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Characterization of Electrical Potential and properties of Calcium Phosphate Coating Containing Zinc Oxide Nanoparticles

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The aim of the present research was the formation of micro arc coatings with ZO nanoparticles on the surface of a titanium as well as the investigation morphology, phase composition and electrical potential of the coatings.

MATERIALS AND METHODS

The plates from commercially pure titanium with sizes of 10×10×1 mm^3 were used as substrates. The titanium plates were ultrasonically cleaned for 10 min in distilled water and 10 min in alcohol (Elmasonic, Germany). In order to form CaP coatings on the titanium surface the technological installation “Micro-arc-3.0” was used [4, 7]. The “MicroArc-3.0” installation was developed at the Institute of Strength Physics and Materials Science SB RAS (ISPMS SB RAS, Tomsk, Russia) .

Obtained porous coatings were functionalized by ZO nanoparticles. ZO nanoparticles were produced by the electrical explosion of zinc wire in an argon and oxygen atmosphere. The morphology of the samples was investigated by scanning electron microscopy (SEM) on LEO EVO 50 electron microscope (Zeiss, Germany) equipped with an INCA-Energy 350 EDS analyzer (Oxford Instruments, Abingdon, UK) in Nanotech Center of Collective Use, ISPMS SB RAS. The electrical potential (EP) was measured using contact potential differences (CPD) techniques. The nonvibrating CPD method based on the Kelvin scanning probe method was realized on a specialized scanning installation (Belarusian National Technical University (Minsk, Belarus)) to measure electrical properties of the CP coatings.

RESULTS AND DISCUSSION

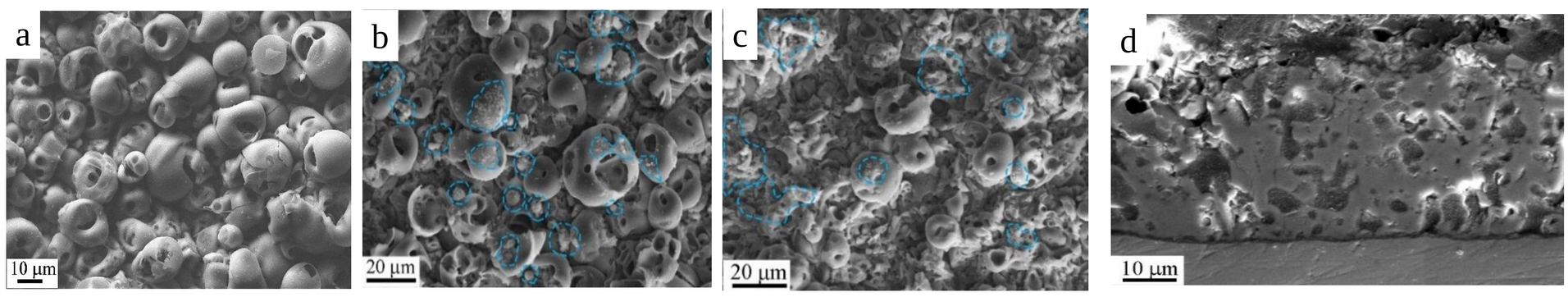

Figure 1. SEM images of CP coatings surface (a-c) and cross-section (d) formed under MAO voltage of 200 V (a) and functionalized by ZO nanoparticles after UD of suspension of different duration (blue dashed lines point to the agglomerates of ZO nanoparticles), min: b) 10, c) 60.

Figure 1 represent the surface of CP coatings before (a) and after modification with ZO nanoparticles (b-c). The coating thickness before modification was equal to 40-45 μm. Its surface morphology was characterized by the presence of numerous spherical structural elements of up to 10-30 μm with pores. The average roughness (Ra) of the coating was 3.5 μm.

The initial dispersion of the suspension of ZO nanopowder for 10 minutes led to the formation of nonuniformly distributed spheroid particles with a size of 9 μm and smaller particles with a size of 0.5 μm (fig.1 b, blue dashed lines point to the agglomerates of ZO nanoparticles). The roughness of such coating increased up to 4.2 μm. EDX analysis of the surface of the modified coating revealed oxygen, phosphorous, titanium from the substrate, calcium and zinc (fig. 2). An increase in the duration of UD of the suspension from 10 to 60 minutes led to disaggregation of spheroid ZO particles and partial destruction of CP coating spheres. The surface roughness of such coating increased up to 5.0 μm. The zinc content in the coating decreased from 4 to 3 at.% with increase of UD duration from 10 to 60 min. Thus the 60 min of UD duration provides uniform distribution of Zn on the coating surface.

The study of the electrical properties of CP coatings showed that all coatings, both before and after modification, had a negative electric potential. The value of electrical potential of the control CP coating (without ZO nanoparticles) was equal –85 mV. The introduction of ZO nanoparticles into the coatings pores after 10 minutes of UD leads to an increase of electrical potential from –85 to –95 mV.

When the UD durations of the suspension with ZO nanoparticles increased from 10 to 60 min, the electrical potential of the modified coatings varied in the range from –95 to –72 mV (Fig. 2). This is due to an increase in the amount of ZO agglomerates and their more uniform distribution over the coating surface. There are more areas with a positive charge in the coating, which contributes to an increase in the electrical potential. Figure 2 illustrates that the dependence of the electrical potential value of the CP coating on the UD duration of ZO suspension is linear.

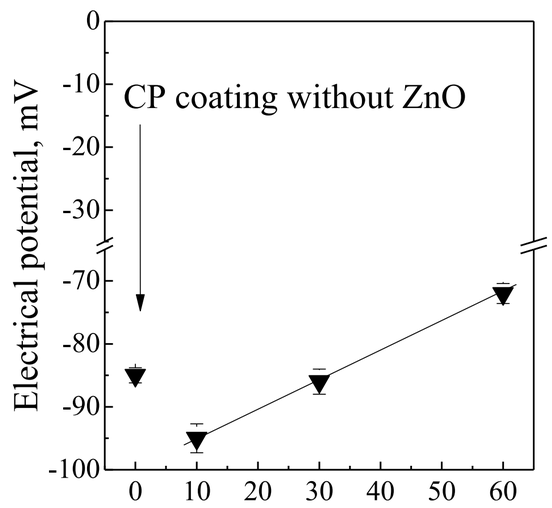

Figure 2. Electrical potential of the control CP coating and the CP coating with ZO nanoparticles after different durations of UD

SUMMARY

The influence of the modification of CP coatings with ZO nanoparticles on their electrical properties and morphology was studied. The coatings formed by MAO method on titanium in an electrolyte containing calcium phosphate compounds had a porous structure. The research of the morphology, elemental composition and electrical properties of the CP coatings modified by ZO nanoparticles was performed. The increase in the duration of ultrasonic dispersion of ZO suspension from 10 up to 60 min led to uniform distribution of ZO nanoparticles. The electrical potential of the coatings depended on the duration of the ultrasonic dispersion. When the UD durations of the suspension with ZO nanoparticles increased, the electrical potential of the modified coatings changed from –95 to –72 mV.

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