Nanotechnologies: a review of inventions and utility models. Part I

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ABSTRACT: A brief review of patents is given. The research performed by scientists, engineers and specialists in the area of nanotechnologies and nanomaterials resulted in increased efficiency of construction, housing sector and adjacent fields of economy. For example, the invention «A method to produce titanium carbide nanopowder» refers to inorganic chemistry and nanotechnology and can be used to produce wear-resistant abrasive materials, high-temperature ceramic materials and coatings, high-strength composite materials. The technical result is TiC nanopowder in free-filled condition in the form of particles with average size no less than 30 nm, as well as TiC nanopowder with controlled ratio titanium-carbon. All that boosts technical opportunities for its application.

The specialists can also be interested in the following inventions in the area of nanotechnologies: a method to obtain a mixture of micro- and nanoparticles of binary alloys, hydrocatalytic processes of recycling heavy oil fractions with the use of perspective nanosize catalysts, a method to produce graphene oxide, a method to decrease electrization of liquid hydrocarbons when applying them, a method to produce composite material boron-carbon, Modeling of static mixer (oil – water) performance for oil desalting and development test, a method of chromatographic separation of single layer carbon nanotubes by chirality and other.

KEYWORDS: nanotechnologies in construction, titanium carbide nanopowder, binary alloy nanoparticles, nanosize catalysts, carbon nanotubes.


INTRODUCTION

The practical application of the results achieved by scientists, engineers and specialists can become efficient tool to increase number of import-substituting goods and to rise labor productivity. An invention is known to be a new, with distinctive characteristics technical solution with proved efficiency (new technologies, structures or new substances). The paper reviews the essence, technical result and practical value of some inventions concerning nanotechnologies.

MAIN PART

A method to produce titanium carbide nanopowder (RU 2707596 C2)

The invention refers to inorganic chemistry and nanotechnology and can be used to produce wear-resistant abrasive materials, high-temperature ceramic materials and coatings, high-strength composite materials [1]. Laminar gas-carrier downflow 2 is supplied to vertical reactor (Fig. 1.) made of thermal-resistant dielectric
material. On top titanium wire is introduced into reactor, then it is heated in high-frequency field of countercurrent inductor 3 up to melting temperature. A drop of melted titanium 4 is obtained at the end of the wire, after that the drop is hanged without contact between spirals of countercurrent inductor, then evaporation of metal titanium from surface of the drop is provided. The gas-carrier flow 2 continuously takes away titanium vapour from the drop 4, vapour condensation into titanium nanoparticles is performed in condensation zone 5 and then the particles are delivered in reaction zone 6 in which carbon-containing gas-reagent 7 is also supplied from leak 8. Obtained titanium carbide nanoparticles are transferred into cooling zone 9, they are caught with filter and thus final product in the form of titanium carbide nanopowder in free-fill condition is produced. The average size of the particles is no less than 30 nm and the ratio between titanium and carbon is specified. Titanium evaporation from the drop 4 is compensated by continuous supplying titanium wire. A rare gas is used as gas-carrier, and hydrocarbon from alkane, alkylene and alkine class is used as a gas-reagent.

A method to produce ferrum-based composite material strengthened with metal nanopowder oxides (RU 2707686 C1).

The invention refers to the powder metallurgy, in particularly to the designed technology for production of steels strengthened with disperse nanooxides. The invention can be used in manufacture of high-strength constructional parts of railway rolling stock [2].

The technical result is: reduced labour intensity, reduced technological process life, 20–30% increase of durability characteristic due to speeded rotation velocity of grinded device (bead mill) up to 3000 rpm, use of monodisperse heat resistant nanooxides obtained through high-energy impact on initial components.

The result described above is achieved due to the method of production of ferrum-based composite material strengthened with metal nanopowder oxides. The stages of the method: mechanical alloying of the mixture prepared from iron oxide powder which is unsteady under deformation and alloy-treated steel powder which is powder of the steel alloyed with yttrium and/or titanium, and/or wolfram, forming heat-resistant nanooxides.

A method to produce ferrum-based composite material strengthened with metal nanopowder oxides (RU 2707686 C1).

The technical result is:

- facilitated technological cycle and provision of continuous production process for titanium carbide nanopowders;
- production of TiC nanopowder in free-fill form with the particles which size is no less than 30 nm, production of TiC nanopowder with specified ratio between titanium and carbon. All that boosts technological opportunities and application areas of the nanopowder.

