THE INFLUENCE OF POLY(L-LACTIDE) SURFACE MODIFICATION BY CO_2 AND EXCIMER LASERS ON MECHANICAL PROPERTIES

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Introduction

Laser surface modification of the polymers can significant influence on the physicochemical and mechanical properties. Depend on the used laser as well process parameters e.g. the length of the light wave, pulse duration, number of pulses or pulse energies obtained results may be different [1-4].

The aim of the study was to investigate the influence of the poly(L-lactide) surface laser modification carried out by two types of laser: CO_2 and excimer ArF on its mechanical properties. According to the best of authors knowledge there is limited number of publication describing the influence of laser irritation on the mechanical properties of the biodegradable polymers for medical application.

In order to determinate the mechanical properties of PLLA specimens irritated by lasers underwent tensile test where form obtained stress-strain curves the tensile strength R_m and Young's modulus E were calculated.

Materials and Methods

The polymer sheets having an average thickness of 300 – 400 μm were extruded from commercial medical poly(L-lactide) (PLLA Evonik L210S) by compression molding of the granules pre-heated up to 200°C. In order to prevent material adhesion to the mold half polyamide spacer were used (Kapton HPP-ST, thickness 127 μm).

This procedure allowed to obtained amorphous poly(L-lactide) sheds having the degree of crystallinity Xc ≈ 2%.

In conducted study two types of laser were used: CO_2 laser with wavelength λ=10,6 μm and maximum average power of 25W. For surface modification three powers were used P_1=24mJ/cm^2, P_2=48mJ/cm^2 and P_3=71mJ/cm^2 (i); excimer laser ArF where PLLA samples were irradiated with respectively 20, 40 and 80 impulses per unit of area with same fluence (ii).

The choice of the applied CO_2 laser powers and number of excimer laser impulses were aimed to obtain the same geometrical outcome on the specimens' surface. For better comparison, in FIG. 1 and FIG. 2, comparative laser modification effects were separated by a dashed line.

Results and Discussion

Based on the obtained stress-strain curves the tensile strength R_m and Young's modulus E were calculated. The parameters describing the mechanical properties of the modified PLLA specimen are presented in FIG. 1 and FIG. 2. Conducted studies shown that surface modification of PLLA by CO_2 laser results in gradual decrease of the tensile strength R_m and increase of the Young modulus E in respect to the reference group. The slightest changes were observed for CO_2 laser for power 24mJ/cm^2 where R_m decreased 3.4% while Young modulus increased 0.8%. With the increase of the laser power up to 48mJ/cm^2 causes decrease mechanical properties of 14.5% and 1.1% for tensile strength and Young modulus respectively. The most destructive impact on PLLA had CO_2 irradiation of power 71mJ/cm^2 where the R_m value is nearly half of the one obtained for reference group while Young's modulus E raise up to 6%.

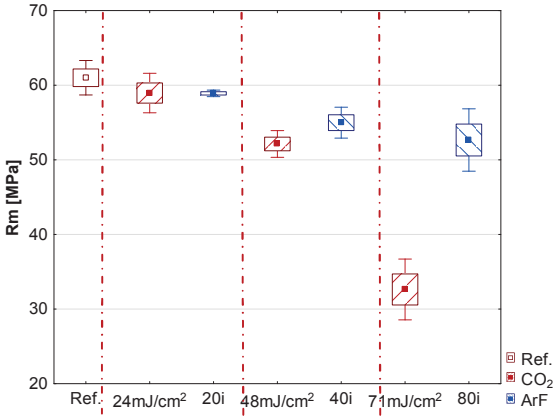

FIG. 1. The tensile strength R_m [MPa] of the reference PLLA and modified by CO_2 and excimer ArF laser.

Changes in mechanical properties of the samples modified by excimer ArF laser are not as significant as for the CO_2 laser. The tensile strength R_m decreases from 3.4%, 9.9% to 13.7% respectively for the 20, 40 and 80 impulses. Irradiation of 20 impulses per area results in increase of the Young modulus up to 2.6% and consequently increasing number of impulses applied on the PLLA surface will lead to a further reduction of the E respectively 1.3% and 3.3%.

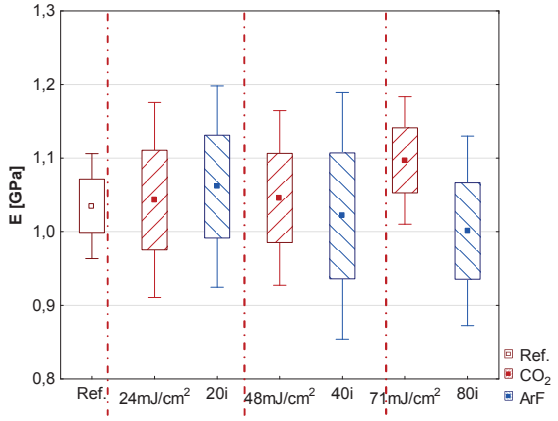

FIG. 2. The Young's modulus E [GPa] of the reference PLLA and modified by CO_2 and excimer ArF laser.

Conclusions

Conducted studies shown that the CO_2 laser irradiation has stronger impact on PLLA than the excimer ArF laser while maintaining geometrical modification of specimens.

Acknowledgments

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