



# Artificial accelerated weathering of poly(vinyl chloride) for outdoor applications: the evolution of the mechanical and molecular properties

Luis Pimentel Real<sup>a,\*</sup>, Adélia Pereira Rocha<sup>a</sup>, Jean-Luc Gardette<sup>b</sup>

<sup>a</sup>Laboratório Nacional de Engenharia Civil, Departamento de Materiais de Construção, Sector de Plásticos, Av. Do Brasil, 1700-066 Lisboa, Portugal

<sup>b</sup>Laboratoire de Photochimie Moléculaire et Macromoléculaire, UMR CNRS 6505, Université Blaise Pascal, 63177 Aubière cedex, France

Received 30 October 2002; received in revised form 29 April 2003; accepted 4 May 2003

## Abstract

We have performed artificial accelerated ageing in xenon light and a natural exposure in Lisbon (hot, Mediterranean climate), using four different types of TiO<sub>2</sub> pigmented PVC formulations, containing various other additives. The experimental results obtained permit us to compare the performance of the additives present in the different formulations and give us information about the sensitivity of each analytical technique used to evaluate the effects of degradation in the PVC samples, originated by the weathering from light, referred to previously.

© 2003 Elsevier Ltd. All rights reserved.

*Keywords:* Poly(vinyl chloride); Weathering; Infrared microscopy; Colorimetry; Mechanical proprieties

## 1. Introduction

The low cost and the good performance of poly(vinyl chloride) products make this polymer very suitable for applications in buildings, mainly in exterior applications, like window profiles, cladding structures and siding. However, the ultimate user acceptance of PVC products for outdoor building applications will depend on their ability to resist the deterioration of their mechanical and aesthetic properties over long periods of exposure. In order to assure the weatherability of these materials, the PVC resin needs to be compounded and processed properly, using suitable additives, leading to a complex material, whose behaviour and properties are quite different from the PVC resin by itself. The outdoor degradation of such products is complex and not completely understood for most of the technical formulations, so the study of the photo-degradation of such products still remains a matter of interest.

In the present work, we have used various analytical techniques to evaluate the variations of the physical, chemical and mechanical properties of extruded PVC samples, resulting from the degradation by light.

## 2. Samples: compounding and processing

The present study concerns 4 different types of TiO<sub>2</sub> pigmented PVC formulations, containing CaCO<sub>3</sub> and various additives, which are designed for outdoor applications. A particular attention was made in the selection of the thermal stabilisers to concern the ecological trends that prevail currently.

The PVC formulations are referred as PVC CZ and PVC S, according the type of thermal stabiliser present in the compositions (respectively calcium/zinc-epoxidized soybean oil or solid tin). The formulations including an additive anti-UV of type benzotriazole (Tinuvin P) are marked with a “T” (referred as PVC CZT and PVC ST).

The compounding of the designed formulations and the extrusion of profiles with 2 mm thickness was made in the Baquelite Liz (Portugal).

\* Corresponding author. Tel.: +351-21-844-3737; fax: +351-21-844-3023.

E-mail address: [luis.pimentel@lnec.pt](mailto:luis.pimentel@lnec.pt) (L.P. Real); [luc.gardette@univ-bpclermont.fr](mailto:luc.gardette@univ-bpclermont.fr) (J.-L. Gardette).