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## Microbiology of Automobile Electrocoat Paint Systems

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### ABSTRACT

*An experiment was conducted to evaluate paint application to a metal surface coated with bacteria. Automobile frames are exposed to a series of rinses prior to electrodeposition of undercoat. Bacteria isolated from pretreatment rinses were inoculated onto steel panels which, as in pretreatment, had been coated with zinc phosphate.*

*Inoculated and control panels were painted and assessed for adherence by a water soak and a corrosion cycling test. Scanning electron micrographs (SEM) were made on unpainted, inoculated panels to view the effects of bacteria on the zinc phosphate coating and to verify that they adhered to the metal. Results show that the bacteria did not interfere with paint adhesion. The SEM showed no adverse effects on the zinc phosphate.*

### INTRODUCTION

Electrodeposition of automobile undercoat is almost universally used in assembly plants. Prior to the application of paint, the car frame is carried through a series of pretreatment rinses (Table 1). These prepare the metal for the electrocoat process, both by cleaning and chemical treatment, that imparts corrosion protection and greater paint adherence.

There are nine pretreatment stages (Table 1). Many of the stages contain bacterial populations, the levels of which vary from around  $10^2$ /ml to as high as  $10^7$ /ml (Table 2). Thus, when a frame reaches the

electrodeposition bath it may be coated with bacteria. This study assumed a worse case scenario in which the auto body would reach the paint bath with a significant bacterial coating. The effects of such a coating on paint adherence were examined.

## METHODS

Samples were taken from each rinse system at two automobile assembly plants in the Detroit, Michigan area and serially diluted onto Standard Methods Agar (GIBCO Laboratories) for enumeration (Table 2). Once enumerated, subcultures were made of predominant colonial morpho-

TABLE 1  
Typical Electrocoat Pretreatment

<i>Rinse stage</i>	<i>Process</i>	<i>pH</i>	<i>Time (s)</i>	<i>Temperature (°C)</i>
1	Spray clean	9.0-9.5	30	49-52
2	Dip clean	9.0-9.5	120	49-52
3	Spray rinse	8.0-8.5	30	43-46
4	Dip rinse	8.5-9.5	30	43 maximum
5	Dip phosphate	3.0-3.5	120	43-46
6	Dip rinse	8.0-8.5	30	ambient
7	Spray chrome, dip chrome	3.8-5.0	30	ambient
8	Spray recirc. DI, dip recirc. DI	6.0-7.0	30	ambient
9	Spray virgin DI	6.0-7.0	10	ambient

TABLE 2  
Bacterial Counts of Pretreatment Systems from Two  
Assembly Plants

<i>Rinse stage</i>	<i>Bacteria/ml</i>	
	<i>Plant A</i>	<i>Plant B</i>
1	<100	<100
2	<100	<100
3	<100	$1.3 \times 10^7$
4	<100	$2.1 \times 10^6$
5	<100	100
6	$1.2 \times 10^7$	$1.3 \times 10^4$
7	$1.2 \times 10^3$	$4.5 \times 10^7$
8	$3 \times 10^3$	$3 \times 10^6$
9	$5 \times 10^2$	<100

TABLE 3  
Selected Bacterial Identifications

Plant A		Plant B	
Organism	Stage No.	Organism	Stage No.
<i>Pseudomonas pickettii</i>	6	<i>Moraxella</i> sp.	3
<i>Pseudomonas aeruginosa</i>	6	<i>Pseudomonas</i> sp.	3
<i>Pseudomonas</i> sp.	6	<i>Pseudomonas putida</i>	4
<i>Pseudomonas pickettii</i>	7	<i>Acinetobacter lwoffii</i>	4
<i>Pseudomonas pickettii</i>	8	<i>Flavobacterium</i> sp.	4
<i>Pseudomonas</i> sp.	8	<i>Pseudomonas cepacia</i>	6
		<i>Flavobacterium multivorum</i>	6
		<i>Pseudomonas maltophila</i>	7
		<i>Pseudomonas paucimobilis</i>	7
		<i>Flavobacterium odoratum</i>	8
		<i>Pseudomonas aeruginosa</i>	8

types. Identification of the organisms was made using the Micro-Scan Gram Negative ID Panel (American Hosp. Supply) (no Gram-positive organisms were found). Table 3 lists some of the dominant organisms from each stage.

