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COMPOSITE NANOBIOSORBENT AS A PROMISING MATERIAL FOR AQUATIC ENVIRONMENT TREATMENT FROM RADIONUCLIDES

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High demand in new materials which are capable of permanently eliminating radionuclides comes from the actuality of the problem of environment contamination by radionuclides in general and water environment contamination in particular. Radionuclides occupy special place among agents which contaminate environment components due to their extreme stability and capability to penetrate underground waters, thus, contaminating drinking water reserves. At present clean up of natural and technogenic waters represent a serious ecological problem which exists in many regions of Russia as well as in majority of countries due to many sources of water contamination by radionuclides. The scale of tasks to eliminate the consequences of environment contamination and prevent further pollution demands appropriate efforts to develop sorbent materials and technologies for their application. In particular sorbents must be cheap and mass, while compact leavings which contain radionuclides must be convenient for long term storage, refinement and disposal.

In recent years research on new class sorbent development is actively progressing in many countries, these sorbents should constitute biogenic substances and include them as the main element – biosorbent. For example, they are produced from microbe mass or fungi which are microbiological industry wastes. Apart from that, application of different nanoforms of metal oxides as a sorbent is viewed as promising one.

In spite of the fact that nanotubes and nanopowders have been deeply studied in foreign literature as material for removal of ions of heavy metals there are some implications of using nanoforms of metal oxides as sorbent. Metal nanoparticles can be applied as matrixes for immobilization of plutonium, technetium, uranium and transuranium elements due to their capacity to eliminate radioactive ions accompanied by deformation of nanomaterial, as a result of which caught radionuclides are permanently trapped in the sorbent structure.

Main characteristics of metal nanoparticles plated on mycelium of growing mold fungi are practically no different from the weighted in solution nanoparticles properties. Small fragments of mold mycelium separated from the main culture and transferred to colloidal solution which contains nanoparticles are finally end up being covered by these nanoparticles. Apart from that no prior modification of neither particles nor mold is required for nanoparticles adsorption on the surface of growing mycelium. Final hybrid material represents tube cell of mold fungi covered by several layers of nanoparticles. Deposition of nanoparticles on mold is not accompanied by their aggregation with each other.

The aim of our research is to develop new effective, composite and safe sorbent, and as component of which we plan to use metallic nanotubes, concretely metal oxide nanomaterials, and modified by this nanomaterials fungi. The prerequisites for metal nanoparticles using are hypotheses that state - the metal nanoparticles can be used as matrices for immobilization of plutonium, technetium, uranium and transuranic elements due to the ability to absorb radioactive ions while the deformation process of the nanomaterial takes place [2]. As a result, the absorbed radionuclides are permanently enclosed in the structure of the sorbent [3].

For the research the nanopowders of cupric and iron oxides, obtained by electrical explosion of cupric wire in air, nanopowder of oxide – hydroxide aluminum phases were used.

It is known that nanoscale materials form poorly stable suspensions. [1] High ability to agglomerate the nanoparticles in an aqueous medium does not allow reaching the maximum surface and, consequently, the adsorption activity of the material. We used the ultrasonic dispergation for agglomerates to breaking up it.

Indeed, when ultrasonic dispergation of nanoparticles was used, sorption activity increased in several times (Table 1). So activation of nanopowders of iron oxide (Fe_3O_4) increases sorption capacity from 18 to 66%.

Table 1

Sorption characteristics of materials

Sorbent	Initial concentrations of uranium-ions, mcg/l	Without ultrasonic dispergation		With ultrasonic dispergation	
		Final concentrations of uranium-ions, mcg/l	Relative adsorption, %	Final concentrations of uranium-ions, mcg/l	Relative adsorption, %
Fe_3O_4	1 800	1 480	18	610	66
CuO	2 100	755	64	628	70
AlOOH	2 100	1 570	25	1 093	48

Best results have been obtained with powders of cupric oxide (CuO) as before ultrasonic dispergation, so and after (64 and 70% respectively). Nanoparticles of oxide – hydroxide aluminum phases (AlOOH) showed worse sorption capacity as before ultrasonic dispergation, so and after (25 and 48% respectively). These results confirm the the fact that nanoparticles have ability to agglomerating in aqueous. Using ultrasound prevents the formation of agglomerates, thus, the active surface of the sorbent increases.

