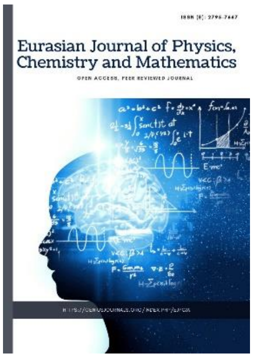

Technology Of Obtaining Carbon Nanotubes And Their Use In Practice.
Practical Use Of Nanomaterials

U.D. Sherkulov
NavSPI

ABSTRACT

Article on the practical use of nanomaterials, author Uktam Dekhkonovich Sherkulov, Republic of Uzbekistan, Navoi State Pedagogical Institute. The article provides information about the main nanotechnologies available in the world, their production and use in the national economy, problems of the application of nanotechnologies, and other information. The article is intended for scientific researchers and graduate students

Keywords: Nanomaterials in industry, titanium and its alloys, gear products, structure, heat-resistant material, nanodiamond, engineering technologies, dispersed phase, abrasive treatment, plasticizer, composite materials.

Introduction

In the last decade, we have increasingly used words such as “nanotechnology”, “nanomaterials”, “nanosystems”.

These words no longer surprise anyone, since they are constantly associated with the development of new technologies that create materials at the atomic level (usually from 1 to 100 nm). Nanoproducts and nanotechnologies have become a part of our lives. They can be found in building materials.

For all developed and developing countries, nanotechnology is one of the priority areas of science and technology, which is designed to bring revolutionary changes to various sectors of industry, energy, medicine, construction and agriculture. This applies to such areas of production as new materials with unique mechanical and thermophysical properties, nanoelectronic elements with record speed and low energy consumption, sensors with selective sensitivity at the level of individual atoms and molecules, lasers in quantum-sized structures. Photodetectors with high radiation efficiency and characteristics several times higher than modern analogues, etc.

Historically, issues of nanotechnology have been actively studied since the early 60s of the last century. This interest was largely purely scientific without significant financial support from the government. The situation changed in 2000 with the adoption by the US government of the National Nanotechnology Initiative, a government investment program aimed at developing nanotechnology.

The impetus for this work was a similar program adopted two years ago in Japan, which has the highest government priority, and the program was financially supported not only by the government, but also by large private companies. Later, government programs for the development of nanotechnology were adopted in the European Union and China. Since 2007, Russia has been included in the list of these countries. All this quickly yielded practical results.

If in 2009 the global market for goods created using nanotechnology was $254 billion, then by 2017 this figure reached almost $1 trillion, and by 2020 it exceeded $3 trillion.

After the prestigious scientific journal Science named nanotechnology the “breakthrough of the year,” public interest in it increased sharply, and the phrase “new industrial revolution” began to be often applied to nanotechnology. Hundreds of conferences are held almost every year on various aspects of nanotechnology. Hundreds of thousands of articles and monographs have been published, special websites have been created on the Internet, and reports regularly appear about new ideas for the use of nanotechnology or new types of products obtained using nanotechnology.

This article has been prepared for use as an interesting source for undergraduates in the master’s specialty “Methods of teaching exact and natural sciences (physics and astronomy)” when studying the subject “Modern physics and modern problems of its teaching.” The article is divided into 3 parts: 1) History of the development of nanotechnology; 2) Technologies for the production of carbon nanotubes; 3) Use of nanomaterials in practical activities.

The materials presented in the article for graduate students and scientific researchers will shed light on the problems that have arisen in this area, ways to solve them and ways to solve them, the development of science and the introduction of new technologies in the near future, and we hope that these materials will help our researchers to develop skills and abilities in scientific activity.

Use of nanomaterials in practical activities.

Recently, a large number of books and articles have been published that are devoted to various types of uses of nanomaterials. Therefore, this tutorial provides a brief overview of the main applications of this new class of substances.

1. Application of nanomaterials in industry.

The use of nano-sized substances for qualitatively new applications in various industries is possible due to the variety of fundamentally new properties of these materials.