A method to modify carbon nanotubes for hydrophilic or hydrophobic surfaces (RU 2707930 С1)

The invention refers to physics and nanotechnology and can be used in production of super condensers, filters and sensors [3]. To provide specified value for wetting angle carbon nanotubes are modified by bombarding flows of ions, for example, argon, helium, ferrum, carbon or terbium ions. An array of carbon nanotubes which diameter is 8–250 nm and density is 0.1–3 g/cm³ is used. To obtain carbon nanotubes which wetting angle is 180° a surface of nanotubes is bombarded with ions and value of displacement per atom (DPA) divided by average diameter of carbon nanotubes in the sample up to 0.0075 DPA/nm inclusive is provided at this. To obtain carbon nanotubes which wetting angle is less 90° nanocarbon surface is bombarded with ions and value of displacement per atom (DPA) divided by average diameter of carbon nanotubes in the sample more than 0.025 DPA/nm is provided. The invention makes it possible to control wettability of carbon nanotubes surface and obtain hydrophobic or hydrophilic coatings.
A method to produce high-strength composite material based on thermoplastic polymer, a modifier for manufacturing composite material and a method to produce modifier for manufacturing composite material (options) (RU 2708583 C1)

The invention refers to the technologies for obtaining a modifier used to produce composite material based on thermoplastic polymer containing carbon, glass or basalt fibers and carbon nanotubes (options) as well as to the methods to produce it and to manufacturing of material containing obtained modifier [7]. According to the first option, the modifier is obtained by mixing thermoplastic polymer (7–15 mass. %), solvent (70–94 mass. %) and alkali salts (3–15 mass. %) until total polymer resolving. Then nanotubes taken in the quantity up to 5 mass. % are added into the mixture. A coagulant is introduced into the obtained dispersion. The dispersion is filtered, the precipitation is washed off and dried. According to other options, a modifier for composite material is prepared on the basis of polyamide. Nanotubes are mixed with caprolactam. Dispersion is heated, can be treated with ultra-sound, then caprolactam polymerization catalyst or polymerization activator is added to it. After that the dispersion is heated and dried. To obtain composite material thermoplastic material is mixed with fibers and modifier which contains car-
bon nanotubes in the quantity from 5 to 33 mass. %. The invention is a solution for creation of high-strength composite material.

**A method to produce modified carbon nanotubes (RU 2708596 С1)**

The invention refers to nanotechnologies and can be used to strengthen mechanical properties of composite materials based on epoxy resins, to modify mixed glue and to obtain supercondensers [8]. A solution containing carbamide and/or thiocarbamide, water and concentrared mineral inorganic acid is processed in ultra sound concentrator. Then fluoridated carbon nanotubes taken in quantity that provides their concentration 1,2 mg/g in solution are added. Processed solution is diluted and filtered with water washing till neutral acidity. Filtered modified carbon nanotubes are diluted with water, processed in ultra sound bath and diluted with water one more time. The obtained solution are filtered and washed with acetone. The carbon nanotubes modified with carbamide and/or thiocarbamide are dried. If it is necessary they can be additionally functionalized with water-soluble epoxy resins, for example, DEG-1, TEG-1 or epoxy-hydantoic resin EG-10. That leads to greater final product outcome, decreased energy consumption and reduced time for production modified carbon nanotubes.

**A method to process cold-worked titanium of great flow (RU 2709416 С1)**

The invention refers to manufacture of nanostructured cold-worked titanium with improved mechanical and corrosion properties and to the methods to process it. The invention can be applied in different engineering areas, including chemical industry [9]. Technical result is a production of cold-worked titanium that combines high values of micro-hardness and high corrosion-resistance: positive steady potential, high capacity to passivation under anodic polarization.

Technical result is achieved due to the following technology: the method to process cold-worked titanium includes great plastic flow deformation by rotation under high hydrostatic pressure no less than 6 hPa under room temperature. According to the invention, the deformation is performed by two rotations and obtained nanostructure of cold-worked titanium consists of 80—85% alpha phase with average size 50—60 nm and 15—20% omega phase. The deformation is performed in Bridgman chamber.

