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Ionizing Radiation as a Tool to Affect Polymer Biodegradation

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The great stability and durability of conventional synthetic plastics and their outstanding properties have allowed a wide range of potential applications among which packaging constitutes the larger market segment. However, due to the specific function, packaging rapidly becomes waste that increasingly accumulates in the environment. Therefore, nowadays the need of biodegradable polymers is growing up and great efforts have been devoted to optimize the use and the disposal of conventional non-biodegradable plastics favoring their degradation in the environment. Aliphatic polyesters have attracted considerable attention combining biodegradability and biocompatibility features with physical-chemical properties comparable with some of the most extensively used polymers. It is well known that ionizing radiation can modify polymers and enhance or degrade their properties, affording many practical applications. In particular, gamma radiation can facilitate the material degradation by inducing oxidative fragmentations of polymer backbone. In this viewpoint, experimental activities have been addressed to investigate if a radiation treatment of bio-based plastics in an ambient promoting or accelerating degradation, could represent an effective pre-treatment for improving their biodegradation.
Commercial and synthesized polymers, such as polyethylene (PE) and polybutylene succinate (PBS), have been irradiated by Co-60 sources and the impact on the rate of biodegradation in compost has been evaluated. Polyesters, in films up to 200 μm, have been irradiated at absorbed doses up to hundreds of kGy in air and aqueous solution, and examined by different techniques. Radiation-induced changes of the chemical properties have been evaluated as a function of the absorbed dose and the effect of the oxidative ambient has been compared with that of irradiation in air. The molecular weight data obtained by Gel Permeation Chromatography indicate that biodegradable polymers show a more significant loss of molecular weight with respect to PE as the dose increases. On the contrary, the thermal behavior investigated by Differential Scanning Calorimetry does not seem to be affected by the treatment at these absorbed doses. In addition, the surface properties have been carefully evaluated in order to correlate their changes to the biodegradability in compost. In the case of PBS systems water contact angle measurements show that the hydrophilicity is affected already at the lowest absorbed doses, coherently with the remarkable decrease of molecular weight. The research performed confirmed that the radiation-induced degradation could be considered as an effective pre-treatment able to enhance the biodegradation rate of some polymeric systems.

Country/Organization invited to participate

Italy

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