First of all, the use of nanomaterials makes it possible to create ***structural materials*** with improved mechanical properties.

The production of ***high-strength threaded products*** from titanium and its alloys is one of the areas of practical application of nanostructured substances as structural materials. Titanium parts are widely used in the aircraft and automotive industries. The formation of a nanostructure leads to an increase in the durability of products by 1.5 times; in addition, the labor intensity of thread manufacturing is reduced.

The use of nanostructured aluminum alloys is effective for producing ***lightweight products of complex shape*** in the mode of high-speed superplastic shaping. The use of nanomaterial allows, in turn, to achieve complete filling of the stamp engraving, which ensures high-quality shaping and a significant reduction in the specific stamping force. In particular, the process temperature is reduced to 350^{0}C, which is 100^{0}C less than the forming temperature of cast alloys. This resulted in a reduction in energy consumption and an increase in productivity by reducing heating time and deformation. Currently, this method is used to produce pistons of complex shapes, which are used in small-sized internal combustion engines. When using nanomaterials, it becomes possible to manufacture dies from cheaper and less heat-resistant steels, as well as to use environmentally friendly technological lubricants during stamping.

Products obtained by compacting nanostructured doped nitride ceramics are used as ***structural and heat-resistant materials***. They are used for the manufacture of internal combustion engines, gas turbines, and cutting plates.

The practice of metallurgical production is being introduced ***refractory ceramics*** made of nanomaterials.

Based on a charge containing ***nanodiamonds***, dies for cold drawing of wire from copper, silver, gold, platinum, and nozzles for hydrocutting products in explosive conditions were developed and manufactured. Nozzles with inclusions of nanodiamonds allow the cutting process to be carried out at pressures of up to 500 MPa and jet speeds of more than 100 m/s.

Nanopowders have already found wide application in various ***materials and mechanical engineering technologies*** as multifunctional additives for motor, transmission and industrial oils; plastic lubricants; technological lubricants for metal forming; cutting fluids used in metal cutting processes; finishing and lapping pastes and suspensions; volume-modifying additives.

The introduction of various ***additives*** into engine oils is one of the ways to improve their performance properties. Insoluble materials are introduced into the product in concentrations not exceeding a few percent. They cannot change the volumetric properties of oils, but their presence significantly changes the hydrodynamic and thermal conditions in the area of the friction unit of high-speed machines. As studies have shown, the effect is especially great when substances in a nanostate are introduced into the lubricant. For example, introducing nanodiamonds into lubricants reduces the coefficient of friction in a ball bearing by 10 times while simultaneously increasing the maximum load by 6 times.

It is possible to use substances such as nanopowders of Fe, Ni, Co, Cu, Al, Pb, Mo and their alloys as particles of the dispersed phase; materials with high hardness - diamonds, carbides and nitrides of metals, silicon, boron; various surfactants: amines, phosphites, fatty acids. The optimal content of nanopowder in the lubricant is 0.1–5% by weight.

In addition, metal nanopowders are added as additives to ***abrasive suspensions and pastes*** for lapping and finishing work. This allows, during the running-in process of friction pairs, to fill cavities and microcracks with particles of the dispersed phase, which helps to level the rubbing surfaces, heal defects, and also separates the friction surfaces with highly dispersed particles.

For finishing polishing of 13–14 roughness classes, nanodiamond pastes with a particle size of up to 10 nm are effective.

They are used as a thin polishing material during finishing operations in the process of manufacturing highly precise parts from various materials and alloys; when polishing jewelry and semiconductor wafers of silicon and germanium; in the manufacture of optics, lasers, glasses and mirrors for special purposes.

In ***electromagnetic abrasive*** processing processes, nanopowders containing ferromagnetic and abrasive components are used as working materials. For finishing polishing, materials with particle sizes of tens of nanometers are used. On their basis, colloidal polishing compositions have been developed, making it possible to achieve the maximum surface roughness for mechanical engineering - above class 14. Composite materials of Fe–TiC, Fe–Co–TiC compositions are used as magnetic abrasive systems.

