ТЕЗИСЫ ДОКЛАДОВ

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ

«Физическая мезомеханика. Материалы с многоуровневой иерархически организованной структурой и интеллектуальные производственные технологии»,

посвященная 90-летию со дня рождения
основателя и первого директора ИФПМ СО РАН
академика Виктора Евгеньевича Панина

в рамках
Международного междисциплинарного симпозиума
«Иерархические материалы: разработка и приложения для новых технологий и надежных конструкций»

5–9 октября 2020 года
Томск, Россия

Томск
Издательство ТГУ
2020

DOI: 10.17223/9785946219242/230

POLY(LACTIC ACID) BASED POLYMER COMPOSITES FOR BIOMEDICINE

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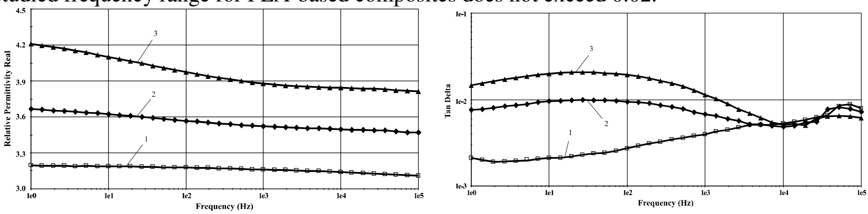
Numerous authors have demonstrated that addition of hydroxyapatite (HA) into poly(lactic acid) (PLA) matrix can improve both compatibility and mechanical properties of polymer-ceramic composites because hydroxyapatite possesses the most similar chemical composition to human bone. At present there are only a few PLA-based commercial products with improved properties suitable for their processing by extrusion and 3D-printing in the market. Besides, almost all biodegradable PLA-based composites were prepared by the solution mixing. However, this method is not particularly attractive for large-scale application as it involves different solvents and it is not an eco-friendly technology. The development of novel PLA-based composites prepared by melt compounding and study of their main properties were the aim of this work.

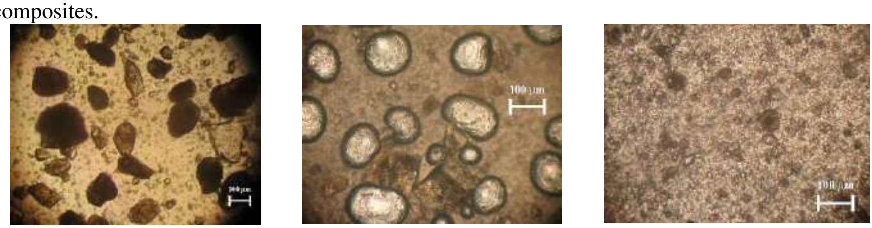
The measuring results of the real part of complex permittivity ε′ and loss factor tanδ for developed composite are presented in Fig. 1. It is obvious that frequency dependencies of ε′(*f*) for PLA and polymer composites exhibit typical behavior: the ε′(*f*) is monotonically decreased with frequency for both polymer matrices and composites based on them. The permittivity of PLA+25% HA composite is increased about 12-15% compared to that for neat PLA over the frequency range studied due to the higher permittivity of HA, which is about 4-9. Increase in the permittivity of PLA+50% HA composite is 23-32% compared to that for neat PLA. Loss factor tanδ over the studied frequency range for PLA-based composites does not exceed 0.02.



a) b)

Fig. 1. Frequency dependencies of real part of permittivity ε′ (a) and tanδ (b) for:
1, PLA; 2, PLA+25% HA; 3, PLA+50% HA

The results of optical microscopy (OM) are shown in Fig. 2. It can be seen that filler particles are quasi-uniformly distributed in the polymer matrix. However the filler particles form agglomerates sized around 100 μm, which are visible both for initial HA powder and for composite with filler content 25 wt%. Decrease in the average size of filler agglomerates for the composite with 50 wt% HA compared to that for composite PLA+25 wt% HA is attributed to de-agglomeration of filler powder particles during compounding due to an increase in the stiffness of composites.



a) b) c)

Fig. 2. OM micrographs of the filler powder (a) and PLA-HA composites: b, 25 wt% HA; c, 50 wt% HA

X-ray diffraction data for polymer matrix (PLA) and composites (PLA+HA) are shown in Fig. 3. These results indicate that for PLA broad diffraction peak around 2θ ≈ 16.2° due to reflections from (200) or (110) crystallographic planes is observed (Fig. 3a). On the other hand, peaks around 26.12°, 29.16°, 32°, 40°, 46.9°, and 49.7° observed for PLA-HA composites are attributed to the characteristic diffraction peaks of HA (Figs. 3b and 3c) due to reflections from (002), (210), (211), (310), (222) and (213) crystallographic planes.

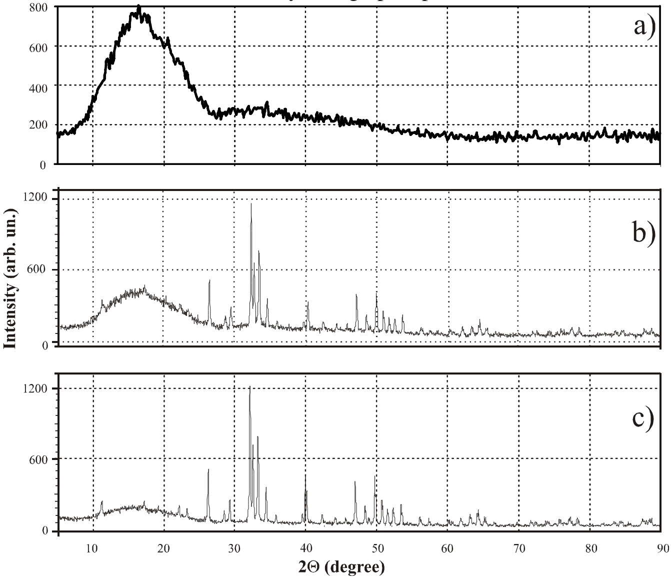


Fig. 3. XRD patterns for: a, neat PLA; b, PLA+25% HA; and c, PLA+50% HA

The degree of crystallinity for polymer matrix and composites are listed in Table 1. It can be seen that the crystallinity degree of PLA-HA composites is increased by 3.27 and 6.16 times for PLA+25% HA and PLA+50% HA composites, respectively, compared with neat PLA.

Table 1. The degree of crystallinity for neat PLA and PLA+HA composites.

Material	PLA	PLA+25% HA	PLA+50% HA
Degree of crystallinity, %	11.6	37.9	71.45

Table 2 lists the results of tensile tests. All studied mechanical parameters except for Young's modulus, tend to decrease with increasing filler content due to an increase in the stiffness of composites.

Table 2. The results of mechanical tests for neat PLA and PLA+HA composites.

Mechanical properties	PLA	PLA+25% HA	PLA+50% HA
Elongation at break, mm	1.66±0.1	1.1±0.08	0.82±0.1
Young's modulus, MPa	1101.3±54.6	711.2±70	832.2±55.9
Stress at break, MPa	83.3±2.9	56.3±5.6	48.6±5.9

Developed biodegradable composites can be used in biomedical applications for regenerative medicine as materials for fabrication of biodegradable scaffolds to stimulate bone growth.