

# **EFFECT OF EXTERNAL MECHANICAL STRESSES ON THE HYGROTHERMAL AGEING OF DGEBA/TETA EPOXY RESIN**

Dan NGUYEN DANG, Stephanie MALLARINO,  
Xavier FEAUGAS, Sebastien TOUZAIN

*Université de La Rochelle, LaSIE FRE-CNRS 3474, La Rochelle, France*  
([dang\\_dan.nguyen@univ-lr.fr](mailto:dang_dan.nguyen@univ-lr.fr), [stephanie.mallarino@univ-lr.fr](mailto:stephanie.mallarino@univ-lr.fr),  
[xavier.feaugas@univ-lr.fr](mailto:xavier.feaugas@univ-lr.fr), [sebastien.touzain@univ-lr.fr](mailto:sebastien.touzain@univ-lr.fr))

Organic coatings have been abundantly used to prevent metals from corrosion. Among them, epoxy-based paints are often industrially chosen, due to their low cost and their efficiency in corrosive medium like seawater. The degradation of these coatings is usually due to the action of environmental factors such as water, UV, temperature and external mechanical stress. The objective of this study is to highlight synergies existing between different ageing factors (temperature, mechanical stress, water) for polymer coating degradation. In order to avoid the influence of pigments, adjuvants and other fillers, a model epoxy system DGEBA/TETA was chosen to obtain the response of the sole polymer.

Firstly, dry DGEBA/TETA free films were mechanically studied using Dynamic Mechanical Thermal Analyzer. Visco-elasto plastic behavior of the DGEBA/TETA networks was characterized using a loading–unloading recovery test [1-2]. By varying the stress – strain state in these loading–unloading recovery tests, the limits between the mechanical domains (EL/VE and VE/VP) can be estimated as  $\sigma_{EL/VE} = 6$  MPa and  $\sigma_{VE/VP} = 12$  MPa.

Secondly, the water absorption of free films was studied. The totally cured DGEBA/TETA specimens were immersed in a NaCl 3wt% aqueous solution at 30, 40, 50 and 60°C, respectively. The water uptake and diffusion coefficients were determined by gravimetry for non-bent free films. It was found that the water uptake and the diffusion coefficient are thermally dependent.

Finally, in order to study the effect of an external visco-elastic stress onto the water absorption process, the DGEBA/TETA system was applied onto

plane steel sheets. These coated panels were bent so as to maintain the coatings under a visco-elastic strain between 6 and 12 MPa. Stressed coated panels (compressed and stretched sides) have been immersed in NaCl 3wt% solution at different temperatures and followed Electrochemical Impedance Spectroscopy (EIS) to determine the volumic water content and the diffusion coefficients under different stress and temperature values.

Gravimetric and electrochemical results were compared in order to identify synergies between the different ageing factors and the following points have been observed:

- the diffusion coefficients of water determined by gravimetry (free films) and by EIS (non-bent coatings) are similar;
- for all kinds of DGEBA/TETA films (free or deposited onto steel panel) and regardless the studied methods (gravimetry or EIS), the diffusion coefficients increase with the increase of temperature.
- the visco-elastic stresses applied on the coated panels (both compressed and stretched sides) lead to the decrease of diffusion coefficients in comparison with the non-bent systems.

A thermodynamic approach [3] was used to propose the explanations of these results.

## References

1. Brusselle-Dupend N, Lai D, Feugas X, Guigon M, Clavel M. Polym Eng Sci 2001;41(1):66-76.
2. Fredj N, Cohendoz S, Feugas X, Touzain S. Prog Org Coat 2008;63(3):316-322.
3. Eyring H. J Chem Phys 1936;4(4):283-291.