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## Polymer Testing

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TESTING

ROGER BROWN

## Test Method

## Comparison of different photo-oxidation conditions of poly(vinyl chloride) for outdoor applications

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## ABSTRACT

Four different PVC formulations, designed for outdoor applications, in the form of calendared films, were submitted to artificial accelerated ageing under different radiation sources, with and without water spray, and also to natural exposure. The influence of the different photo-oxidation conditions was evaluated by means of surface analysis using X-ray photoelectron spectroscopy (XPS) and infrared spectroscopy. The photo-oxidation of PVC is well monitored by FTIR measurements by following the formation of oxidation products of the carbonyl type, which are due to radical attack on the double bonds in the molecular structure of PVC, and enhanced by radiation and temperature. Results show that relative rates of PVC degradation reactions are different under different photo-oxidative conditions. XPS results show that, in technical PVC formulations, the fraction of chloride ions trapped in the inorganic filler is a better parameter to measure the PVC degradation (measured by the yellowing index variation) than the total remaining (or lost) chlorine in the surface. When the ageing method includes water jets, the top superficial layers made from the inorganic filler and the organic products from the PVC degradation are removed and leave behind a much more homogeneous layer which is more resistant to ageing than the “as processed” one that contains defects introduced by the calendaring process. XPS also makes clear that zinc–calcium additive is a better thermal stabilizer than dibutyltin–maleate, and the presence of tinuvin P retards the PVC degradation. The best simulation of the natural weathering of such PVC materials under laboratory conditions needs to consider, besides the light, the intervention of water jets and/or humidity as well as the existence of light and dark periods.

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## 1. Introduction

The ultimate user acceptance of poly(vinyl chloride) (PVC) products for outdoor building applications will depend on their ability to resist deterioration of their mechanical and aesthetic properties over long periods of exposure, which is only achievable by means of a careful compounding, always demarked by the nowadays environmental demands and quality requests.

The outdoor degradation of such compounds and the resulting final products is complex and not completely understood for most of the technical formulations. Therefore, the study of the photo-degradation of such products still remains a matter of interest.

Many degradation studies of PVC have been performed to test the best additives to minimize damage to the polymer under outdoor conditions. Those studies are usually performed using pristine PVC with a single or a mixture of thermal stabilizers, such as tin maleates [1–3], organic stabilizers [4–6] or calcium–zinc soaps together with organic co-stabilizers [7–9]. However, since industrial PVC products generally have an inorganic filler, studies in the

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