POLITECHNIKA WROCŁAWSKA
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Rozprawa doktorska

Zastosowanie promieniowania laserowego do modyfikacji warstwy wierzchniej materiałów na bazie poli(L-laktydu)

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Synopsis

The subject of the thesis focuses on modifying the surface layer of a polymer (poly(L-lactide)) and composite (poly(L-lactide) with hydroxyapatite) foil, which enables the control of physicochemical properties that are significant from the viewpoint of tissue engineering.

Three laser systems generating radiation in different spectral bands were used to modify surface: a gas (CO_2) laser ($\lambda = 10{,}6\ \mu m$), an excimer (ArF) laser ($\lambda = 193$ nm) and a femtosecond fibre laser ($\lambda = 1030$ nm).

Obtained results were analysed (depending on the type of the modification) with regard to surface morphology and topography, thermal properties, chemical and supramolecular structure, molecular weight, mechanical properties, surface wettability and with regard to biology.

Research on modifying the composite foil with a CO_2 laser, both below and above the ablation threshold, showed changes in physicochemical properties of the material, among others the reduction of: the degree of crystallinity of the polymer, molecular weight and strength parameters proportionate to radiation fluence. Conducted experiments confirmed the possibility of selective modification of the surface layer, which can be applied when designing materials with controllable degradation for use in living organisms.

The excimer laser was used for surface activation of a PLLA foil in order to increase its affinity for ions present in the solution of simulated body fluid (SBF). Research has shown that exposing a polymer to laser radiation below the ablation threshold can selectively initiate the deposition of an apatite layer on the modified surface. Additionally, it has been shown that laser modification significantly accelerates hydrolysis processes of the polymer in the SBF solution.

The femtosecond fibre laser was used for precise structurization of the PLLA surface. Four types of structures differing in roughness and geometry were made on the surface with the laser. Biological research has shown merits of laser modification, resulting from increased affinity of fibroblasts and osteoblasts for the surface, controllability of their behaviour and the possibility of targeting the location of the cells' adhesion at selectively chosen areas.

All the experiments have confirmed the possibility of using laser techniques for selective changes of the number of properties which are significant in terms of potential uses of modified materials in biomedical engineering.