor additive for archaeological iron rinse procedures. SDS at concentrations of 0.5% and 1% noticeably slow the rate of rust production on corroded steel surfaces, which would reduce the necessity of removing flash rust mechanically after rinsing. Mechanically reducing flash rust puts the object at greater risk, and minimizing this step would be beneficial, particularly for sensitive or friable objects.

Hostacor® IT would be the more effective corrosion inhibitor for this purpose, but its disadvantages are substantial. SDS is readily available at a reasonable cost in the product Orvus® WA paste. These factors, along with the ease of disposal for Orvus® WA paste make it a more appropriate choice given its efficacy at concentrations above the CMC. Further research is still necessary to evaluate the effect of SDS residues on archaeological iron objects.

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