The low sorption activity of nanopowder of AlOOH is probably a result of its inherent high hydrophilicity. AlOOH nanoparticles in aqueous environment form strong agglomerates which cannot be destroyed by ultrasonic dispergation

In general, we can say that using ultrasonic dispergation significantly increases the sorption capacity of nanomaterials. Thus, most perspective materials are nanopowders of cupric and iron.

Another component of the composite sorbent can be mold fungi as the main characteristics of metal nanoparticles deposited on the growing mycelium of fungi do not differ from the nanoparticles properties suspended in the solution. During the research we used pure culture of mold «Aspergillus niger», cultivated on Sabouraud medium. Fragments of the mold mycelium were transferred to a colloidal solution containing nanoparticles of titanium dioxide. At the same time there was no any preliminary modification of the particles or mold for the adsorption of nanoparticles on the surface of the growing mycelium.

The conducted researches have shown the benefit of using composite materials in comparison with nanomaterials or fungi, which are used by themselves (Fig., Table 2).

Table 2

Sorption characteristics depend on types of sorbent

Type of sorbent	Initial concentrations of uranium-ions, mcg/l	Final concentrations of uranium-ions, mcg/l	Relative adsorption, %
Aspergillus niger	2 325	1 152	50
Aspergillus niger + TiO_2	2 325	393	83
Aspergillus niger + AlOOH	2 325	477	80

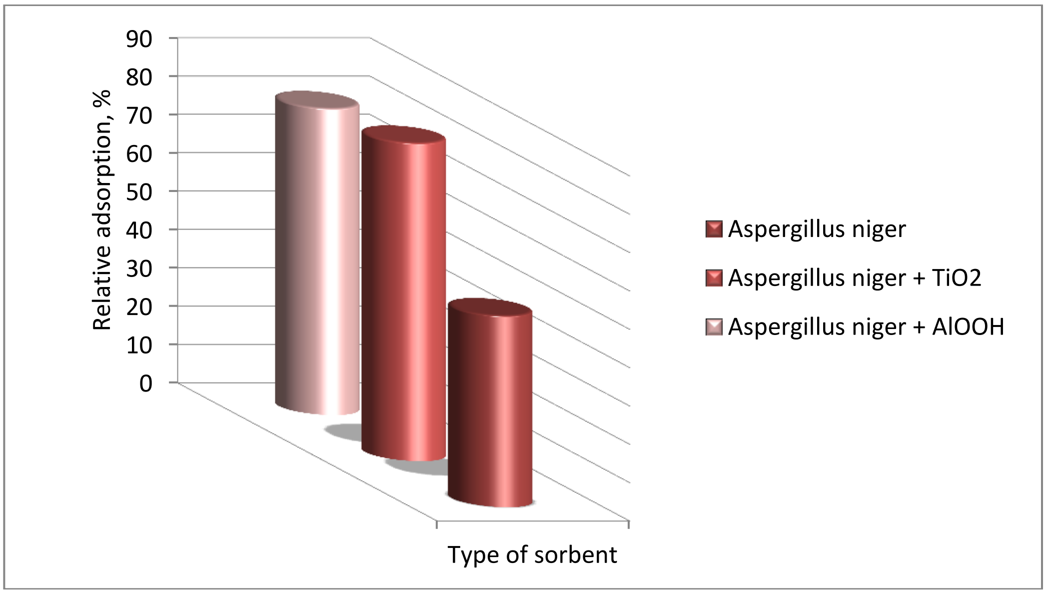

Fig. Relative adsorption depends on types of sorbent

Thus, we would like to note the high sorption characteristics of composite nanobiosorbent and we can say that this is a promising material for aquatic environment treatment from radionuclides.

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