With the development of powder materials with nano-sized particles, it has become possible ***to create dry lubricants***, solid lubricant coatings, solid lubricant sticks, etc. They have a low coefficient of friction, fairly high magnetic properties and high dispersity and, therefore, have virtually no abrasive effect on the sealed part (shaft, rod, etc.). Magnetic powder dry lubricants can be held in the working gap by a magnetic field, in this case performing the function of a magnetic fluid sealer. These products are made from nanopowders of iron, nickel, and diamond-containing charge.

Increasing the efficiency of cold and hot metal forming processes is facilitated by the use of nanopowders of various compositions in ***stamping lubricants***. For example, the use of nanodispersed materials as starting components during hot pressing makes it possible to obtain materials with unique strength characteristics: the strength of materials increases by 2–3 times, and hardness by 6–10 times compared to modern structural materials. At the same time, along with an increase in strength, a sufficient margin of ductility is maintained.

Additives of nanopowders to lubricating and cooling technological fluids for ***metal cutting*** allow shielding of contacting surfaces, promote the appearance of strong oily films on juvenile surfaces, reduce the coefficient of friction, reduce cutting forces by 10–20% and tool wear by 1.5–2.5 times .

The effectiveness of using nanomaterials as ***volume-modifying*** additives has been established. As a result of their use, the wear resistance, strength, crack resistance, yield strength and tensile strength of hard alloys increase. For example, small additions (up to 0.01 vol.%) of nanopowders of refractory compounds have a positive effect on the quality of castings made of steel, alloys, and semi-continuous ingots of aluminum alloys. Nanopowders Al_2O_3, SiC, TiN, TiCN, WC, etc. are used as modifying additives.

It is possible to intensify the sintering process of industrial powders by adding nanopowders of aluminum, nickel, iron, aluminum nitride, etc. as ***sintering activators***. The introduction of only 0.5–5% (wt.) of nanomaterials into industrial mixtures allows reducing the sintering temperature by 400–8000C and reduce its time several times. At the same time, the hardness and impact strength of the final product increase. The use of additives from nanopowders is cost-effective, since the amount of this material is several percent, and the developed technology for manufacturing hard alloys is practically no different from the traditional one. Currently, this method is used to produce hard alloys based on titanium nickelide with a binder of titanium carbonitride nanopowder, corundum and zirconium ceramics with the addition of 1–3% and 0.5–5% aluminum nanopowder, respectively. Quartz was sintered with the addition of tungsten nanopowder.

Additives of nanomaterials as ***hydrodynamic plasticizers*** make it possible to obtain high-density products during molding. Additives made from nanopowders intensify the sintering process, streamline the synthesis of compounds, which makes it possible to reduce the firing temperature by 300–400^{0}C; significantly reduce the pore size in products and thereby increase the slag resistance of refractories.

The use of nanomaterials as ***components of solders and intermediate layers*** in various types of welding technologies is very effective. Diffusion welding through intermediate layers is one of the promising methods for joining dissimilar materials: both metals and non-metals. The use of intermediate layers made of nanomaterials makes it possible to increase the strength of the joint, reduce the chemical heterogeneity of the weld, remove residual stresses and eliminate the influence of differences in the thermal coefficients of linear expansion of the materials being welded, which helps prevent their plastic deformation. In addition, the parameters of the technological process itself - temperature, pressure and time - are sharply reduced. In particular, when diffusion welding copper and St35 steel in a vacuum and using copper and nickel nanopowders with a thickness of about 0.5 mm as interlayers, it was possible to significantly reduce the process temperature from 1173 K to 673–733 K for copper and from 1373 K to 973 K for St35.

