DURABILITY OF INCRALAC, EXAMINATION OF A TEN YEAR OLD TREATMENT

David Erhardt, Walter Hopwood, Tim Padfield and Nicholas Veloz

Abstract

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THE DURABILITY OF INCRALAC: EXAMINATION OF A TEN YEAR OLD TREATMENT

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SUMMARY

Ten year old Incralac varnish on four outdoor gold plated bronze statues in Washington, D.C. was found to be cracked and insoluble. The Incralac was removed from the statues by softening with paint remover containing methylene chloride followed by pressurized water spray. In comparison with fresh Incralac, the ultraviolet absorption of the weathered material was greater and the benzotriazole had mostly disappeared. The infrared spectrum was little changed.

Introduction

Flanking the east end of the Arlington Memorial Bridge and the entrance to Rock Creek Parkway in Washington, D.C. there are four large gold plated bronze statues (Figure 1).

Figure 1 The gilded bronze 'Valor' on the southeast corner of the Arlington Memorial Bridge.

They were put in place in 1951. By 1971 their condition had deteriorated to the point where extensive repair and restoration was required. Corroded steel bolts, nuts, tie rods and braces were replaced with brass or bronze, accessible residual mould materials, including gypsum and sand, were removed from the interior, and cracks and pits were filled with a tin-silver solder. The original fire gilded surface was entirely removed by sandblasting. The statues were then brush plated with two layers of nickel followed by at least one layer of gold.

The final treatment in 1971 was the application of a coating of Incralac varnish. The procedure was described by Ogburn, et. al.[1] It is this coat of Incralac which is the subject of this report.

Condition of the statues in 1983

By 1983 the statues, located within 30 metres of roads carrying over 100,000 vehicles per day and under the flight path of National Airport which handles over 900 flights per day, again needed attention. Nicolas Veloz and other Park Service personnel undertook the treatment. The statues were quite dirty and there were areas of deterioration: deposition of core material, some corrosion around weepholes and seams and apparent loss of detail. Despite their poor appearance, the statues and gold plating were basically in good condition. The Incralac had failed over virtually all surfaces. There was a darkened, "painted" appearance overall and a grey cloudiness over parts of the statues which was, on closer inspection, found to be due to cracking and breakup of the Incralac layer (Figure 2). Air under the loosely adherent polygonal plates caused the cloudiness. Loss of Incralac had left some areas bare. These exposed areas were bright gold. The worst areas were those exposed to both sun and weather. Exposed areas on the north sides had an extensive craquelure, but little loss of Incralac. Only in sheltered areas did the Incralac still appear to form a coherent film, but even here there was an invisible craquelure. This was revealed by spotting dilute aqueous sodium carbonate on the lacquer film. Tests showed that electricity could be conducted between the

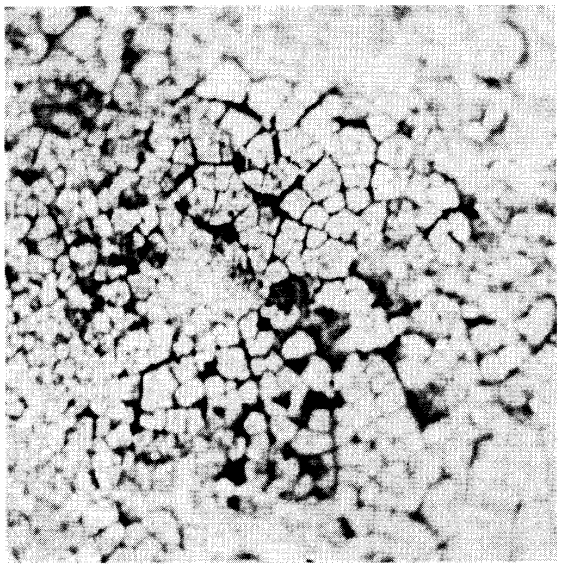

Figure 2 Fragmentary remnants of Incralac on the base of 'Valor'. This area is 12 mm across.

lacquer surface and bare metal areas, indicating that the sodium carbonate solution had penetrated the lacquer.

The 1983 Treatment

The Incralac coating proved resistant to solvents and paint strippers which readily dissolve fresh Incralac. These did not dissolve or emulsify the Incralac, but they did soften it enough to allow mechanical removal. The method found to be most effective was repeated applications of methylene chloride based paint stripper followed by cold water spray at a line pressure of 6 Meganewtons per square metre. The gold layer was adherent enough to withstand the water spray. Loss of gold was insignificant. The statues were then washed with nonionic detergent solution (Igepal CO 630), coated with an aqueous solution of benzotriazole (BTA) and finally covered with paste wax containing BTA.[2]

