

INVESTIGATION OF THE PHOTOCATALYTIC ACTIVITY AND RADIOPACITY OF NANOPOWDERS PRODUCED BY PULSED ELECTRON BEAM EVAPORATION IN VACUUM*

A.S. GERASIMOV^{1,2}, A.S. CHEPUSOV², V.G. ILVES², O.A. SVETLOVA^{1,2}, S. YU. SOKOVNIN^{1,2}

¹*Ural Federal University, Yekaterinburg, Russia*

²*Institute of Electrophysics, UB, RAS, Yekaterinburg, Russia*

Nanopowders (NP) are promising substances for use in the medical and pharmaceutical field due to antimicrobial, antitumor and other properties of their shell and bioinert core. Various methods of obtaining nanopowders can significantly affect their properties. Thus, bismuth and zirconium oxide nanopowders produced by the pulsed electron beam evaporation (PEBE) method showed high biological and photocatalytic activity [1].

In this work, were investigated the photocatalytic properties and radiopacity of titanium TiO₂ and zinc Zn-ZnO oxide nanopowders produced by the PEBE method in vacuum [2]. These compounds can be used as photocatalytic thin coatings, whose nanoparticles have antimicrobial properties [3]. The high atomic number of metals and high density of atoms per nanoparticle in these oxides makes them prospective for implementation as a contrast agent for computed tomography (CT).

The photocatalytic activity of examined NP at the concentration of 300 mcg/ml was evaluated in comparison with the decomposition of methyl violet (MV) in the medium under ultraviolet light irradiation. The rate of decomposition of MV from the time of exposure to UV radiation can be described by the linear equation $y=kx+b$, where the coefficient k is the rate of photodestruction. The higher the coefficient k , the faster the solution discolors [4]. The measurement of k is exemplified below.

Table 1 – The k coefficient values for TiO₂ and Zn-ZnO NP

Sample	Absolute value	Relative to MV
MV	-0,0053	1
TiO ₂	-0,0078	1,47
Zn-ZnO	-0,0085	1,60

Both NP showed significant photocatalytic activity. However, it was found that zinc oxide has better photocatalytic properties compared to TiO₂ samples.

The radiopacity of NP was evaluated relative to commercial iodine CT contrast agent Ultravist[®], by analogy with the work [5]. For the study were prepared solutions of 0.75% Na-Carboxymethylcellulose containing nanopowders in various concentrations. X-ray images of the samples were processed in the “ImageJ” software package. During the analysis, were calculated linear X-ray attenuation coefficients.

The highest attenuation coefficient was found in a sample of titanium oxide at a concentration of 12.5% and amounted to 70% relative to Ultravist[®]. At the same time, the ZnO-Zn sample did not show high radiopaque ability.

REFERENCES

- [1] O.A. Svetlova, V.G. Ilves, S.YU.Sokovnin, “Investigation of biological and photocatalytic activity of multimodal nanopowders produced by pulsed electron beam evaporation in vacuum,” J. Phys.: Conf. Ser., vol. 2064, no. 1, p. 012087, September 2021.
- [2] Sokovnin S. Y., Il’ves V. G., Zuev M. G. “Production of complex metal oxide nanopowders using pulsed electron beam in low-pressure gas for biomaterials application,” Engineering of Nanobiomaterials, vol. 2, pp. 29-75, February 2016.
- [3] Pang S. et al. “Multifunctional ZnO/TiO₂ nanoarray composite coating with antibacterial activity, cytocompatibility and piezoelectricity,” Ceramics International, vol. 45, no. 10, pp. 12663-12671, March 2019.
- [4] Sokovnin S. Y. et al. “Investigation of biological and photocatalytic activity of nanopowders metal oxides with nanosized silver coating,” J. Phys.: Conf. Ser., vol. 1954, no. 1, p. 012047, May 2021.
- [5] Ghazanfari A. et al. “Synthesis, characterization, and X-ray attenuation properties of polyacrylic acid-coated ultrasmall heavy metal oxide (Bi₂O₃, Yb₂O₃, NaTaO₃, Dy₂O₃, and Gd₂O₃) nanoparticles as potential CT contrast agents,” Colloids and Surfaces A: Physicochemical and Engineering Aspects, vol. 576, no. 5, pp. 73-81, May 2019

* The work was supported by the RFBR and GACR under grant No. 20-58-26002