CONSIDERATIONS REGARDING THE USE OF NANOTECHNOLOGIES IN THE ENERGY SECTOR

TĂTAR ADINA - University „Constantin Brâncuşi", Tg-Jiu, ROMANIA
MIHUŢ NICOLETA - University „Constantin Brâncuşi", Tg-Jiu, ROMANIA
PĂSCULESCU DRAGOŞ- University of Petroşani, Petroşani, ROMANIA
VELEV GEORGI - Technical University of Gabrovo, BULGARIA

Abstract: *The field of nanotechnology is one of the fields that has experienced the fastest growth and the most important scientific achievements in the last quarter of a century. In the context of today's economic instability, investing in renewable energy technologies is a scenario with multiple gains: for energy security, economy, environment. The paper makes a study of the properties of magnetite nanoparticles and their obtaining by the method of co-precipitation, respectively the applications of nanotechnologies in different fields of activity, especially in the energy sector.*

Key words: *energy, nanotechnologies, magnetite, nanoparticles, Fe_3O_4*

1. INTRODUCTION

European industry has recognized its importance for many industrial sectors and the fact that it will bring extraordinary benefits to industry, the economy and social welfare in the coming years. [1]

The energy revolution is sure to create significant energy production. Solid fuel costs are estimated to be around $ 15.9 trillion by 2030, more than would be needed to implement renewable energy. Renewable energy can produce electricity at no fuel cost by creating a large number of jobs and helping out of the recession. [2]

Nanotechnologies can be used to increase the amount of electricity generated by wind turbines. pave the way for many new forms of light bulbs. The use of nanoparticles in the production of solar cells is beneficial.

Due to the unique electronic and optical properties of nanostructures, they can reduce production costs and should reach global levels of efficiency, higher than conventional ones. [3]

2.Magnetite nanoparticles

Interest in nanotechnologies and nanometric materials, especially magnetic nanoparticles (NMPs), has grown significantly in recent times.

Their applications have attracted the attention of both the research communities and the industrial communities in the chemical, ecological and medical sectors. [4].

Magnetic nanoparticles represent a specific class of nanomaterials, composed of at least one magnetic element.

These materials can be used in a variety of forms: in solution as ferrofluids for audio speakers [5, 6], as particle aggregates in magnetic storage media [7-12], as functionalized particles for biosensor applications [13-15], in the form of compact powders for energy production, conditioning, and conversion [5,6], in medical applications that include targeted (magnetic) drug delivery [16-18] and contrast agents in magnetic resonance imaging [19-21].

Although there are many pure iron oxide phases in nature, the most popular MNPs are obtained from zero-valent iron (nZVI), Fe_3O_4 and -Fe_2O_3.

Magnetite nanoparticles have different physicochemical properties, resulting from the difference between the oxidation states of iron and their ability to remove contaminants from water.

Of these, magnetite (Fe_3O_4) has been the most intensively studied.

It has ferromagnetic properties, being the most resistant iron oxide to acids and bases. It crystallizes in the cubic system, with the chemical formula Fe_3O_4.

The iron ion in the mineral can be bivalent or trivalent iron, so magnetite is presented as iron oxide (II, III).

The paramagnetic crystal produces randomly aligned magnetic moments, and the global structure has zero net magnetization.

When a paramagnetic state is subjected to an external magnetic field, the moments align to produce a net magnetization of the crystals. [22]

In ferromagnetic and antiferomagnetic states, the individual moments are randomly aligned without an external magnetic field.

A plurality of ferromagnetic states contain several magnetic domains in which there are uniformly magnetized regions.

Each domain has uneven magnetization distributions that associate different magnetization vectors.

Because the vectors of each domain are not aligned, the net magnetization is low.

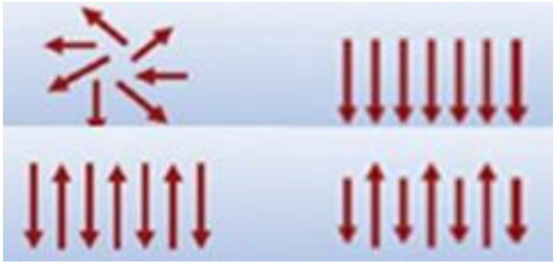

Fig.1 Alignment of magnetic moments of iron atoms (paramagnetism, ferromagnetism, antiferomagnetism, ferimagnetism) [23]

Many applications of magnetic nanoparticles are based on the use of magnetic fields to manipulate their properties, which depends on the efficiency of the magnetic moment of the particle and the field gradient [24].

The force exerted on single-core superparamagnetic nanoparticles is lower due to their small diameter and magnetic moment.

However, in the case of multi-core composites, the induced magnetic fields are large enough to allow magnetic targeting using moderate values of field strength and gradient.

Dipole-dipole and dipole-magnetic field magnetic interactions can lead to the formation of large-sized linear aggregates of the order of micrometers, with a drastic decrease in the specific surface, subsequently leading to blockage of blood capillaries [25].

2.1. Co-precipitation method

Magnetite can be obtained by chemical, physical and biological methods.

The chemical methods for obtaining magnetite powder are: coprecipitation method, sonochemical method, sol-gel method, hydrothermal reactions, electrodeposition, oxidation, flow injection, hydrolysis and thermolysis of precursors.

The most common and widely used method is the co-precipitation of Fe^{2+} and Fe^{3+} salts.