The use of metal nanopowders in ***composite materials*** containing plastics and polymers is very promising. This technique makes it possible to produce plastic magnets, electrically conductive rubber, conductive paints and glue, and other electrically conductive composite materials. For example, based on Ni nanopowder, an elastic layered electrically conductive material was obtained containing Ni and rubber in a ratio of 2:1 parts by weight, which has a low, stable and well-reproducible electrical resistance of the conductive layers upon repeated compression. The material can be used for connecting liquid crystal and cathodoluminescent indicators, LEDs and integrated circuits to printed circuit boards.

Polymer materials with additives of metal nanopowders with a controlled level of flammability have been developed. It has been determined that the mechanism of polymer decomposition depends on the content of nanoadditives: at concentrations of the order of 0.005%, the metal accelerates the thermal oxidation of the material, and at a metal content of 1% this process slows down. Al, Cu, and Fe nanopowders were used as additives.

The use of nano-sized diamond in composite materials is effective. Thus, the addition of nanodiamond increases the microhardness of aluminum-based composite materials by 4–5 times, and copper-based ones by 3–10 times. Additives of diamond-containing mixture to rubber, ceramics, and plastics have shown significant improvements in their characteristics: increased wear resistance, decreased friction coefficient, and increased ultimate loads.

The use of nanomaterials to create ***protective, decorative and wear-resistant coatings*** is promising. Technologies have already been developed for producing finely dispersed coatings of Pd, Ir, Rh, Co, Ni, Ag, Cu on ceramic, quartz, metal, plastic, and composite products with shapes of any complexity. Coatings made of nanomaterials are denser and more corrosion-resistant, are uniform in thickness, are preserved on parts with complex profiles, and are better soldered compared to galvanic or vacuum-sprayed coatings.

Coatings from a two-phase composite nanomaterial consisting of a metal matrix and embedded dispersed diamond particles were obtained. A wide range of metals can be used as matrices: chromium, nickel, zinc, copper, silver, gold, cobalt. Composite metal-diamond coatings are characterized by a significant increase in adhesion and cohesion, increased microhardness, wear resistance, corrosion resistance, reduced porosity, good anti-friction properties, and high dissipation ability.

For example, when applying chrome-diamond coatings, the service life of press equipment for cold pressing of metal powders increases by 15-20 times, dies and punches for deep drawing of metals - by 2.5-4 times, hacksaw blades - by 4-8 times, gas distribution shafts of internal combustion engines - 2–2.5 times. After applying cobalt-diamond coatings to the recording heads of tape recorders, their wear resistance increases 6 times. Compared to metal coatings, the durability of diamond-silver nanomaterials increases by 3 times, and diamond-nickel nanomaterials by 4–5 times.

A unique set of electromagnetic properties has found application in the creation of a wide range of ***magnetic nanomaterials***, namely: liquid magnets, magnetic and video recording tapes, credit cards, magnetic screens, memory disks, high-frequency transformer cores, permanent magnets and magnetic circuits, electrical contact materials, etc.

γ-Fe2O3 powder is used as the material for ***magnetic recording***. An increase in recording density is achieved by using a nanomaterial consisting of needle-shaped particles with a long axis of 300–500 nm and a short axis of 50–70 nm.

In the manufacture of ***electrical contacts*** for low-voltage equipment, the use of ZnO nanopowders ensures electrical erosion resistance, low tendency to welding, low contact resistance, significantly simplifies the manufacturing technology, reduces the silver content in the final product, and increases environmental performance during production and operation due to the replacement of toxic CdO. One of the first and most effective areas of application of nanomaterials is catalysis. The high level of catalytic properties of nano-sized structures is due to the large number and high activity of surface centers, which provides, in comparison with traditional catalysts, a significant acceleration of chemical reactions.

For industrial use, it is convenient to apply catalysts to various supports, among which oxides γ-, η-, δ-, θ-Al_2O_3, SiO_2, spinels, $ZnAl_2O_4$, $MgAl_2O_4$, and organic films are often used. The use of nanosized metals Pt, Pd, Fe, Ni, bimetallic systems Fe–Mo, Pt–Re, Pt–W, oxides of copper, cobalt, chromium, manganese and many others is promising as catalysts.

