Polymer materials, reinforced with carbon nanotubes for medical design

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Synthetic materials are widely used in modern medicine to rehabilitate the functions of patient's body, which were lost. In 20-40% cases patients have a reaction on exogenous material which is expressed as local non specific inflammation with formation of fibrous capsule and, in the worst-case scenario, leads to the prosthesis fracture (1-2). The reason of such kind of rejecting the polymers is the surface defects – the interruption of polymer chains that could be recognized by patient's immune system. The polymer reinforcement with carbon nanotubes (CNT) provokes the structure changes of practically all their physical properties like electro and thermal conductivity, temperature\point of melting and crystallization, glass-transition and etc., but most important, in increasing of strength properties. In this work the influence of polymers reinforcement - polytetrafluorethylene (PTFE), polypropylene (PP) with CNT on their biocompatibility were investigated

Materials and methods

The samples of nanocomposites PTFE+CNT, PP+CNT with different content of CNT (from 0,1% up 5%) as tablets and monothread PP+CNT were obtained for in vivo experiments. The initial polymers and nanocomposites were implanted to experimental animals (rats) under the total anesthesia. In the case of the use of monothead there were ligated muscles of back. At the end-point of the investigation, the samples of polymers were separated from surrounding tissue and their surface was studied with atomic force microscope. In addition, the histological analysis of tissue was performed

The topography of pure polymer samples without CNT in 4 weeks after implantation demonstrates that surface has dramatically changed. Histological analysis of surrounding tissue showed that there were parts of polymer in phagocytes. Perifocaly there were formed fibrous capsule with dissections and cysts and with inflammation infiltrates, mainly the lymphocytic kind. All this results confirmed that polymer implantation accompany with expressed local aseptic inflammation. In the case of using nanocomposites the surface went through the minimal changes and influence of body. The capsule, which covers them, had the minimum traces of inflammation and was like an isolated element. The thickness of capsule for samples PTFE with 15%CNT was 56±12 mcm in compare with 456±124 mcm for pure PTFE. For PP samples with CNT concentration from 0% up to 5% there was found nonlinear dependence of increasing biocompatibility with variation of CNT concentration, and it corresponded to improvement of nanocomposites strength properties (Tab).

CNT concentration	Thickness of fibrous capsule around sample (mcm)	Tablet		Monothread	
		compressive deformation, MPa	breaking stress, MPa	tensile strength, MPa	tensile strain, %
0%	253 ± 64	12.5	43.5	413.9	20.5
0,5%	167 ± 45	4.3	42.0	353.2	15.8
1%	54 ± 23	5.4	55.5	423.4	19.8
1,5%	145 ±35	6.0	56.0	-	-
5%	198 ± 56	7.9	66.0	-	-

In the case of using PP+CNT monothread it was showed the total structure retention of thread with sharp contours at the site of ligation.

Conclusion

In vivo studies it was showed that introduction of CNT into the polymer matrix appreciably influence on nanocomposites biocompatibility.

The appearance of the CNT on the surface shade the active centers such as interruption of macrochaines which leads to the prevention of the body reaction on exogenous material because carbon does not arise activation of the immune system.

References

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