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INTRODUCTION

Polypropylene is a commonly used thermoplastics in various applications ranging from packaging, automotive industry, textiles…Polypropylene production has increased a lot during the last decades thanks to many useful attributes such as–low density, high melting temperature (170 °c) and good mechanical properties (high Young's modulus). Despite these inherent advantages, there are concerns regarding the long-term durability of these materials, especially their capacity for sustained performance under harsh environmental conditions. Furthermore, the degradation of polypropylene has environmental impact since toxic residual chemicals and degradation products can potentially be released into the environment [1]. It is therefore important to understand the ageing mechanisms of such polymer in order to design product with good environmental resistance. In this work, nanomechanical techniques have been used to characterize ageing behavior of PP. Advantages of this technique are to measure the mechanical properties with a high spatial resolution allowing to characterize the mechanical degradation at the early stage of ageing. Polypropylene samples have being ageing in an ARTAAC chamber (SEVAR Company) under dry environment. The samples were submitted to UV- irradiation issued from a pressure mercury vapor lamp (irradiance level equivalent to 2 suns), the chamber temperature was kept at 60°C and ageing duration varied from 0 to 20 days (480 hours). The kinetic of chemical degradation was studied by infra-red spectroscopy. Evolution of both carbonyl groups (absorbance at 1735 cm^{-1}) and hydroxyl groups (3400 cm^{-1}) as a function of ageing time has been studied in order to characterize oxidation rate of the polypropylene [2]. The evolution of the Young's modulus and the brittleness of PP with ageing time was characterized by means of nano indentation and nano scratch techniques. During the scratch test the normal force increases up to 200 mN with a loading rate close to 7 $mN.s^{-1}$. A topographic profile of the surface is performed during and post scratch in order to follow the elastic polymer recovery. The evolution of carbonyl index (CI) and hydroxyl index (HI) as a function of ageing time is shown in figure 1. We can clearly see an induction period (up to 100 hours) corresponding to the consumption of anti-oxidant additives, then a rapid increase of the CI due to the carbonyl built-up (C=0) during oxidation. After 350 hours, the CI stabilized at around 10^{-3} which corresponds to a full oxidation of the sample. The evolution of the Young's modulus as a function of the indentation depth is shown in figure 2a for 0 day and 18 days aged samples. Young's modulus value increases significantly with ageing indicating a higher rigidity of the ageing polypropylene probably due to cross-linking induced by UV irradiation. Figure 2b presents the profiles recorded during scratch tests (solid lines) or after the scratch (dashed-line). The higher scratch depth as well as the lower elastic recovery observed on aged PP clearly indicate that during ageing, the elasticity of PP decreases and that brittleness increases. The evolutions of these different parameters as a function of ageing time will be presented here and nanomechanical analyses shown as a powerful tool to predict the durability of polymer.

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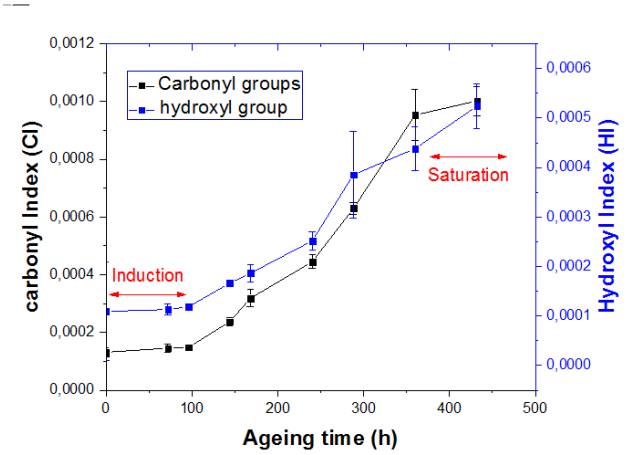

Figure 1: Evolution of carbonyl index and hydroxyl index as a function of ageing time

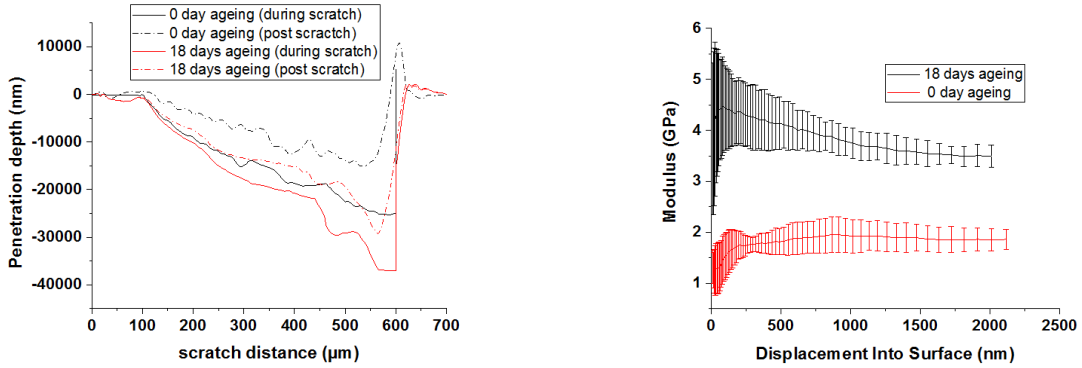

Figure 2: nanomechanical test recorded on 0 day or 18 day ageing PP under weathering accelearted chamber a) Evolution of the Young's modulus as the indentation depth b) the scracth profiles (solid lines) and post scratch profil (dashed line).