In processes of fine organic synthesis in the production of intermediates based on aromatic and heterocyclic compounds, Al nanopowder is a promising catalyst.

Purification of industrial waste gases is an important area of catalysis. As is known, during the operation of technological equipment, waste oils accumulate, the disposal of which is currently carried out by combustion. The exhaust gases contain soot, oxides of carbon, nitrogen, sulfur, and mechanical impurities. Reducing the level of harmful substances in exhaust gases by varying combustion modes and installing filters does not give the desired effect. The introduction directly into the combustion device, together with the fuel, of microscopic quantities of catalytically active nanopowders of simple and complex oxides of transition and rare earth metals is a fundamentally different approach to solving this problem. Due to the small size and high specific surface area of the nanopowder, soot is effectively burned in the exhaust gases of process furnaces.

For example, deep oxidation catalysts containing nanopowders of base metal oxides (composition CuCrCoNiCe - 60:30:5:2:3) showed a degree of purification of furnace exhaust gases from carbon monoxide and methane within 94–99%.

Catalytic converters for automobile engine exhaust gases created on the basis of nanomaterials have made it possible to reduce the carbon monoxide content for a diesel engine by 7–40 times, and for a gasoline engine by more than 10 times.

Recycling industrial waste is another area of use of nanostructured catalysts. For example, by adding 1% iron powder to the catalyst, high efficiency can be achieved in the processes of deep processing of viscous waste from the oil industry to produce gasoline and other hydrocarbons. In addition, iron forms iron oxide III, which is an effective catalyst for the neutralization of compounds such as CO, NOx, SO_2.

To solve a wide range of technological and environmental problems, it is advisable to use nanomaterials as highly efficient ***adsorbents*** in modern membrane technologies. In particular, nanooxides have shown high activity in the processes of fine complex purification of drinking water from heavy metals and organic contaminants. These nanomaterials make it possible to extract a wide range of impurities of inorganic and organic origin from aqueous media; purify wastewater from electroplating industries, enterprises producing, transporting and refining oil and petroleum products. Adsorbent nanopowders, due to the difference in the adsorption rates of individual ions, can also be used for the extraction and selective separation of individual valuable components from drilling waters and aqueous industrial wastes.

To purify liquids from suspended impurities, filters using nanocrystalline membranes have been developed. The main component of these devices are filter elements, which are hollow cylinders made of porous polyethylene, on the outer surface of which porous coatings of nanodispersed nitrides, oxides, oxynitrides of titanium, aluminum, and zirconium are applied. As a result, the resulting membranes have high filtering characteristics, sufficiently high filtrate productivity, the ability for repeated hydrodynamic regeneration without disassembly and a long service life.

The creation of highly efficient small-sized equipment for the purification of oil-containing wastewater became possible thanks to the combination of adsorbent nanopowders with high-capacity fibrous materials (carbon fabrics, basalt fibers, etc.). One device containing three layers of nanoadsorbent separated by layers of fibrous material ensures the purification of petroleum product emulsions with an initial concentration of 200–300 mg/l to the level of sanitary standards.

The use of metal nanopowders makes it possible to produce microporous materials with an open porosity of 35–70%. Microporous materials of the composition Ni_3Al, NiAl, Ti_3Al have been obtained, which are effective in the manufacture of evaporators, separators and filters in thermal control systems.

The action of ceramic humidity sensors is also based on the adsorption properties of nanomaterials. They use zirconium dioxide nanopowders, the developed surface of which has a major effect on the process of absorbing moisture from the air flow. As a result, the resulting structures with a wide range of pores make it possible to significantly exceed the technological parameters of currently used humidity sensors.

One of the most important areas of application of nanomaterials is the creation of various ***means of protection***, where they are used as components of light and heat-absorbing compositions, absorbers of electromagnetic radiation, and radiation protection.