The simplest, fastest, easiest and most convenient way to manufacture nanometer-sized particles of Fe_3O_4 and γ-Fe_2O_3 uses the method of chemical co-precipitation in aqueous solutions. The basis of this liquid phase synthesis is the known LaMer mechanism [26] in which: a somewhat monodisperse phase occurs, the concentration of a component must be increased beyond the saturation point.

The production of Fe_3O_4 by adding a base to a mixture of ferric chloride and ferrous chloride was first described by Lefort in 1852.

Modern methods of producing magnetite nanoparticles are based on the work of Reimers and Khalafalla and Massart who used ferrous and ferrous salts in alkaline and acidic aqueous solutions to produce Fe_3O_4 nanoparticles with dimensions between 10-20 nm.

The simplest method is to add a strong alkaline solution (NaOH or NH_4OH) over an aqueous mixture of ferric chloride ($FeCl_2$) and ferrous chloride ($FeCl_3$) to produce the reaction.

The equation of the chemical reaction to obtain magnetite can be written as follows:

$$Fe^{2+} + 2Fe^{3+} + 8OH^- \rightarrow Fe_3O_4 + 4H_2O \qquad (1)$$

During the synthesis, oxygen can be removed from the solution by bubbling nitrogen gas into a closed system in the reaction medium.

Usually the synthesis takes place at room temperature or at slightly elevated temperatures.

The resulting nanoparticles can be removed from the solution by magnetic settling, centrifugation or both.

The size, shape and composition of the resulting nanoparticles depends very much on:

• type of salts used: chloride, sulphate, perchlorate or nitride

• Fe^{2+} / Fe^{3+} ratio

• mixing order

• degree of mixing

• reaction temperatures

• pH value

• ionic strength of the solution

Due to oxidative sensitivities and low stability, magnetite converts into the presence of oxygen in maghemite, so this method is often used to obtain small nanoparticles of magnetite and maghemite.

Grüttner and colleagues classified the magnetic nanoparticles produced by the co-precipitation method according to size, deposition layer, heating behavior and magnetic properties [27].

Although co-precipitation is undoubtedly the easiest process for the formation of magnetite nanoparticles, this method encounters some problems.

Nanoparticles can be much more polydisperse than in other methods, and their shape is difficult to control.

2.2. Sol-gel method

A wide range of nanoparticles are obtained using the sol-gel method.

The simplest principle is to add a solution of NaOH over a solution of $FeCl_3$, under continuous stirring at a temperature of 50 ° C to 100 °C.

The result is an inorganic polymerization process in which an $Fe(OH)_3$ gel is produced due to the binding of OH groups. Subsequently, the $Fe(OH)_3$ gel is kept at temperatures between 50–100 °C, for 2-8 days to produce α-Fe_2O_3 particles.

Particles with dimensions between 30-300 nm with various shapes are obtained: from pseudo-cubic to ellipsoidal shapes. The sol-gel process is a simple way to produce functionalized magnetic nanoparticles.

In general, sol-gel methods provide excellent control of the composition, size and shape of the nanoparticles obtained [33].

Among other methods of obtaining magnetite we list: flow injection, electrochemical method, hydrothermal method, electric arc discharge method, etc.

Properties of magnetite nanoparticles

• Stability of magnetite

Magnetite oxidizes rapidly in air and has a low magnetic response. The rate at which oxidation occurs is determined by the rate of diffusion of Fe^{2+} ions and the distance to the surface.

This process is called magnetization and takes place on the surface of the crystals.

• Magnetic properties

Magnetic materials fall into six categories:

1. Diamagnetic
2. Paramagnetic
3. Ferromagnetic
4. Antiferomagnetic
5. Ferimagnetic
6. Superparamagnetic

Magnetic materials range from very weakly magnetic to permanently magnetic.

The magnetic properties of a material are governed by the electronic structure of the atoms that make up the respective material.

The most important property of a magnetic material is magnetic susceptibility.

3. CONCLUSIONS

The electrical properties of Fe_3O_4 nanoparticles prepared by different methods indicate that the transition of metal insulators into films depends on the film thickness and the deposition conditions.

Tv estimates are between 75 and 165 K for Fe_3O_4 nanoparticles prepared by different methods. [28].

In this regard, it can be expected that Fe_3O_4 nanoparticles can have stronger optical, magnetic, thermal, electrical and catalytic properties than conventional iron ion solutions [29, 30].

As the population grows, so does the demand for energy. In this sense, energy production has become a key issue of this century. Thus, it is necessary to create alternative energies to reduce the dependence on current fuels, fuels, moreover, pollutants.

Thus, nanoparticles have been created which, due to their unique electrical and optical properties, can greatly reduce production costs.

These nanoparticles are transparent, which makes them accessible to many locations, not just the roofs of houses.

In the research stage are also a certain type of light bulbs that produce light similar to solar light and can be made in any shape and size.

They have the advantage of being shock resistant and have twice the efficiency of others already on the market. In the near future they will be marketed.

Nanotechnologies - technologies of the future. [31]. Nanotechnologies can be used to increase the amount of electricity generated by wind turbines.

For example, an epoxy resin containing carbon nanotubes is used to increase the strength of turbine blades.

Lighter blades are possible by using an epoxy resin filled with nanotubes.

The longer blades obtained allow to increase the amount of electricity generated by each wind farm. In this type of product, nanomaterials are integrated into a composite, with no risk to consumers.

The intelligent control systems used in the industry allow a more efficient management of the production, storage, transport and consumption of energy using electrical networks and smart devices. [32-36]

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