The study on agglomerates of WC, TiC, TaC nanopowder mixtures obtained from hard-alloy waste products

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Abstract. The paper presents findings of the nanopowder obtained from hard-alloy waste (a mixture of tungsten, titanium, and tantalum carbides) under a unique technology. Dispersion, particles’ morphology have been studied. Chemical purity of this nanopowder has been confirmed by X-ray spectral microanalysis.

1. Introduction
Today introduction of nanopowders into various industries offers great opportunities to improve properties and characteristics of various materials. However their production on industrial scale is constrained by the need to use expensive equipment.

One of the promising and needed materials on the nanopowder market is high-melting compounds and/or their mixtures (tungsten W, tungsten carbide WC, titanium carbide TiC, etc.). It’s known that carbides of these metals are characterized by high hardness, ruggedness at high temperatures, high-resistance to oxidation, abrasion resistance, etc.

In [1] there was proposed a method to produce nanopowders of high-melting metals and their carbides under a unique technology using hard-alloy metal scrap. This technology has no world analogues. This method opens up opportunities for production of nanopowders in production quantities, as it needs minimal technological equipment, environmental safety, relatively low operating costs and high purity of the powder.

This paper is a continuation of the papers [2-6]. Previous studies have shown availability to use powders of high-melting metals and their compounds as modifying additives in lubrication compositions [2], building materials [3], epoxy resins [4], plastics [5], radioprotective materials [6], and so on.

2. Experimental details
As a starting material to produce nanopowders we’ve used hard-alloy wastes (tungsten carbide WC – titanium carbide TiC – tantalum carbide TaC – cobalt Co).

Dispersion and particles’ morphology were studied with the help of a PHENOM proX scanning electron microscope with an integrated system of energy-dispersion analysis. The elemental analysis of the hard-alloy wastes and studied powders was obtained using the Phenom Element Identification program. Particle Metric software was used to analyze size, shape, and morphology of the particles. Figure 1 shows micrographs of alloy, used as a raw material for the production of powders.
Figure 1. Micrograph of hard alloy.

Almost the entire volume of the structure is occupied by the carbide phase, which consists of grains of tungsten carbide, titanium carbide, tantalum carbide, which is confirmed by elemental analysis (table 1). Grain sizes are 1 - 7 microns.

**Table 1.** The chemical composition of alloy.

| Element symbol | W  | Ta | Ti | C  | O  | Co |
|----------------|----|----|----|----|----|----|
| Weight conc.   | 78.0 | 7.8 | 1.9 | 1.5 | 2.8 | 8.0 |

The technology to produce nanopowders of high-melting metals and their carbides from hard-alloy wastes (fig. 2) is described in [1, 2].

Figure 2. Alloys before/after processing.

This method is based on destruction of alloy matrix by specially prepared solutions using adapted microorganisms.
3. Results

The results of the study of sample elemental composition (table 2) showed that the powder obtained is a mixture of tungsten, titanium, and tantalum carbides (fig.3).

![Figure 3. Spectra of the powder under study.](image)

**Table 2.** Elemental composition of the powder under study.

| Element symbol | W  | Ta  | Ti  | C  |
|----------------|----|-----|-----|----|
| Weight conc.   | 83.75 | 1.22 | 7.3 | 7.73 |

Figure 4 shows micrographs of particles (and their agglomerates) of the sample powder that is a mixture of tungsten, titanium, and tantalum carbides at different magnifications.

![Figure 4. Micrographs of particles of the sample powder at different magnifications: a) 26500 times as much b) 52000 times as much, c) 57000 times as much.](image)
From the presented photos (fig.4) it is clear that most particles have an irregular shape. It resulted in larger surface and therefore interaction reaction proceeds more actively. The powder is prone to agglomeration during storage (Fig.4, c). Multiple accretion of agglomerates among themselves is observed, boundaries of accreted points are uneven, tortuous.

The diagrams of particles (distributed in size) are shown in fig. 5. According to the diagram particles’ (agglomerates’) size of the powder under study 65-500 nm.

Thus, high purity of the nanopowder (agglomerates) that is a mixture of tungsten, titanium, and tantalum carbides powder was obtained as a result of processing of production hard-alloy wastes.

4. Conclusion

Based on the results of the experiment to produce nanopowders out of hard-alloy waste (a mixture of tungsten, titanium, and tantalum carbides) we can conclude the following:

- the powder obtained is a mixture of tungsten, titanium, tantalum carbides.
- powder particles are of irregular shape, some of them are agglomerates.
- the particles are 65-500 nm by size.

Further studies will involve ultrasonic destruction of agglomerates structure.

References

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