Since the mass attenuation coefficient of a material depends on the percentage of polydisperse inclusions, this makes it possible to achieve both an increase and a decrease in the protective properties of the material. Therefore, it becomes possible to use in practice the effects of anomalous attenuation of X-ray and gamma radiation by nanodispersed systems to create ***radiation protection means*** for medical and industrial purposes.

For these purposes, it is necessary to create various types of nanomaterials.

Firstly, radiation protection requires nanomaterials with unchanged structure and composition. This category includes various kinds of woven and non-woven textile materials that are modified with nanopowders. The process consists of applying a thin (on the order of nanometers) layer of a metal modifier to the surface of the threads and fibers that make up the material. At the same time, the physical, mechanical and consumer properties of the textile material remain virtually unchanged.

Secondly, for these purposes, nanomaterials are needed, which are a “matrix-filler” type system. These include various types of plastics, rubbers, latexes, etc. These materials are obtained as follows. At the initial stages of the synthesis of the material, when it is in a fluid state, a certain amount of filler in the form of a polydisperse modifier is introduced into its composition, as into a matrix. Protective products are formed from the composite thus formed.

In addition, there is a need for nanomaterials that are a combination of the first two types. These are systems of the “matrix-filler” type, but the latter uses specially prepared carriers that have radiation-protective properties. As a rule, weaving waste, sugar production, sawdust, etc. are used in this capacity. To prepare the filler, a nano-sized layer of a polydisperse modifier is applied to its surface. The filler prepared in this way is mixed with the matrix and products are formed from the resulting mixture. This group of radiation protection means includes asbestos, concrete, bricks, plasters, putties, plastics such as textolites, etc.

The use of nanomaterials in various ***energy sources*** to create means of direct energy conversion is promising; semiconductor, emission, switching materials; materials for hydrogen energy.

In particular, the use of yttrium-stabilized ZrO_2 nanopowders reduces the ceramic synthesis temperature by 100–200^{0}C, which significantly reduces energy consumption in the production of fuel cells and increases the service life of thermal equipment. This, in turn, allows the use of fundamentally new technologies for the manufacture of fuel cells. In addition, it becomes possible to reduce by 1.5–2 times the number of fuel cells in a power plant or the operating temperature to 800^{0}C.

2. Use of nanomaterials in biology and medicine.

Along with the use of metal nanopowders in the traditional fields of materials science and catalysis, recently there has been increased interest in their use in agriculture: crop production, animal husbandry, animal husbandry, fisheries, as well as medicine and the food industry.

Numerous experiments have shown that metal nanopowders have high biological and physiological activity. Apparently, this is due to the very small size of the particles, due to which they easily penetrate cell membranes and actively participate in the processes of microelement balance and redox reactions. Metal ions that appear in the biological environment during these processes, due to uncompensated bonds, easily form complex compounds with organic substances, as a result of which various enzymes are synthesized. For example, iron, cobalt, copper ions are part of enzymes such as carboxylase, polypeptidase, aminopeptidase and other biologically active substances that are necessary for protein, carbohydrate and fat metabolism, for protein synthesis and cell respiration.

In addition, metal nanopowders have such a remarkable property as prolonged action. In other words, they can affect mineral nutrition, carbohydrate and nitrogen metabolism, amino acid synthesis, photosynthesis and respiration reactions for a long time.

The application of mineral fertilizers to the soil is still used as the main way to increase productivity. However, salt anions pollute the soil, which has a negative effect on both the plants themselves and their consumers. The use of nanopowders for microelement effects on the cells of living organisms eliminates the negative effect of salt anions on the biological activity of organisms.

Due to the fact that a number of substances widely used to intensify agricultural production are poisons, it is important to search for drugs that are non-toxic to humans, animals and the environment. Therefore, the great advantage is that nanometals are environmentally friendly. Thus, when using metal nanopowders, an increase in the yield and quality of agricultural crops is achieved, the incidence of disease is reduced, a balanced diet for feeding animals is ensured, and the safety of production and the resulting product is increased.

To date, a number of methods have been developed for the use of metal nanopowders in crop production, livestock farming, poultry farming, fisheries and feed production as growth stimulants.

