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THE TECHNIQUE FOR PRODUCING ANOTECHNOLOGIES WITH CARBON AND FERROMAGNETIC METAL OR ALLOY

G M Ahmadiev

Kazan Federal University, Naberezhnye Chelny Institute, 420008, Russia, Kazan, Kremlyovskaya St., 18

GMAhmadiev@kpfu.ru

Abstract. Nanoparticles according to the method and technology including metal-carbon particles, particularly particles of a ferromagnetic metal or alloy encapsulated in graphitic carbon are suitable for use as a detectable moiety for imaging by the method of a magnetic resonance and fluorescence, drug delivery, cell marking and for local thermal therapeutic treatment such as hyperthermia.

Introduction.The given technology relates to nanoparticles with metal ferromagnetic nanocrystals combined with amorphous or graphite carbon which has chemical groups capable of dissociation in aqueous solution. The scope of the given research includes detectable moiety for imaging by the method of a magnetic resonance and fluorescence, drug delivery devices, cell labeling, and local thermal therapeutic treatment such as hyperthermia.

Currently one of the most important applications of ferromagnetic nanoparticles belongs to detectable moietyfor imaging by the method of a magnetic resonance. The presence of an inhomogeneity in a magnetic field leads to shorter triggering time of T1 and T2 in a magnetic resonance. Therefore, the presence of ferromagnetic particles leads to black spots in displaying the magnetic resonance of protons. A good resolution requires small ferromagnetic particles with rather high magnetization.

The interest fordetectable moiety for imaging by the method of a magnetic resonance shows the number of recently filed applications for patents. WO-A-2004/107368 describes magnetic particles of iron-based oxide with sizes less than 20 nm, which surface is modified by amino groups. The isoelectric point is greater than 10 or equal to 10. WO-A-2009/109588 depictsparticles of iron-based oxide with two different ligands, where the first ligand contains an electrostatically charged group and the second ligand is a hydrophilic group. WO-A-2009/135937 describes a linker bound at the first end with a polyethyleneimine polymer and at the other end with a nanoparticle core or a polyethylene glycol polymer grafted to a polyimine polymer. Such ferromagnetic oxides can have a wide distribution of particles by their sizes, agglomeration of individual particles, instability due to reaction or recrystallization into non-ferromagnetic iron-based oxide and toxic properties. The fact that ferromagnetic particles are strongly clustered is especially problematic [1-15].

The given researchinvolves scientific justificationof the method for obtaining nanoparticles with carbon and ferromagnetic metal or alloy.

Research Methodology

Particles of a ferromagnetic oxide are used to produce a magnetic resonance imaging. The oxide particles are relatively stable in the air. The most known ferromagnetic iron-based oxides are magnetite, Fe_3O_4 or Fe (II) Fe (III) $_2O_4$ and maghemite, γ-Fe_2O_3. The combination with other atoms of divalent metal such as cobalt or nickel also yields ferromagnetic oxides, for example $CoFe_2O_3$ and $NiFe_2O_3$.

Study Results and their Discussion

Small particles of magnetite are usually obtained by mixing solutions containing Fe (II) and Fe (III) compounds. The method can lead to small cluster particles of magnetite depending on mixing. The formation of magnetic domains leads to the fact that magnetic particles do not have a magnetic moment in the absence of an external magnetic field. Sufficiently small ferromagnetic particles do not form a set of domains. It should be noted that small ferromagnetic particles are single-domain particles, which indicate that moments of magnetic atoms in individual particles are not ordered into different domains, but they are oriented in the same direction. Therefore, single-domain particles have a ferromagnetic moment even in the absence of an external magnetic field. When particles are suspended in a liquid without forming clusters, they can rotate freely. Then the orientation of magnetic moments of individual particles reaches thermodynamic equilibrium which depends on the magnetic moment of particles, the strength of the external magnetic field and thermal energy (temperature). Since in contrast to paramagnetic materials magnetic moments of ferromagnetic particles include thousands or millions of atomic magnetic moments, this paramagnetic response is referred to superparamagnetism. Magnetic particles that can move more or less freely in the liquid do not have retained magnetization; in the absence of an external magnetic field the magnetic moment of single-domain particles suspended in the liquid is negligibly small. When the energy of magnetic anisotropy of ferromagnetic particles has the order of KG, i.e. the order of thermal energy, the orientation of magnetic moments of individual particles can reach thermodynamic equilibrium also in cases when particles cannot rotate.

The magnetic coupling between single-domain particles suspended in a liquid leads to the fact that particles usually form clusters in which magnetic moments of individual particles are oriented in a way the external magnetic field not to exert influence on clusters. The cluster is for biomedical applications.

As a result, the current state in the field of ferromagnetic metal particles involves the application of inert layers to metal particles. The United States Patent No.4855091 describes the obtaining of small particles of nickel, iron, or cobalt by reducing corresponding precursors applied to a highly porous ceramic carrier and then undesirable subsequent exposure to small particles of a gas stream with carbon of magnetic particles [2].

Results

Nanoparticles by primary technologies including metal-carbon particles, particularly particles of a ferromagnetic metal or alloy encapsulated in graphitic carbon are suitable for use as a detectable moiety for imaging by the method of a magnetic resonance and fluorescence, drug delivery, cell marking and for local thermal therapeutic treatment such as hyperthermia.

The research can be used in medicine, biology and veterinary medicine in manufacturinga detectable moiety for imaging by the method of a magnetic resonance or fluorescence, drug delivery, cell marking. Carbon-contained particles from microcrystalline cellulose, colloidal carbon and mixtures are infiltrated with an aqueous solution of at least one ferromagnetic metal precursor, such as a citric, acetic or formic acid salt, hydroxy acids or ammonium citrate. The infiltrated particles are dried and heated in an inert and substantially oxygen-free atmosphere at a temperature of 450-600 ° C or more than 700 ° C. The resulting nanoparticles contain graphite carbon and 3-100 particles of at least one ferromagnetic metal, at least partially encapsulated in a graphite carbon. Ferromagnetic particles comprise a metal selected from the group consisting of nickel, cobalt, nonreactive metals and their combinations. The particles of ferromagnetic metal are distributed uniformly and do not form clusters.

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