Incorporation of Surface Techniques to the Study of PET Artificial Weathering

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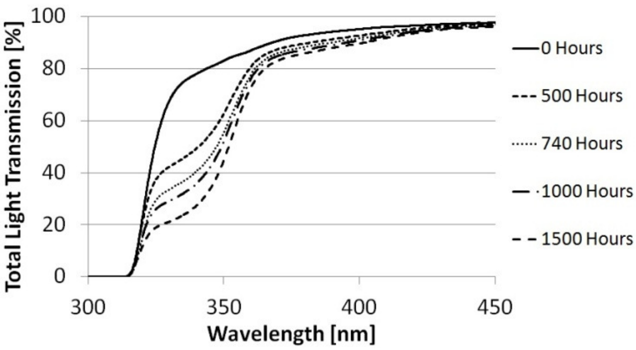
The study of polyethylene terephthalate (PET) weathering and degradation has over recent years (1957-Present) been dominated by chemical techniques and bulk property analysis since these techniques are readily applied to polymer films and provide a measure of the extent of property degradation. This information is critical for the sponsoring company DuPont Teijin Films UK Ltd (DTF) and their customers who must choose to invest in one of a very broad range of products all vying for application as a component layer in multilayer devices - such as Photovoltaic (PV) solar panels - based upon their performance lifetime and cost.

As a condensation polymer PET is inherently sensitive to Ultraviolet (UV) light[1,2], elevated temperatures and levels of humidity, and is thus often unsuitable for outdoor applications in its most basic, unstabilised form. However, with the addition of stabilising additives PET provides a very cost effective solution for consumers requiring a durable, environmentally stable and lightweight film product available in the large quantities often required for PV applications[3]. Accelerated weathering is employed to enable manufacturers and consumers to judge the weatherability of products such as PET relative to their competition as it is impractical to naturally weather test new product developments when the performance lifetime is 25 years. Thus, it is critical for DTF to improve understanding of how accelerated degradation occurs, propagates and relates to actual outdoor exposure in order to progress research into stabilisation techniques and strategies for new product development.

It is understood that PET UV degradation occurs primarily at the surface[4] and yet surface techniques often comprise a relatively small proportion of the analysis toolkit. This project further explores the landscape of PET degradation by incorporating surface techniques such as White Light Interferometry (WLI), Atomic Force Microscopy (AFM), Force Spectroscopy (FS), Scanning Electron Microscopy (SEM) and Contact Angle (CA) analysis. This new perspective will yield a more complete picture of the degradation process and help to further inform decisions on stabilisation strategies.

The early stage of outdoor simulated UV degradation of PET has been well characterised in this project, including sophisticated surface characterisation techniques previously unused in the literature. As expected, photochemical modification of the polymer has occurred[5], manifesting as modification to the optical properties (Fig. 1), but also as subtle changes to the total surface roughness (Fig. 2). It is predicted that this previously poorly characterised roughening is a precursor to surface cracking which will, after further accelerated weathering, come to dominate the surface structure of the PET, adversely affecting its desirable material properties. In addition, it is becoming evident that elevated temperature and humidity are playing a greater role than was previously suspected in the degradation of PET.



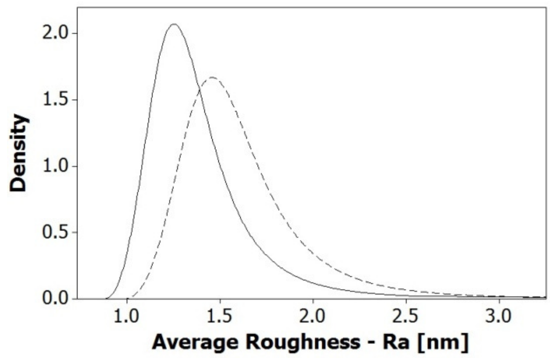


Fig. 1. **Modification of light transmitting behaviour of PET with exposure to simulated solar radiation.**

Fig. 2. **Observed difference in surface roughness distribution between unexposed (Solid line) and 1500h UV exposed PET (Dashed line).**

Current work within this project includes utilising surface techniques, particularly imaging (WLI, AFM, SEM) to capture the onset of surface microcracking due to accelerated weathering and also applying force spectroscopy to analyse the effect of weathering on surface modulus, thereby enabling a non-destructive means of characterising the mechanical properties of weathered film products and potentially reducing the reliance upon destructive sample testing.

References

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