A number of areas for the use of nanomaterials in ***crop production*** have been identified. For example, pre-sowing treatment of cucumber, wheat, corn, cotton, potato, rapeseed, vetch, and beet seeds with an aqueous suspension of iron nanopowder increases the yield of these crops compared to control samples. In plants, in addition, qualitative changes in the content of nutrients, in particular amino acids, are observed.

The study of the influence of nanoiron suspensions and powder on the ***vital activity of farm animals and birds*** (chickens, laying hens, broilers, calves, cows, piglets, pigs, foals, horses, as well as dogs and cats) made it possible to establish an increase in the natural resistance of the body, expressed in a decrease in morbidity young animals, increasing their safety, viability, and growth rates.

The use in ***fisheries*** by treating caviar with iron nanopowder and its addition to feed allowed accelerating the growth of juveniles and increasing their safety.

Experimental data were obtained on the possibility of using iron nanopowders in the production of feed preparations of proteins and lipids.

Nanomaterials are increasingly used in ***medicine*** as ***implants, prostheses and instruments***. In civilized countries, there is an increasing need to find reliable materials to replace damaged parts of the human body. Therefore, modern surgery and dentistry require materials with high chemical inertness while maintaining high mechanical strength. Recently, lightweight and durable nanostructured titanium alloys and pure titanium have been used as joint endoprostheses, special plates for fixing traumatic areas of long bones, conical screws for fixing the spine, and implants for dental purposes.

The use of Ti in implantology is explained by the almost complete, in contrast to other materials, biological compatibility of this metal and some of its alloys with living tissue.

Solving the problem of the optimal ratio of strength characteristics with maximum biological compatibility is possible through the use of metallic nanostructured materials.

In particular, many problems can be solved by using nanodispersed aluminum alloys. The high level of physical, mechanical and operational properties provided by the nanostate of these materials makes it possible, depending on the treatment objectives, to manufacture from them devices for external fixation and control of the position of bones or their fragments, load-bearing structures of traumatological devices, sets of standardized parts assembled into devices of various configurations and complexity.

Nanomaterials have now been tested in the ***production of medicines, drugs, and vitamins***. In particular, ferromagnetic liquids containing nanopowders of iron and nickel are promising for the treatment of a number of oncological diseases. It is also possible to create medicines based on iron nanopowder with a prolonged action for the treatment of diseases of the hematopoietic organs, healing of wounds, and stomach ulcers.

Since various modifications of iron nanooxides are colored from brown to red, these materials have been successfully tested as color pigments in ***dentistry***.

Anti-burn dressings using silver nanopowder have shown high effectiveness, which eliminates dressings during the entire healing period. This feature significantly reduces recovery time and minimizes pain.

Very convenient for practical use are ***radiopaque suture materials***, which are silk, lavsan or nylon threads with a layer of nanodispersed tungsten applied to them using a special technology.

The feasibility of using ***nanoadsorbents*** in microbiological, medical and membrane technologies is due to their high adsorption ability towards microorganisms.

Conclusion

To summarize, it should be noted that the study of the nanostate of substances and their application in technology is one of the promising areas of modern materials science. Along with the obvious advantages and prospects of using a new class of materials, the main problems in this area have already clearly emerged today. First of all, they are associated with the difficulty of obtaining pure substances, without foreign impurities, with the same size of structural components. Therefore, the task of regulating the dispersity and other properties of nanomaterials during their production using technical and methodological techniques is relevant. Solving this problem would significantly expand the range of these materials and increase the efficiency of using the resulting product.

Another problem is the high cost of nanomaterials. The cost of the final product greatly depends on the production method, but it significantly exceeds that of traditional materials. In this regard, the problem of finding cheap raw materials and reducing the cost of technology arises. In addition, nanopowders are subject to requirements to prevent their pyrophoricity and ensure explosion safety.

The main ways to solve these problems are outlined. Control of technological parameters of synthesis processes allows you to regulate the dispersion, shape and other properties of the resulting products, expanding the scope of their application.