Incralac: Product Description

Incralac is an acrylic coating formulated for protection of copper and its alloys. It is based on Acryloid B-44 which is a co-polymer of ethyl acrylate and methyl methacrylate, available as a 40% solution in toluene. Seventy-five parts of this solution is further diluted with 20 parts toluene and 5 parts ethanol. One half part each of benzotriazole and Paraplex G-60 are also added.[3] Benzotriazole is a chelating agent used as a corrosion inhibitor. It can function both to prevent corrosion of the metal, and to protect the Incralac from the degrading effects of copper ions which diffuse into it. Paraplex G-60 is an epoxidized soyabean oil used as a levelling agent. Incralac is described in product literature as a hard, transparent acrylic having excellent resistance to ultraviolet light, which should last at least five years.[3,4]

Properties of Aged Incralac

Infrared spectra of this aged and fresh Incralac[5] are essentially the same. Their UV spectra, however, are quite different (Figure 3). The increased absorption of aged Incralac could be due either to the reaction products of degradation, or to absorption of UV absorbing pollutants from jet fuel or car exhausts, for example.

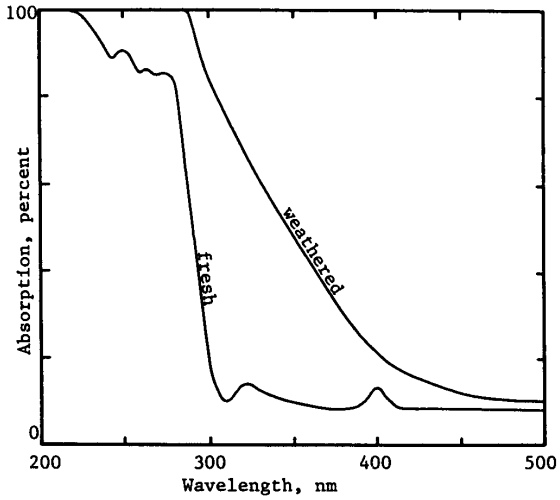

Figure 3 Ultraviolet spectra of fresh and of weathered Incralac.

Assays by the Sherwin Williams Chemical Company, a manufacturer of BTA, found concentrations of BTA in the aged Incralac samples of less than 0.1%. This is much less than the starting concentration of 1.5%.

We compared the solubilities of fresh Incralac with those of aged Incralac taken from a vertical, north facing section of the left rump of the horse of "Music and Harvest". The results are summarized in the following table. The aged Incralac did not dissolve in any solvents. It did swell, however, in the solvents which most readily dissolved fresh Incralac. Solubility tests were conducted according to the method described by McCrone.[6]

Solvent action on fresh and aged Incralac

	Fresh			Aged	
Solvent	insoluble swells	soluble	very soluble	insoluble swells	
isooctane	x			x	
propanol	x			x	
N,N-dimethyl formamide	x			x	
diacetone alcohol	x			x	
turpentine	x			x	
dimethyl sulfoxide	x			x	
carbon disulfide	x			x	
butanol	x			x	
methyl cellosolve	x			x	
methanol	x			x	
cellosolve acetate	x			x	
carbon tetrachloride	x			x	
butyl acetate		x		x	
methyl isobutyl ketone		x		x	
1,1,1-trichloroethane		x		x	
dioxane		x		x	
ethanol		x		x	
toluene		x		x	
nitromethane		x		x	
chlorobenzene		x			x
methyl ethyl ketone		x			x
ethylene dichloride			x		x
trichloroethylene			x		x
ethyl acetate			x		x
methylene chloride			x		x
acetone			x		x

Discussion

The Incralac coating on these statues has failed as a coherent protective layer, and it has failed to remain soluble. The failure has not resulted in any major damage to the statues. Corrosion was not evident except at points such as soldered seams or casting pits where the nickel and gold plating was imperfect or at weep holes where corrosion products were washed out of the unplated interior. The plating withstood the harsh measures required to remove the insoluble Incralac.

The failure of the Incralac during ten years of outdoor exposure is not surprising. Incralac product literature suggests a film life of at least five years. The increasing insolubility of Incralac is also suggested by product literature ("In some instances it may be necessary to use a brass wire brush to loosen stubborn, old lacquer film."[4]), and it has been reported by Lafontaine.[7]

The infrared spectra indicate that there is little change in the type or number of functional groups as Incralac ages, which is why the solvents which swell the aged Incralac are solvents which also dissolve fresh Incralac. The insolubility is therefore probably due to crosslinking of polymer chains. Crosslinking of acrylics as a result of exposure to UV light is well known.[8] The acrylics commonly used in conservation are those which tend to crosslink most slowly, but one must keep in mind that insolubilization of Incralac will eventually occur.

The mechanical failure of the film may be due to thermal stress. The B-44 used to formulate Incralac is one of the harder acrylics, with a glass transition temperature of 60°C.[3] Below this temperature, B-44 becomes brittle and resistant to flow. Acrylics have a coefficient of thermal expansion about five times that of copper alloys.[9] Changes in temperature will cause differential contraction or expansion of Incralac and metal, and set up stresses within the Incralac. Crosslinking of the Incralac will make it even more brittle, and reduce its ability to relieve stress. Thermal extremes combined with crosslinking of the Incralac may eventually result in the mechanical failure observed.

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