Low-VOC Clear Coatings on Mild Steel for Applications in Outdoor Sculpture Conservation: Evaluation and Comparison

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Introduction

This pilot project investigated relatively environmentally friendly coatings for application on modern outdoor metals. The properties of the coatings listed below were evaluated visually while coating efficacy was determined through natural outdoor aging for two-weeks in winter conditions in Kingston Ontario.

Permalac Original Clear Coat Satin

- Acrylic Film Coating, with toluene, n-butyl acetate, and methanol carriers
- Not-rated Low-VOC (Volatile Organic Compound)
- Original formulation with recorded use in conservation

Permalac NT (No-Toluene) Satin

- Acrylic Film Coating, with methyl-based solvent carriers
- Certified ultra-low VOC
- Contains other materials for stabilization, like silicon dioxide

Ship-2-Shore Corrosion Shield

- Calcium alkylarylsulfonate/carboxylate compound in aliphatic hydrocarbon solvent carriers
- Certified ultra-low VOC
- Functions through polar bonding to metal substrate, producing a hydrophobic monolayer on surface

Sample Preparation

- Each coating sample set had 7 coupons
- Samples were coated on both sides following the manufacturers' instructions (using brush application)
- Previous to coating, each coupon was rinsed with ethanol and acetone.
- 5% oxalic acid solution in distilled water, was used to remove any residues from previous studies. Loose corrosion products were reduced with a Scotch-Brite abrasive pad.

Fig. 1

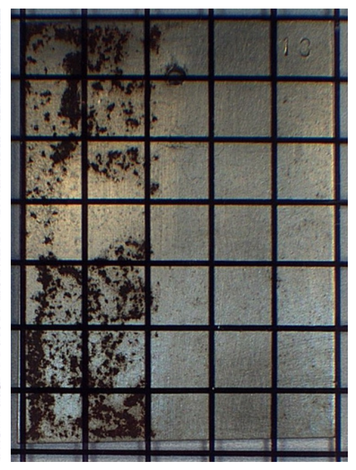

Fig. 2

Coupon 13 recto, before initial cleaning (Fig. 1) and after initial cleaning/corrosion removal and coating with Permalac NT (Fig. 2). Fig. 2 shows mylar grid overlay, used to compare any corrosion development after aging.

Outdoor Natural Ageing

- Samples were aged naturally outdoors in Kingston, Ontario for two weeks.
- During this period, the coupons were exposed to a variety of weather events including rain, snow, freezing rain, and sunlight.
- The coupons were attached to a polyethylene grid using nylon zip-ties and polycarbonate board to position the coupons at an approximately 45% angle. This aging apparatus was placed on a bench located approximately 60cm from the ground.

Fig. 3: Coupons in aging setup before aging

Fig. 4: Coupons in aging setup during aging, showing start of rust formation in snow

Fig. 5: Coupons in aging setup after aging, showing rust and yellowing in areas

Results and Discussion

Visual Assessment - ESEM

- Sample coupons were subjected to Environmental Scanning Electron Microscopy (ESEM) before aging
- Permalac NT (Fig. 6) has small particles embedded in the film, likely product additives like silicon dioxide
- Permalac coatings appear as discreet films, while Ship-2-Shore can be seen to adsorb to surface (dark areas in Fig. 8)

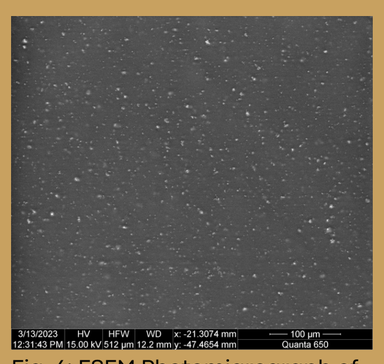

Fig. 6: ESEM Photomigrograph of Permalac NT

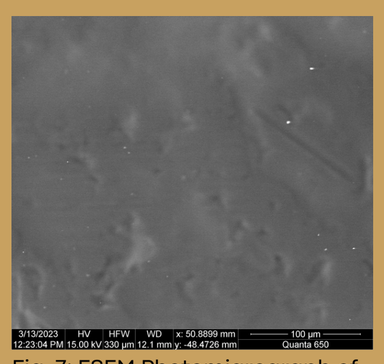

Fig. 7: ESEM Photomigrograph of Permalac Original Clearcoat

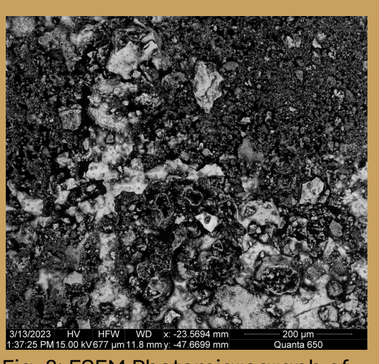

Fig. 8: ESEM Photomigrograph of Ship-2-Shore Corrosion Shield

Gravimetric Analysis

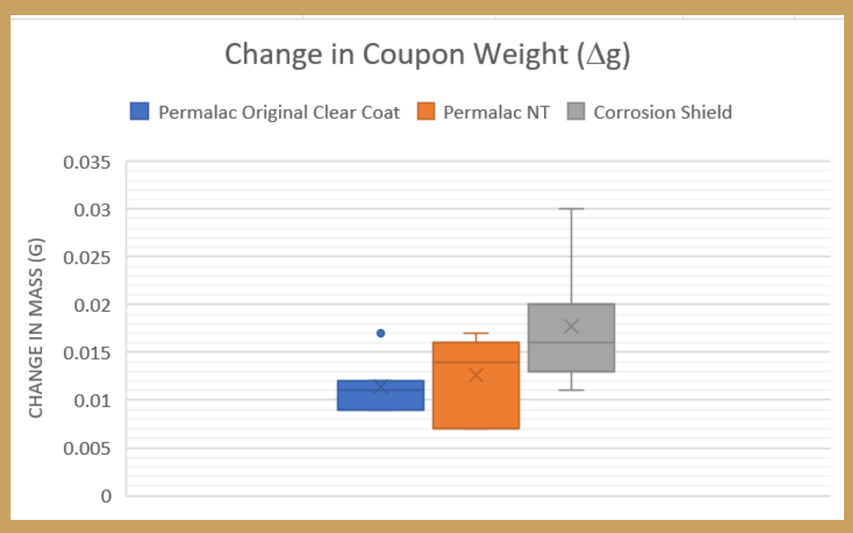

Fig. 9: Box and whisker plot showing the change in coupon weight before and after aging. It is possible to determine that there was the greatest variability within the Ship-2-Shore Corrosion Shield Sample Set.

Conclusion

- Through ESEM, it is possible to distinguish differences in the film formation for each coating type
- Gravimetric analysis proved that all of the coatings functioned better than no coating in preventing corrosion
- Some minor loss in weight of coated, uncorroded coupons after aging could indicate some deterioration of the coating itself
- At this time, further research is needed to discern a quantitative difference between each coating type through gravimetric analysis

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