Reducing the cost of nanomaterials, in turn, could be facilitated by the use of cheaper types of raw materials, for example, waste from various industries, such as scrap, sludge, spent etching solutions, and a reduction in pyrophoricity should be ensured by the development of special technologies and passivation methods.

All of the above leads to the fact that active developments are currently underway to solve a number of problems to increase the efficiency of methods for obtaining, studying the properties and using nanomaterials in modern technology and the industries of the future.

Used Literature

1. Р. А. Андриевский, А. В. Рагуля. Наноструктурные материалы.Учеб. пособие для высш. учеб. заведений. — М.: Издательский центр «Академия», 2005.
2. Р. З. Валиев, И. В. Александров. Наноструктурные материалы, полученные интенсивной пластической деформацией. — М.: Логос,2000.
3. М. Б. Генералов. Криохимическая нанотехнология. Учебное посо-бие для вузов. — М.: ИКЦ «Академия», 2006.
4. А. И. Гусев. Наноматериалы, наноструктуры, нанотехнология. — М.: Физматлит, 2005.
5. Н. В.Меньшуткина. Введение в нанотехнологию. — Калуга: Издательство научной литературы Бочкарёвой Н. Ф., 2006.
6. И. Д.Морохов, Л. И. Трусов, В. Н. Лаповок. Физические явления вультрадисперсных средах. — М.: Энергоатомиздат, 1984.
7. И. Д.Морохов, Л. И. Трусов, С. П. Чижик. Ультрадисперсные ме-таллические среды. — М.: Атомиздат, 1977.

8. С. А. Непийко. Физические свойства малых металлических час-тиц. — Киев: Наукова думка, 1985.
9. Ю. И.Петров. Кластеры и малые частицы. — М.: Наука, 1986.
10. Ю. И.Петров. Физика малых частиц. — М.: Наука, 1986.
11. Г. Б. Сергеев. Нанохимия / Учебное пособие. — М.: КДУ, 2006.
12. И.П. Суздалев. Нанотехнология: физико-химия нанокластеров,наноструктур и наноматериалов. — М.: КомКнига, 2006.
13. Soliyev T.I., Sherkulov U.D., Muzaffarov A.M. Determination of mixing factors of daughter radionuclides in the uranium decay chain., Neuroquantology | September 2022 | Volume 20 | Issue 11 | London, Page 2722-2725.https://www.neuroquantology.com/article.php?id=7677
14. Allaberganova G.M., Urunov I.A., Sherkulov U.D., Muzafarov A.M., Radiometric methods for measuring radiation factors in uranium production facilities, Science and innovation international scientific journal Volume 2 Issue 3 March 2023 UIF-2022: 8.2 | ISSN: 2181-3337 | SCIENTISTS.UZ, PP. 224-229.https://doi.org/10.5281/zenodo.7772855
15. Allaberganova G.M., Urunov I.A., Sherkulov U.D., Muzafarov A.M., Determination of radionuclides and ways to reduce their impact on the environment, Science and innovation international scientific journal Volume 2 Issue 3 March 2023 UIF-2022: 8.2 | ISSN: 2181-3337 | SCIENTISTS.UZ, PP. 219-223.https://doi.org/10.5281/zenodo.7772118
16. Холов Д.М., Холбоев И., Шеркулов У.Д., Музафаров А.М., Определение величин влияний радиационных факторов урановых производств на окружающую среду., Международный форум «ФИЗИКА-2022», Узбекистан, Наманган. – Посвященную обсуждению статуса и перспектив развития физики. Наманганский инженерно-технологический институт. Адрес: Узбекистан, 160115, г. Наманган, ул. Касансай, 7, Стр. 35-38.
17. Искандарова Д.Б., Шеркулов У.Д., Гравитационные аккумуляторы из заброшенных шахт. Central Asian journal of education and innovation, Volume 2, Issue 6, Part 2 June 2023., p.70-78.