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OSTEOCONDUCTIVE COMPOSITE MATERIALS BASED ON POLY-L-LACTIDE AND NANOCRYSTALLINE CELLULOSE MODIFIED WITH POLY(GLUTAMIC ACID)

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Abstract. Currently, there is an urgent need for biocompatible and biodegradable materials for bone tissue regeneration, capable of closely mimicking physical and mechanical properties of natural bones and leading to rapid and effective restoration of bone defects. At the same time, the possibility of initiating the mineralization process is key for bone substitute materials. Thus, the development of biofunctional materials with improved osteoconductive properties for bone tissue replacement is an actual medical task today. The most promising biocompatible and biodegradable materials for tissue engineering, including bone tissue engineering, are polyesters [1], but their hydrophobic properties impair the cell adhesion on their surface and thereby limit their application. The use of glutamic acid-rich peptides, which have been shown to improve the osteoconductive properties of the material [2], also seems prospective in the development of bone substitute materials.

The aim of this work was to obtain the series of composite polymeric materials based on poly-L-lactide (PLLA) with different contents of hydrophilic nanocrystalline cellulose (NCC) and modified with poly(glutamic acid) (PGlu) nanocrystalline cellulose (NCC-PGlu) (5, 10 and 15 wt%) as fillers. For this purpose several methods for modifying NCC with poly(glutamic acid) were tested. The best result was demonstrated by the partial oxidation of the NCC and the subsequent interaction of the obtained aldehyde NCC groups with the terminal amino groups of PGlu. The modification was confirmed by NMR and IR spectroscopy, dynamic light scattering, thermogravimetric analysis. The quantity of covalently bound PGlu with NCC was also determined. The protective benzyl groups of PGlu were not completely removed to improve the distribution of the filler in the PLLA. Further, a series of materials were obtained in the form of films with various fillers based on NCC. A significant improvement in all parameters for materials filled with NCC-PGlu was shown by a comparative study of morphology by optical, polarized light and scanning electron microscopy; tensile mechanical properties; mineralization in model solutions containing Ca^{2+} and PO_4^{3-} ions. Good cell adhesion on the surface and biocompatibility of the developed materials were also observed. Thus, the resulting composite materials based on PLLA and NCC-PGlu demonstrated their potential suitability for bone tissue engineering and the possibility of obtaining three-dimensional materials based on them by 3D printing.

References

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