Bacterial suspensions were made in sterile distilled water using pure culture isolates. Separate suspensions were made of organisms from each assembly plant. The initial inocula were made to contain  $10^8$

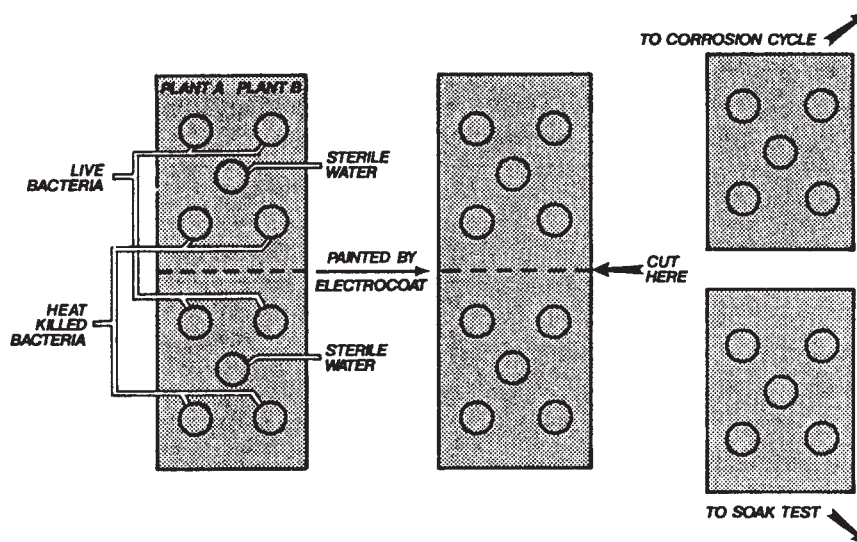


Fig. 1. Inoculation and treatment of panels.

bacteria/ml using a barium sulphate standard (Horwitz, 1975). The inocula were diluted to give suspensions of  $10^4$  bacteria/ml. A portion of each inoculum was removed and steam sterilized allowing each panel to be inoculated with both live bacteria and a heat-killed control.

Panels were inoculated as shown in Fig. 1. The samples were triplicated so that levels of  $10^8$ ,  $10^4$ , and zero bacteria/ml could be studied. From each inoculum, 0.2 ml was removed and pipetted onto designated areas of the panel.

After inoculation and drying, the panels were painted and cut in half for testing. The top was subjected to a corrosion cycle test while the bottom portion was put into a water soak test. The latter involves immersion of the test panel in deionized water ( $52^\circ\text{C}$ ) for 72 h. At the conclusion of the test, the painted surface is visually examined and adverse conditions such as blisters, sags, rust spots, or scratches, are noted.

The corrosion cycle test combines the specifications of two American Society for Testing and Materials (ASTM) procedures (ASTM D1654-799, Painted or Coated Specimens Subjected to Corrosive Environments (ASTM, 1986a); and ASTM B117-73, Standard Method of Salt Spray [Fog] Testing (ASTM, 1986b)) with two General Motors specifications (GM 4298P: Salt Spray Testing; and GM 9102P: Corrosion Creepback Test Method). At time zero, a scribe is made in the test panel. The test, on a Monday to Friday cycle, involves immersion in a 5% sodium chloride solution each day for 15 min. Next, the samples are set out to dry at room temperature for 75 min and then placed in a humidity cabinet ( $60^\circ\text{C}$  and 85% relative humidity) for 22 h and 30 min. On Monday only, the panels are also subjected to a twice repeated cycle of 1 h storage in a  $60^\circ\text{C}$  oven followed by 30 min in a  $-10^\circ\text{C}$  cold cabinet. The test lasts 5 weeks.

