NANOCOMPOSITE COATING FOR MEDICAL APPLICATIONS

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Introduction

Nanotechnology has opened new possibilities for surface modification of metallic implants designed for orthopedic, dental and maxillofacial surgery [1]. A special role in this domain may play carbon nanotubes. The layers made of carbon nanotubes on a metal surface enable to form a characteristic topography and unique chemical and physical properties of the material providing new opportunities for medical applications, e.g., the hierarchical micro/nanotopography significantly enhances the spreading, adhesion and proliferation of bone cells as well as improves activity of alkaline phosphatase [2-4]. Despite various advantages of such a layer formed by the EPD technique (electrophoretic deposition) on metals, this kind of nonmetallic coating has also some disadvantages resulting from a relatively poor adhesion to the substrate and often unsatisfactory interactions between the nanotubes forming layer. The aim of the work was to manufacture a nanocomposite coating on a metal surface, containing carbon nanotubes, free from drawbacks that are associated with the carbon nanotube layers obtained in the EPD process.

Materials and Methods

The study was based on carbon nanotubes subjected to the process of functionalization and a sol prepared from alkoxysilanes (dimetylodietoksysilanu and methyl triethoxysilane molar ratio of 2: 1), HCl catalyst and ethanol as solvent. Layer on the titanium surface, was prepared in a two-step method; EPD + sol-gel. In the first the appropriately prepared substrate was coated by a layer of carbon nanotubes which are then coated with sol and subjected to drying. The objectives of this study were the nanocomposite layer CNT/SIL and a layer made of carbon nanotubes. The two types of layers were subjected to microscopic examination. Then assesses the adhesion of layers to the substrate using the scratch test. Both materials were incubated in a physiological fluid (SBF) to determine their bioactivity. Cytotoxicity of these materials was determined in contact with the MG-63 cells, using the LDH assay which detected level of lactate dehydrogenase release from cells growing in the presence of materials. Also we conducted studies of genotoxicity of materials based on test γ-H2AX as a biomarker of DNA damage - double-strand breaks – dsb.

Results and Discussion

The results of microscopic nano-composite layer are shown in FIG. 1. From microscopic study indicate that nanocomposite layer CNT/SIL retains the topography characteristic of the layers produced from the carbon nanotubes. The sol gel process that takes place in the presence of carbon nanotubes leads to a solid layer, built of carbon nanotubes with surface modified by silanol groups. From the study of scratch testing indicate that the destruction of the CNT layer is starting already at a force of approx. 1 N and that in the case of a nanocomposite layer is followed at a fraction of the higher strength of about 45 N. The total destruction layer formed nanocomposite will occur at a much higher strength as compared with the layer made of the same CNT.

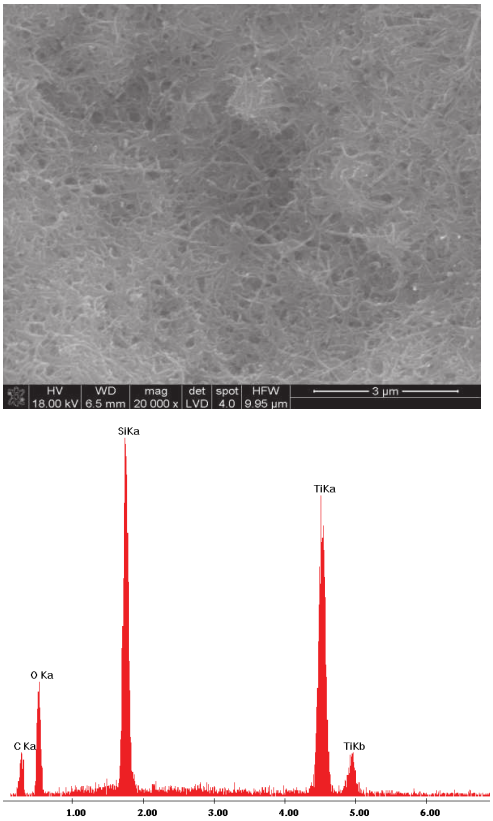

FIG. 1. SEM image and elemental analysis of CNT/SIL layer on titanium surface.

The results of the cytotoxicity study of titanium and both types of coatings are shown in TABLE 1.

TABLE 1. LDH release from MG63 cells in contact with Ti surface and CNT, CNT/SIL coating on metal surface.

Time of culture	PS (control)	Titanium surface	CNT coating	CNT/SIL Coating
1 day	6.3±0.3	11.0 ±1.3	7.4±0.9	8.2±0.6
3 days	7.8±0.3	11.6±0.7	8.0±0.2	6.1±0.5

The results of LDH test performed after 1 and 3 days of culture are significantly better for both types of layers in the entrainment of the titanium surface (TABLE 1). Produced, under the working, nanocomposite layer CNT/SIL are non-cytotoxic and non- genotoxic as well as have a high bioactivity in contact with the artificial plasma.

Conclusions

Two-stage method for the modification of metal implants leads to the production of layers which use a high potential of carbon nanotubes to modify biomedical devices also can provide a material without the disadvantages that may accompany the processes for producing coatings of carbon nanotubes in a EPD method.

Acknowledgments

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