41. INFLUENCE OF THE CURING TEMPERATURE OF A CATHAPHORETIC COATING ON THE DEVELOPMENT OF FILIFORM CORROSION OF ALUMINIUM

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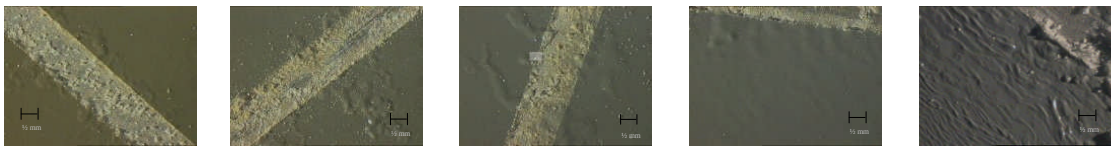
INTRODUCTION

To diminish the weight of car bodies, aluminium alloys are used and coated with a primer for corrosion protection. The primer used is generally an eletrodeposited organic coating. In this work, the influence of the physical properties of the coating on the sensitivity to filiform corrosion of Al 6016 substrate coated with a cataphoretic paint was investigated. The cross-linkage was performed at different curing temperatures- 185°C,175°C,165°C, 155°C and 135°C- in order to modify the mechanical properties and the permeability of the coating.

A. FILIFORM CORROSION OF ELECTROCOATED Al 6016

A.1. Normalized test (ISO/DIS 4623-2)

Painted and scratched samples were inoculated in HCl vapours for 1 hour and exposed in a climatic chamber at 40°C and 82% RH for maximum 21 days.

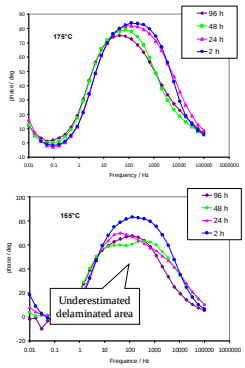


185°C	175°C	165°C	155°C	135°C
narrow filaments	narrow filaments	wide filaments	filaments and disbonding	disbonding
lenght : 2-3 mm	2 mm	2 mm	4-5 mm	4 mm

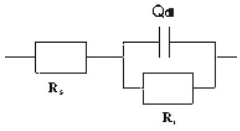
When the curing temperature increases, the permeability to O_2 decreases and the adherence increases.

A.2. Electrochemical Impedance Spectroscopy /EIS

The samples were painted and scratched before inoculation for 1 hour in HCl and then exposed in a climatic chamber at 40°C and 82% RH for a maximum of 4 days. The samples were tested by EIS in an acidified 0.1M Na_2SO_4 electrolyte solution at pH 1. The immersion time in the electrolytic solution before EIS measurement was fixed to 4 hours in order to allow the dissolution of the corrosion products formed inside the filaments[1,2].

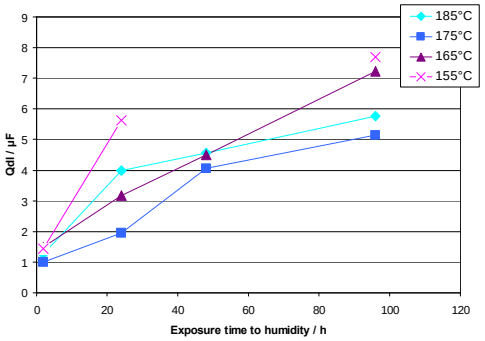


After the complete dissolution of the corrosion products, the resulting impedance spectra can be analyzed by the following electrical equivalent circuit :



Active area = exposed metallic surface

→ filaments or delamination area directly ÷ Q_{dl}



Q_{dl}:

→ Best adherence for a curing temperature of 175°C while adherence for a coating cured at 155°C is probably poor

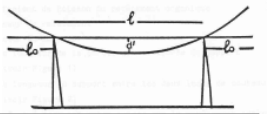
→ Results obtained in a short time (max: 96 h)

B. STRESS MEASUREMENTS OF THE COATINGS

To measure the internal stress, the electrocoatings were applied on a calibrated carbon steel substrate. The cantilever method used to measure the internal stress is based on the works of Y.Perera[3].

CANTILEVER METHOD

For a coating under stress, the coated substrate will deflect in the direction which relieves the stress.

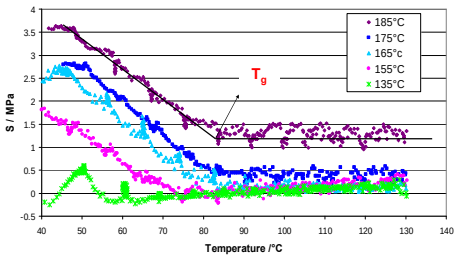


deflection d'(m) measurement

→ stress S (N/m²) can be calculed

$$S = \frac{4d'E_s t^3}{3\ell^2 c(t+c)(1-\nu_s)} + \frac{4d'E_c(t+c)}{\ell^2(1-\nu_c)}$$

E = elastic modulus (N/m²)
υ= Poisson's ratio
$_c$ = coating , $_s$ = substrate
t ,c = thickness of the substrate, the coating (m)
l = distance between the 2 knife edges (m)



- For T < T_g : the stress decreases with the curing temperature
- For coatings cured at 185°C, 175°C, 165°C, the T_g values are very close (81°C). The lowest T_g (75°C) is measured for a curing T of 155°C. (For 135°C, the organic coating reticulation is not complete)
- For T > T_g : S ~ 0 MPa (at 185°C there is a residual stress)

CONCLUSION

The filiform corrosion tests give some information about the adherence and the permeability of the coating. The stress measurements can be correlated with these data. The T_g value does not seem to be the only determining physical parameter. The best compromise between permeability and adherence seems to correspond to an optimisation of internal stress below T_g. For this system, this optimum is obtained at a curing temperature of 175°C. If S is lower, the permeability to oxygen increases, the adherence decreases and delamination is observed. If the S is higher, the adherence is good, the permeability to oxygen decreases and the system will be subjected to filiform corrosion rather than delamination.

References : 1-Fedrizzi, J. Adhesion Sci. Technol. 13 (1999) 629; 3-Perera, 22th FATIPEC Congress, Budapest (1994) 1 ; 2-M.-G Olivier Prog. Org. Coat. 52 (2005) 263.
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