ORIGINAL ARTICLES

Study of the physical and biological properties of nanocomposite materials obtained with laser radiation

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Abstract
The new method of the formation of nanocomposite materials based on carbon nanotubes for the regeneration of connective tissues has been developed.
Aim. Study of the structure, mechanical characteristics and biocompatibility of the obtained materials.
Materials and methods. The experimental samples of nanocomposite materials were based on multi-walled and single-walled carbon nanotubes, the matrix was bovine serum albumin. A layer of liquid dispersion of the components on a silicon substrate or in a container was irradiated with laser radiation to form the solid nanocomposite material. The microstructure of the obtained samples was analyzed with X-ray microtomography, the tensile strength was investigated using a testing machine. Fibroblast cells were incubated with experimental samples for 3, 24, 48, and 72 h and then fixed with glutaraldehyde. Cell growth during incubation with samples was studied using optical and atomic force microscopy.
Results. It was found that a slight decrease in tensile strength and increase in the degree of deformation were observed with an increase in the concentration of carbon nanotubes. At the same time, the mechanical parameters of the samples corresponded to the requirements for materials for the restoration of connective tissue defects. Microscopic studies indicate good adhesion of cells to the nanocomposite material, no toxic effect of the samples on the cells was found. After 3 hours of incubation, the cells had their original rounded shape, after 24 hours of incubation cells began to proliferate on the sample's surface and were spindle-shaped. After 48 and 72 hours, the cells practically formed a monolayer on the surface of the samples.
Conclusion. The results of the study show that the structural and mechanical parameters of the developed nanocomposite materials meet the requirements of biomedicine. It was also shown that nanocomposite materials do not suppress cell growth and can serve as a scaffold for the regeneration of damaged tissues.

Keywords: carbon nanotubes; serum albumin; scaffold; laser structuring; atomic force microscopy; tissue engineering; fibroblasts; connective tissue defects
MeSH terms:
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List of abbreviations:
AFM – atomic force microscopy
CNT – carbon nanotubes
MWCNT – multi-walled carbon nanotubes
SWCNT – single-walled carbon nanotubes

Today one of the most rapidly developing areas of biomedicine is biophotonics. Laser radiation is widely used for theranostics of a wide range of diseases. A large number of biocompatible materials, in particular, scaffolds for tissue engineering, can be obtained with the technology of laser polymerization [1]. To increase the similarity of such materials to the natural extracellular matrix and thereby improve the proliferation of cells in their volume, various nanoparticles can be embedded in them [2].

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MATERIALS AND METHODS

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RESULTS

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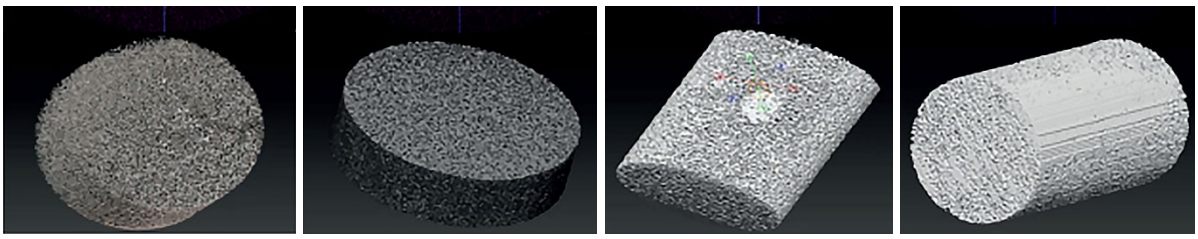

a b c d

FIG. 1 3D visualization of samples of nanocomposite material
a – sample with SWCNT (0.01 wt %), b – sample with SWCNT (0.1 wt %), c – sample with MWCNT (0.01 wt %), d – sample with MWCNT (0.1 wt %)
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Table. **Mechanical characteristics of samples of nanocomposite materials**
Translation into Russian of the title and content of the table is carried out by the editors

Sample / Образец	**Average tensile strength, MPa Средняя прочность на разрыв, МПа**	**Average relative extension, % Среднее относительное удлинение, %**
SWCNT (0.01 wt %) Одностенные углеродные нанотрубки (0,01 мас.%)	3.7	12.2

SWCNT (0.1 wt %) Одностенные углеродные нанотрубки (0,1 мас.%)	3.6	13.7
MWCNT (0.01 wt %) Многостенные углеродные нанотрубки (0,01 мас.%)	3.8	11.7
MWCNT (0.1 wt %) Многостенные углеродные нанотрубки (0,1 мас.%)	3.6	13.5

Note / Примечание: SWCNT – single-walled carbon nanotubes; MWCNT – multi-walled carbon nanotubes

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DISCUSSION

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CONCLUSION

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AUTHOR CONTRIBUTION

Alexander Yu. Gerasimenko developed the concept and the plan of scientific work, Uliana E. Kurilova and Alexander Yu. Gerasimenko were responsible for obtaining and interpreting data, preparing materials for publication. All authors approved the final version of the publication.

Translation into Russian of author contributions is carried out by the editors

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