MICRO AND MACRO SCALE MECHANICAL DEFECTS ON PAINTS

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Introduction

For an industrial product not only the functionality (corrosion and wear resistance) but also the aesthetic - perceptive properties are becoming increasingly important. All these surface properties are obtained with coatings and surface treatments. Paints are the most common methods to obtain corrosion protection and surface aesthetics. In the service life the surface properties could be modified by corrosion and damage phenomena, due to aggressive environments and mechanical actions. The corrosion aspects are well studied; on the contrary the damage produced by mechanical action is less considered due to the difficulty to simulate the mechanical action. This degradation occurs at two levels: microscopically on the surface with a consequent gloss modification (marring) [1] and macroscopically with a reduction of corrosion protection properties. In this work some examples about the influence of mechanical damage on aesthetic and protective properties of organic coatings are shown.

Experimental

Q-panels of carbon steel were powder coated with an epoxy - polyester paint. The mean coating thickness was 70±10 μm. To simulate the abrasion damage modified Taber test was carried out (ASTM D 4060 and ASTM D 6037); instead of the abrasive wheels, two rubber wheels with free abrasive agents were employed, using a load of 250, 500 and 1000 g.[2] To simulate the erosion action Falling Sand Tester was used (ASTM D 968). To have a comparison between both damage procedures the same abrasive means were used. In particular ASTM standard Ottawa sand (silicon oxide with a rounded grain size of 751±138 μm, hardness about 11GPa), aluminium oxide (size of 716±154 μm with very sharp edges, about 20GPa), sharp edges sodium chloride (hardness 182MPa) and regular hexagonal shape sucrose (hardness 680MPa) with two grain dimensions (average size of 2–3 mm and hundreds of μm) were considered. The micro damage with the consequent change in the appearance was evaluated by gloss measurements. To evaluate the reduction of corrosion protection electrochemical impedance spectroscopy (EIS) was used. [3]

Results and Discussion

Micro-damage – reduction of surface gloss
Considering the characteristics of these samples, in a previous paper [4] it was demonstrated that 20° is the most sensitive angle to obtain information on the change in the surface gloss.
The sample abraded with small size sucrose showed a higher loss of gloss than the sodium chloride means (fig.1).

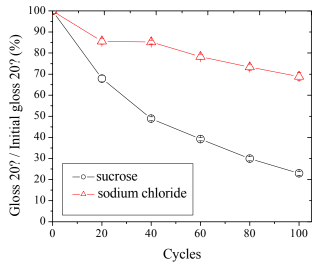

Fig.1 Gloss/initial gloss(%) at 20° during Taber Test.

The difference could be attributed to the difference in the hardness because the grain sizes of the abrasives are comparable. The data show that larger particles produce lower loss of gloss; on the contrary (as following shown), bigger grains cause a greater reduction of the corrosion protective properties. This different behaviour probably could be attributed to the damage morphology. Big grains produce few deep scratches which influence the reduction of protection properties. On the contrary the gloss is more sensitive to the defects density on the surface and less influenced by the scratches depth. Considering the Falling Abrasive test (fig.2.), just after 500g of abrasive a big drop of the gloss was produced. Unlike the Taber test, bigger size of the abrasive particles produced a higher reduction of the gloss properties. The difference could be correlated to the damage mechanism. In case of Falling Abrasive test the damage is produced by erosion action and the abrasive grains acquire kinetic energy by falling; smaller particles with a lower weight acquire lower kinetic energy with a consequent lower damage of the sample surface. The sucrose turns out to be, also in erosion damage, the most aggressive mean, confirming the abrasion results.

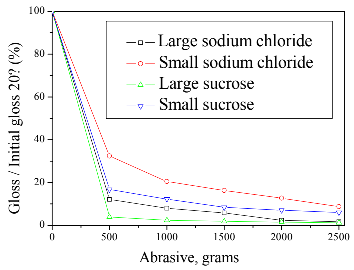

Fig. 2 Gloss/initial gloss (%) as a function of abrasive amount.

Macro-damage – reduction protection properties

EIS technique is widely used to evaluate the properties of organic coatings. In particular the coating resistance R_p, obtained from the data fitting, is related to the coating protection properties and allows to monitor the reduction of these properties caused by mechanical damage. The threshold R_p value of 10^6 Ω cm^2 is often considered the loss of protection properties of the paints. [3]

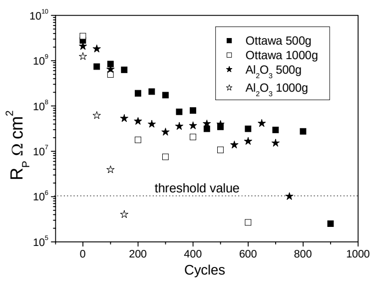

Fig. 3 R_p as a function of Taber Test cycles.

Considering the trend of R_p value as a function of the Taber test cycles (fig.3), it is clear the influence of the applied loads and the abrasive type. The alumina results more aggressive than the Ottawa sand, probably due to the sharp geometry of its grains, given that the dimension of the particles and their hardness result very similar.

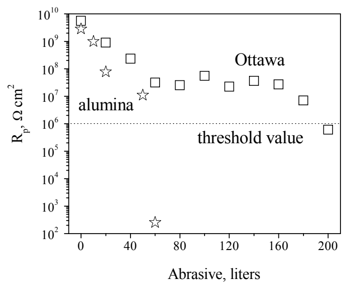

Fig.4 Rp as a function of abrasive amount.

In Falling Abrasive test (fig.4), using Ottawa sand three steps are distinguishable: a first R_p decrease until 60 liters of sand, a plateau around 10^7 Ωcm^2 and after 180 liters a final loss of protection properties. Using alumina, a more drastic reduction of resistance values was obtained.

Conclusion

The gloss measurement could quantify the level of aesthetic damage of the surface. The R_p parameter permits to evaluate the reduction of corrosion protection properties caused by mechanical damage.
It is possible to investigate the micro and macro damage as a function of dimension, grain shape and hardness of abrasive means.

References

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