

## **POST-IRRADIATION OXIDATION OF POLYPROPYLENE.**

Luigi Costa<sup>a</sup>, Pierangiola Bracco<sup>a</sup>, Jun Fu<sup>b</sup>, Xing Wei<sup>b</sup>.

<sup>a</sup>*Chemistry Department and Nanostructured Interface and Surface (NIS)  
Centre of Excellence, Università degli Studi di Torino, via Pietro Giuria 7,  
10125 Torino, Italy*

<sup>b</sup>*Polymer and Composite Division, Ningbo Institute of Material  
Technology and Engineering, Chinese Academy of Sciences, Zhuangshi  
Road 519, 315201 Ningbo, China  
luigi.costa@unito.it*

The high energy irradiation process has recently assumed increasing importance as sterilization process for polymeric materials used in the medical field. Among these, the PP is widely used. The process of radiation-induced oxidation of e-beam irradiated UHMWPE has been recently investigated<sup>1</sup>. The present study aims to verify if the mechanisms observed there may be also translated to isotactic, syndiotactic and atactic PP.

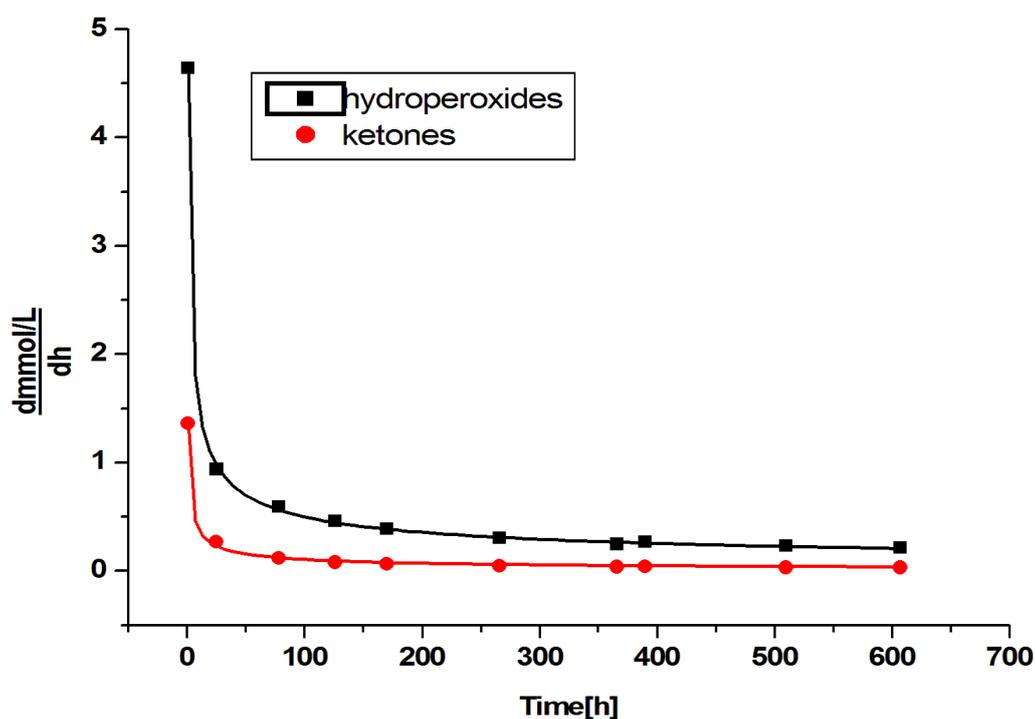
The irradiation process induces homolytic bond scissions in the crystalline and amorphous phase. Most of the radical pairs formed rearrange with formation of hydrogen and a double bond. The H<sup>o</sup> radicals, being of minimum size and having therefore some mobility, can migrate from the radical pair and, for extraction of an H<sup>o</sup> from a polymeric chain, lead to the formation of a second polymeric macroradicals and H<sub>2</sub>. These macroradicals, in the amorphous phase, in the presence of oxygen, decay in short time, while in the crystalline phase possess longer lifetimes.

At room temperature, the alkyl macroradicals can be transferred from the crystalline to the amorphous phase<sup>2</sup>, at a rate depending on the size of the crystallites, and react with the species present there (oxygen, chain imperfections and stabilizers, if any). The oxidation process takes place in the solid state and, consequently, the morphological structure and steric hindrance acquire a fundamental importance. The oxidation cascade is due essentially to macroradicals formed in the crystalline phase. Figure 1 shows the kinetics of formation of hydroperoxides and related ketones in isotactic PP e-beam irradiated at 100 kGy. The rate of oxidation at room

temperature decreases quickly with time and after one hundred hours approaches zero.

Therefore the existence of a termination reaction, involving two radical species, must be hypothesized. A reaction between the alkyl macroradicals, that migrate along the polymer chains, and the peroxy macroradicals fixed on the polymer chain seems to be the most reliable hypothesis.

The addition of vitamin E does not prevent completely the reaction with oxygen, but reduces its efficiency, the reaction with the additive being in competition with oxidation. The remarkable efficiency of vitamin E is due to the possibility of introducing a further termination reaction of the oxidation process.



**Figure 1. Oxidation rate of isotactic PP irradiated at 100 kGy**

1. L. Costa I. Carpentieri, P. Bracco, Poly. Degr. Stab. 2009, 94, 1542-1547
2. A. Rivaton, D. Lalande, J.-L. Gardette. Nuclear Instruments and Methods in Physics Research B 2004, 222, 187-200