**A method to produce coating on the surface of non-ferrous metal workpiece (RU 2710094 С1)**

The invention refers to mechanical engineering, in particularly to the methods for obtaining coating on the surface of non-ferrous metal workpieces by transferring with high-temperature nanoparticle gas flow [10]. The method includes formation of high-speed atomizing cone of high-temperature gas flow by burning fuel in oxidant in combustion chamber; supply of high-speed atomizing cone of liquid initial material which is a source of nanoparticles formation into combustion chamber; formation, heating and transfer of nanoparticles by means of high-temperature gas flow and precipitation of the nanoparticles on the workpiece surface. At this the material which is a source of nanoparticles formation is simultaneously used as a fuel for high-temperature gas flow formation, and the material is a molecular or colloid solution of organic and/or inorganic compounds in organic solvent or mixture of several solvents. Transfer by means of high-temperature gas flow of nanoparticles and precipitation of them on the workpiece surface is performed jointly with workpiece surface prior processed with electric arch generated between two wolfram electrodes under alternate current 35—45 A, resistance 12—16 V and moving along workpiece surface with the rate of high-speed spray atomized set to spray at the distance between the arch and gas stream with sprayed powder material 2—4 mm. Technical result of the invention is increased adhesion strength, increased cohesion durability of material coating and reduced porosity of the coating.

**A method to purify polluted subsoil water with nanosize ferrum of zero valency ( RU 2709593 С1)**

The invention refers to water treatment [11].

![Fig. 2](http://nanobuild.ru)
size zero-valent ferrum with normalized water till values pH 4.5–5.5. Metal guide tube 3 is placed into the hole 1. One pole terminal of alternating-current source with frequency 0.5–5 Hz is coupled to the guide tube, and the second terminal pole is coupled to ground which distance from the hole 1 is two-three depths of the hole 1. The invention makes it possible to increase the value of water treatment and prevent from purification substances loss.

A catalyst of combined hydrotreatment for a mixture of vegetable and oil hydrocarbon stock and a method to prepare it (RU 2707867 C2)

The invention refers to chemistry, in particular to production of catalysts used for hydrotreatment of vegetable and oil hydrocarbon stock and can be applied in oil refining and petrochemical industries [12]. Technical result is creation of a new catalyst of combined hydrotreatment for a mixture of vegetable and oil hydrocarbon stock. The catalyst possesses increased activity in reactions of sulfur and oxygen removal compared to traditional bimetal systems due to simultaneous employment of two promoting metals (Co и Ni) as promoter. Technical result is achieved due to catalyst of combined hydrotreatment for a mixture of vegetable and oil hydrocarbon stock which contains in calcined under 550°C state: Mo – 9,0–15,0% mass., Co – 0,5–3,5% mass., Ni – 0,5–3,5% mass., the rest – porous carrier with carbon content 0–5% mass.; specific surface of the catalyst is 100–250 m²/g, specific volume of the pores is 0.3–1.1 cm³/g, average diameter of the pores is 4.0–10.0 nm.

These are inventions in nanotechnological area that can be interesting for specialists:

• A method to increase tensile strength of composite material by preliminary impregnation of carbon fibers with carbon nanotubes [13].
• A method to obtain a mixture of micro- and nanoparticles of binary alloys [14].
• Hydrocatalytic processes of recycling heavy oil fractions with the use of perspective nanosize catalysts [15].
• A method to produce graphene oxide [16].
• A method to produce lateral nanostructures [17].
• A method to decrease electrization of liquid hydrocarbons when applying them [18].
• A method to produce composite material boron-carbon [19].
• Strengthened glass jar (options) and a method to strengthen glass jar [20].
• A method to produce diamond tool with modified cutting part [21].
• Modeling of static mixer (oil - water) performance for oil desalting and development test [22].
• A method of chromatographic separation of single layer carbon nanotubes by chirality [23].
• Waste water treatment plant with the use of nano-modified natural sorbents [24].
• Ceramic composite material [25].

CONCLUSION

It is known that it is precisely the popularization and introduction of inventions that is an important factor for the success of many successful companies. For example, General Electric, which entered world history as one of the most innovative companies of the 20th century, is a company that was originally listed in the Dow Jones index in 1896 and is still there. Therefore, we hope that the information published in this section will be in demand and useful for specialists. Confirmation that articles from the «Invention Review» column are particularly popular is information on the number of views of materials, for example, in the full-text database of open access scientific journals Open Academic Journals Index OAJI (USA), link – http://oaji.net/journal-detail.html?number = 6931.

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31

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