Effect of ionizing radiation on physicochemical properties, in vitro toxicity and biodegradation of poly(trimethylene carbonate) and poly(lactic acid) copolymers

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Aliphatic polyesters, as biodegradable and biocompatible polymers, are getting more widely used in many industries, including biomaterials for medical applications. A prerequisite for their employment are the corresponding appropriate physicochemical properties and biodegradation profile. These can be provided by copolymers of the optimal composition and microstructure. An important element that allows the use of biomaterials is the possibility of their sterilization, in many cases advantageously by radiation.

This work presents a study on the simultaneous and sequential polymerization synthesis of poly(trimethylene carbonate) (PTMC) and poly(D-lactic acid) (PDLA) copolymers [1], evaluation of the effect of ionizing radiation on their chemical structure and on selected properties relevant to biological application, potential toxicity assessment and in vitro simulated biodegradation.

The combination of two polymers of PTMC and PDLA with different functional properties in a copolymer results in a material that is more flexible than PLA copolymer, but with greater mechanical strength compared to PTMC. The research resulted in elucidation of the mechanisms of changes in PTMC-co-PDLA copolymers exposed to ionizing radiation. In copolymers consisting of flexible TMC segments and rigid DLA blocks, the processes initiated by ionizing radiation of crosslinking and degradation of TMC segments and degradation of DLA segments occur simultaneously. The breaking of ester bonds and the formation of an alkoxy radical characteristic of polyesters result in a decrease in the molecular weight of macromolecules. Radicals generated simultaneously on carbonate segments cause crosslinking and degradation reactions, out of which the former process mainly involves radicals on the beta atom with respect to the carbonate group, while stabilized allylic radicals are responsible for the degradation process. The outcome of copolymer irradiation depends on its molar composition and microstructure [2].

PDLA-co-PTMC copolymers, sterilized by ionizing radiation (as well as irradiated with a dose several times higher), were shown to cause no negative cellular reactions and to be non-(geno)toxic to the cell lines of murine and human fibroblasts and to human endothelial cells. This was demonstrated with XTT, LIVE/DEAD and comet assay. Results of hydrolytic, as well as oxidation- and enzyme-assisted in vitro simulated biodegradation, showed that the biodegradation mechanisms depends on the copolymer molar composition, as the lactide part is susceptible for hydrolysis but the carbonate component to enzyme-catalyzed processes.

PDLA-co-PTMC copolymer biomaterials can be modified and sterilized using ionizing radiation.

References:

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