SYNTHESIS OF TUNGSTEN, MOLYBDENUM AND TITANIUM OXIDE NANOPARTICLES USING A PULSE UNDERWATER DISCHARGE [[1]](#footnote-1)\*)

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One of the applications of discharges in contact with liquids is the synthesis of metal or oxide nanoparticles [1, 2]. In the simplest versions, discharges between two metal electrodes immersed in a liquid are used. Plasma is formed in vapor-gas bubbles arising due to overheating of the solution near the electrode, or as a result of the development of streamer discharges [3].

The aim of this work was to obtain nanoparticles of molybdenum, tungsten, and titanium oxides using a direct current discharge plasma with two metal electrodes immersed in water.

An underwater discharge was ignited between two rods with a diameter of 1.0 mm placed in distilled water at a distance of 3 mm. The electrodes were made of tungsten, molybdenum or titanium. To excite the discharge, a constant high voltage source (up to 5 kV) was used; the average discharge current in different experiments was 0.2–0.5 A. Plasma emission spectra were recorded with an AvaSpec-3648 spectrometer. The size distributions of the obtained nanoparticles and their zeta potential were determined by dynamic light scattering (Malvern Zetasizer Nano ZS, Malvern, UK). The surface of the crystals precipitated from the solution and their elemental composition were studied using a TESCAN VEGA 3 SBH scanning electron microscope (SEM) (Czech Republic) equipped with an EDS attachment for energy dispersive microanalysis (Oxford Instruments, United Kingdom).

The discharge burned in a pulsed mode. The oscillograms of current and interelectrode voltage were used to estimate the power dissipated in the discharge. It was found that in the plasma emission spectra there are not only the lines of atomic hydrogen, oxygen and OH radical bands, but also atomic lines of metals used as electrodes. It has been established that sputtering of electrodes during discharge burning leads to the formation of aqueous dispersions of metal oxide nanoparticles. The average nanoparticle diameter in dispersions (125 - 400 nm) depends on the discharge current, and the zeta-potential is about -30 mV. SEM results showed that after drying the samples, the nanoparticles agglomerate quite strongly. However, the size of individual particles in the agglomerates is consistent with the results obtained by dynamic light scattering. In the energy dispersive spectra of the powders, only lines of metal atoms and oxygen were present. In the case of tungsten electrodes, the ratio of atomic concentrations in the obtained products is close to the stoichiometric in WO3 oxide ([W]: [O] = 1: 3.1). Using molybdenum rods, nanoparticles of non-stoichiometric MoOx molybdenum oxide were obtained with the ratio [Mo]: [O] = 1:4. Titanium oxide nanoparticles (TiO2) were obtained using titanium electrodes. The average values of the energy required for the formation of oxides are 170-350 eV/molecule.

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References

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1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVII/Lt/ru/EH-Sirotkin.docx) [↑](#footnote-ref-1)