BIOLOGICAL RESPONSE OF CH/Ag COATINGS DEPOSITED ON NiTi SHAPE MEMORY ALLOY

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Introduction

NiTi alloy due to the properties associated with the shape memory effects is increasingly used in medicine and veterinary medicine [1]. However, current applications require protection of the surface from unwanted migration of nickel ions. For this reason, the surface is modified with multifunctional layers/coatings, paying attention to the preservation of the shape properties of the NiTi substrate. One of the materials used for the coatings is chitosan and/or silver due to their bactericidal properties [2]. The paper attempts to evaluate the cell response to the silver content in the chitosan coating covering the surface of the NiTi alloy.

Materials and Methods

The alloy with a chemical composition of 50.6% at Ni and 49.4at% Ti was used as a substrate for the deposition of chitosan (Sigma Aldrich) coatings containing silver nanoparticles (AEE). The layers were electrophoretically deposited (EPD) using a deposition voltage of 20-40V and a deposition time of 30-120 s. The Ag content in the suspension was 0.6 g/l and 2 g/l. Cytotoxicity of the coated alloy was evaluated by MTT assay. Test was based on the activity of NADPH-dependent oxidoreductase enzymes which reduce the dye (MTT) to its insoluble form-formazan only in living cells. The cytotoxicity of coated alloy on L929 cells (NCTC clone 929: CCL 1) was assessed under the influence of eluates obtained from examined materials after 24 h of incubation (37°C, 5% CO_2) in culture media.

Results and Discussion

The deposition conditions (voltage and time) of the electrophoresis are determinants of layer properties composed of CH itself as well as the CH/Ag composite.
The first of all, increasing the deposition voltage results in increased adhesion of the chitosan layer to the surface of the NiTi alloy. Consecutively, the prolongation of the deposition time leads to an increase in the thickness and roughness of the layer. For example, by extending the time from 30 s to 600 s, the layer thickness can be increased from 0.5 µm to 12 µm [3]. In opposition to that, the surface roughness decreases as the deposition time decreases. An increase of the deposition voltage with a prolongation of the deposition time leads to an intensification of the electrophoresis process. In consequence, it causes an increase in the amount of emitted hydrogen. It blocks the flow of chitosan particles to the surface of the sample, strongly affecting the topography of the chitosan surface - the coating becomes rougher. The presence of silver in the suspension reduces the above effects and the surface, even with relatively long deposition times and high voltages (35 - 40V), adheres closely to the surface of the alloy.

Silver content in CH/Ag layer is strongly affected by concentration of silver in suspension, as well as by both values of deposition parameters. Increasing the amount of silver provides more material for building composite coatings. Hence, with the same voltage-time parameters, the amount of silver in the layer increases (FIG. 1). On the other hand, increasing the deposition voltage results in more intense silver incorporation in the chitosan layer. A smaller number of islands, formed by silver agglomerates, were visible on the surface. However, the agglomerates revealed a larger diameter [4].

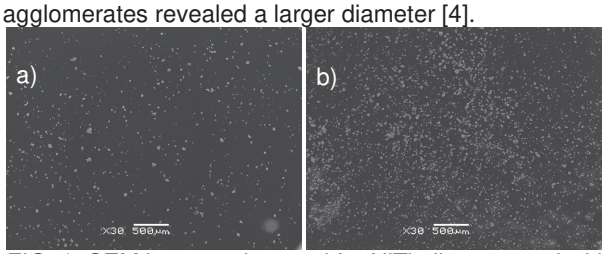

FIG. 1. SEM images observed for NiTi alloy covered with CH/Ag coating deposited at 25V/120s for Ag content 0,6 g/l (a) and 2 g/l (b).

Due to the content (0.6 g/l, 2 g/l) and the favorable distribution of nanosilver particles in chitosan, the alloys covered with 25V/120s and 35V/90s were selected for biological tests. The results of MTT assay on selected samples, NiTi alloy without cover and control group are shown in FIG. 2.

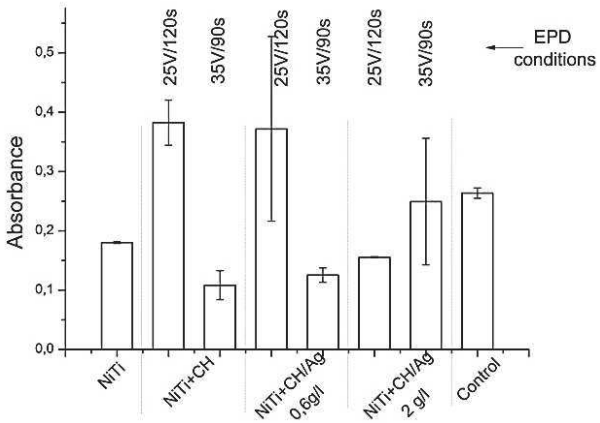

FIG. 2. Absorbance (λ = 570) of dissolved formazan (MTT assay) measured for studied groups.

Summary

The best results of cells proliferation were found in the alloy covered with chitosan as well as composite CH/Ag with a silver content in suspension of 0.6 g/l. This fact indicates that a small amount of silver does not adversely affect the proliferation of cells. By increasing the silver content in the CH/Ag coating (the amount of Ag up to 2 g/l and the deposition voltage to 35 V), cell survival drastically decreases by almost 70%. As a result, the cell survival rate is lower than for the uncoated alloy. This fact is related to both the thickness of the chitosan coating and the content of silver.

References

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