After completion the panels are rinsed with warm water and visually examined for corrosion, blistering, peeling, or scribe line corrosion creepback (loss of adhesion between primer and steel).

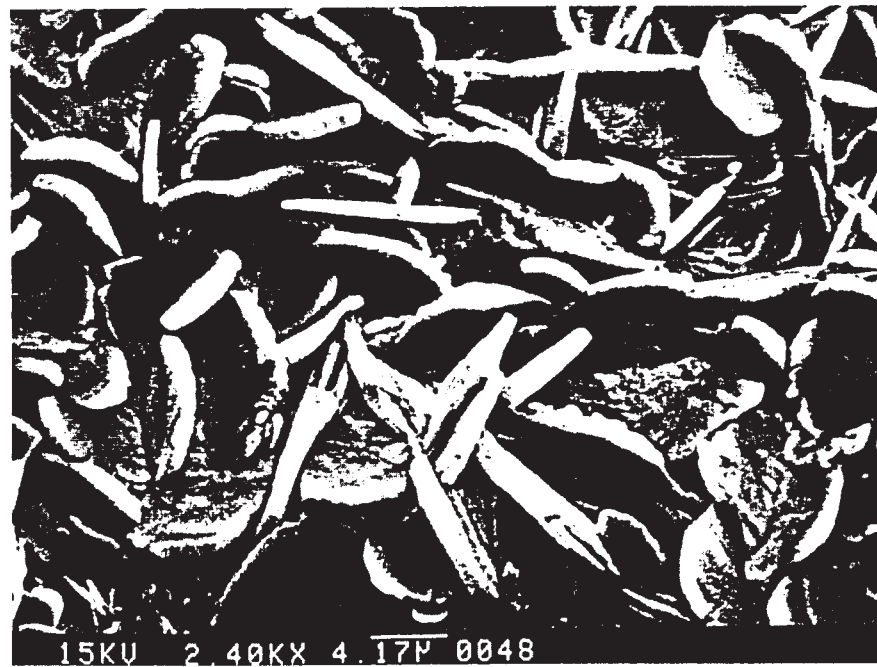
One set of panels was inoculated according to Fig. 1 but were not painted. Instead, they were air dried and platinum coated (300 Å thick) using a Polaron SEM coating unit E-5000. They were then examined by a Phillips 505 SEM operated at 30 kV (Hyat, 1972).

## RESULTS AND DISCUSSION

Visual observations of the panels following the 72 h soak test revealed no adverse changes in paint film adherence. Regardless of inoculation level,



(a)



(b)

Fig. 2.

no increase in corrosion, blistering, or peeling was seen in the inoculated panels.

The corrosion cycling test yielded the same results. Increased loss of adhesion between primer and steel in those panels inoculated with bacteria was not demonstrated.

The SEM photos were able to show bacteria associated with the phosphate crystals (Figs 2(a) and 2(b)). However, based on previous data from SEM examination of phosphated surfaces as well as results from the present study, bacteria were judged to have no negative effects on the phosphated surface.

A worse case scenario was chosen to establish the protocol for this study. It is not likely that bacteria levels used in the experiments ( $10^8$ /ml) would ever be seen in the plants. It is also doubtful that the organisms would ever have a chance to dry and adhere to the metal, as they did in this test, simply because the auto frames are almost constantly moving from one rinse to the next.

Laboratory studies involved in studying biodeterioration and its prevention generally contrive a system of exaggerated conditions. If a substance can resist deterioration under harsh laboratory testing, successful resistance in the field can be predicted. It is on this basis we conclude that regardless of the degree to which pretreatment rinses are contaminated, adverse adherence of paint to metal is not expected.

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