Influence of ageing conditions on durability of PVC formulations in outdoor applications

The state of the art in predicting weatherability lags far behind the need for such predictions. The exact prediction of the useful lifetime of a given polymer in a specific geographic location is still the dream of both specifiers and manufacturers. As a result, the estimation of durability of these materials remains one of the most challenging issues in weathering studies.

Polyvinyl chloride's (PVC) largest market is in construction where weatherability is a primary design factor. The low cost and good performance of PVC products make this polymer very suitable for applications in buildings; this is mainly in exterior applications like window profiles, cladding and siding.

However, the ultimate user acceptance of PVC products for outdoor building applications depends on their ability to resist the degradation of their mechanical and aesthetic properties over long exposure periods. With the expected growth of this market and its applications, the outdoor durability of PVC will become more and more critical.

In order to assure the weatherability of these materials the PVC resin needs to be compounded and processed properly leading to a complex material whose behaviour and properties depend on both these aspects. Hence PVC is a polymer with a significant interest for weathering studies due to the increased behaviour variability resulting from incorporation of additives.

Some artificial accelerated weathering methods are currently used for predicting polymer lifetimes. This subject is controversial. In order to evaluate the durability of these products it is necessary to reproduce as closely as possible natural weathering phenomena. To achieve this it is necessary to understand the contribution of atmospheric agents in the photo-degradation of such products and to evaluate the performance of various artificial accelerated methods.

As a result, LNEC Materials Department and the Molecular and Macromolecular Photochemistry Laboratory of the Blaise-Pascal University (Clermont-Ferrand, France) undertook, in Lisbon, a four-year (2000-4) cooperative research project which compared different artificial accelerated weathering methods with natural exposure. The study also evaluated the suitability of several chemical, physical and mechanical methods to characterise PVC degradation as influenced by sample composition (particularly of additives) and geometry (including thickness and processing conditions).

To achieve this goal thermal ageing of film- and plate-shaped samples at several temperatures was undertaken along with photo-oxidative weathering of different PVC formulations in both natural exposure conditions and in the laboratory (using a variety of commercially available testing equipment).

Figure 1 illustrates the 45º racks used to perform the natural exposure in Lisbon. The instrumental techniques used to evaluate the weathering action at molecular level were infrared and UV-visible spectrometry for films and infrared microscopy for plates. The characterisation at macroscopic level was performed by means of gloss and colour measurements and the determination of tensile and impact properties of the plates. Figures 2 and 3 present respectively the spectra and plot that result from infrared microscopy of a specific artificially weathered PVC plate formulation (PVC ST).

A statistical distribution analysis of experimental data was undertaken. It enabled a comparison to be made between different photo-oxidation conditions (artificial weathering and natural exposure) thus making it possible to develop correlations and determine acceleration factors.

Besides determination of activation energies, a longevity function was also established for each formulation and weathering condition (artificial and natural). The set of functions enabled the characterisation of compound durability through the definition of critical values for properties considered relevant.

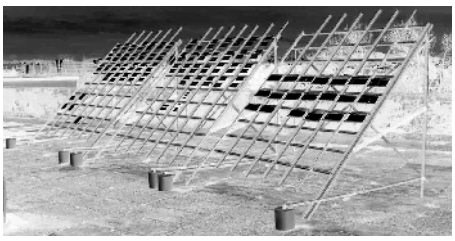

Figure 1 Natural exposure in Lisbon

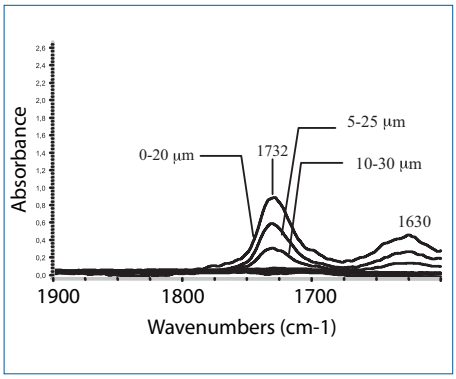

Figure 2 Micro-FTIR Spectra of a specific PVC plate formulation (PVC ST) submitted to Xenon radiation during 12255 hours

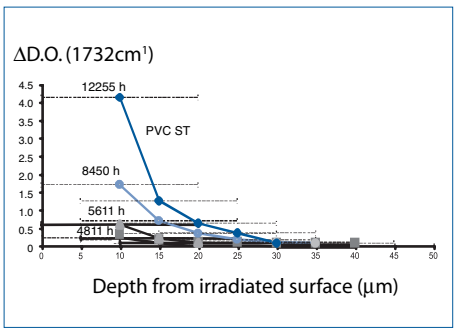

Figure 3 Oxidation profile of a specific PVC plate formulation (PVC ST) submitted to Xenon radiation during different periods of weathering

For further information please contact:
Luís Eduardo Pimentel Real
T +351 21 8443737
F +351 21 8443023
E luis.pimentel@lnec.pt