Antifriction properties of electrochemical coatings based on carbon materials

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Abstract. As a result of research by the detonation synthesis method, chemically stable nanodiamond particles with a size of up to 100 nm were obtained. Aqueous solutions of the obtained particles can be used as an electrolyte to obtain carbon coatings by the electrochemical method.

1. Introduction
Numerous studies in the field of mechanical engineering are aimed at studying the processes of friction and wear of materials, as well as the possibility of controlling these processes to ensure the effective functioning of machines and mechanisms [1-5]. Particular attention is paid to anti-friction coatings, characterized by a low coefficient of friction, which can significantly increase the resource of friction units and increase the service life of machines and mechanisms.

2. Main part
In the last decade, close attention has been paid to materials that have layered structure such as molybdenum disulfide MoS₂, disulfide tungsten WS₂ or graphene oxide [6,7], which are widely used as solid lubricants or additives to liquid base oils [8, 9]. The low coefficient of friction of these materials is usually associated with the possibility of easily breaking weak van der Waals forces between layers. In the process of interaction of tribo-conjugated surfaces, tungsten disulfide WS₂ is characterized by high thermal stability up to 594°C, and molybdenum disulfide MoS₂ has better self-lubricating properties. This can contribute to the formation of an antifriction self-lubricating coating during friction on the sliding surfaces.

In recent years among materials with self-lubricating properties, nanodiamond particles are increasingly attracting scientific interest due to their unique mechanical and tribological properties, including high hardness, thermal conductivity, adsorption capacity, and low coefficient of friction [10-12]. The presence of functional groups on the surface of nanodiamonds leads to a pronounced ability to influence their adsorption capacity with respect to surfactants during friction.

Also, much attention is paid to the stability of suspensions of nanodiamonds in water and in buffer solutions. Experimental data prove that stabilization of nanodiamonds by both ionic and nonionic surfactants does not lead to a significant effect on the size distribution of nanoparticles. Based on the previously obtained data [13], it was determined that there is a positive charge on the surface of nanodiamonds, which can interact with the negative charge of surfactants.
Thus, self-lubricating coatings do not require additional oil-based lubricants in the friction unit, which attracts significant research and commercial interest.

Recently, antifriction coatings based on carbon materials such as graphene or nanodiamonds have attracted more and more attention. In this study, an attempt is made to obtain nanodiamonds with the aim of their subsequent use as an electrolyte for the creation of antifriction coatings by electrochemical deposition on a steel surface.

One of the most widespread methods of obtaining nanodiamonds is the method of detonation synthesis under various conditions. As a result of this synthesis, nanodiamonds were obtained, the size and shape of which were investigated using atomic force microscopy. The scanning of nanodiamond particles was carried out in the semi-contact mode with a single-crystal silicon probe with an aluminum coating with a resonance frequency of 190 kHz ± 60 kHz and a constant stiffness of 48 N / m. Scan speed 0.3 ms / line with 512 × 512 resolution. The results obtained were processed in the gwyddion program.

As can be seen from the results of atomic force microscopy, the obtained nanoparticles have a size of up to 100 nm, and the shape of their particles is close to spherical, figure 1. At the same time, nanoparticles practically do not form agglomerates, which indicates their chemical stability.

![Figure 1. Results of atomic force microscopy of nanodiamond particles obtained by detonation synthesis.](image)

3. Conclusion

Thus, as a result of research by the detonation synthesis method, chemically stable nanodiamond particles with a size of up to 100 nm were obtained. Aqueous solutions of the obtained particles can be used as an electrolyte to obtain carbon coatings by the electrochemical method.

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