STUDY OF STRUCTURAL MODIFICATIONS IN POLY(L-LACTIDE) (PLLA) INDUCED BY HIGH-ENERGY RADIATION

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Abstract. The high-energy radiation is frequently applied to tailor specific properties of polymeric materials, achieve sterility of medical devices, preserve food or modify waste materials. In this process, the transfer of the radiation energy, from typical sources like particle accelerators (electrons and X-rays) or Co-60 (the gamma radiation) to absorbing materials is achieved through secondary electrons, while the revealed physical and biological effects are very similar for both types of radiation sources.

Poly-L-lactide (PLLA) is a well-known biodegradable and biocompatible semi-crystalline polymer, used in a wide variety of applications, from implantable medical devices and drug release matrices to environmentally friendly packaging materials; diversity in the initial preparation, morphology and crystallinity plays a significant role in most of these applications. In this report, we will show the PLLA response to high-energy radiation and for that reason, two varieties of samples with substantial and in practice almost maximal reachable differences in microstructure and crystallinity are prepared and exposed to the gamma radiation to various absorbed doses (up to 300 kGy). Since the PLLA morphology is sensitive to preparation conditions and radiation, surface microstructures are analysed by scanning electronic microscopy (SEM). The chain scission degradation is followed using a gel permeation chromatography (GPC), while the additional characterization is conducted by differential scanning calorimetry (DSC), wide-angle X-ray diffraction (WAXD) method and IR spectroscopy (FTIR). The presence and evolution of free radicals are monitored using electron spin resonance (ESR) spectroscopy. The annealing treatment is also applied to part of the samples. Presented results show that depending on the initial preparation conditions, the radiation-induced changes in the structure and properties of PLLA, as well as the evolution of free radicals, can differ significantly. The low crystalline samples are found to be initially more susceptible to the gamma radiation than the high crystalline ones. On the other hand, due to the presence of long-lived free radicals the high crystalline samples are more prone to the post-irradiation degradation. Finally, the applied annealing treatment substantially reduces the concentration of long-lived radicals, but can also induce additional crystallisation.

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