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RESEARCH ARTICLE

Green Synthesis of Nickel Nanoparticles using Plant Extract

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Abstract

The application of the green synthesis method helps to reduce the toxicity of nanomaterials both when they are obtained and when they are used in various areas. Therefore, in recent years, in order to ensure the sustainability of ecosystems, special attention has been paid to ecological approaches using simple and safe reaction conditions and harmless precursors. This article presents the results of SEM and XPS studies of nickel nanoparticles obtained by green synthesis using the extract of the Fumaria officinalis.

Introduction

Today, physical and chemical methods for producing nanoparticles are widely used, which most often involve the need to use high pressures or temperatures and toxic chemicals. Potential danger to the environment and living organisms may be present both during synthesis and during the direct application of nanoparticles as a result of the residues of the precursors used. In this regard, an alternative method of obtaining nanoparticles – green synthesis has been actively researched and applied over the past few decades [1-3].

The method of green synthesis consists in obtaining particles using safe materials as reducing agents and stabilizers, for example, products of biological origin. For example, the method can be carried out using extracts of plants or their individual parts, as well as microorganisms (fungi, yeast, bacteria) [4]. Synthesis involving biological organisms is compatible with the principles of green chemistry: an environmentally safe approach, the type of reducing agent used and a stabilizing agent in the reaction.

The resulting particles most often have new or improved properties (optical, electronic, chemical, etc.), in connection with which great attention is paid to the synthesis of nanoparticles using materials of biological origin. The use of biomaterials (plants and microorganisms) also makes it possible to reduce economic cost indicators, often increase the speed and reduce the synthesis time, and, most importantly, increase the environmental friendliness and safety of work during synthesis and when using the obtained particles.

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Many studies have proved the high stability and non-toxicity of metal nanoparticles obtained by green synthesis, such as [5-9]. Many works are devoted to the production of nickel nanoparticles by green synthesis using various biological sources, for example plants Aloe vera leaves extract [10], leaf extract of Coriander [11], Peumus boldus extract [12], Citrus paradise (grapefruit) peels [13] and others.

Of great interest is the application of the resulting "green" nanoparticles, including nickel nanoparticles, in research related to the living organism and the environment, in such areas as: biotechnology, biosensors and sensors, biomedicine, catalysis, optical devices, various coatings, targeted drug delivery, water purification and agriculture [14-19].

In this work, an extract of the Fumaria officinalis was used as a restoring and stabilizing agent. Infusions and settings from this plant are used as a tonic, as well as for analgesic purposes. Fumaria officinalis is a source of fumaric acid, alkaloids, tannins, resins [20].

Experimental

The plant extract was obtained using a Soxlet extractor. A water-alcohol solution in a ratio of 1:1 (water and isopropyl alcohol) was used as an extractant. For 150 ml of distilled water, there were 25 g of dried plants.

For the synthesis of nickel nanoparticles, 15 mol of nickel sulfate was mixed using a magnetic stirrer with 10 ml of the obtained plant extract and 1 ml of 2% NaOH solution. Then the solution was placed in an ultrasonic bath, washed, centrifuged and dried at 50°C.

The morphology of the obtained particles was studied by Scanning Electron Microscopy (SEM) using a Zeiss Supra 25 scanning electron microscope (Carl Zeiss, Germany).

The atomic composition of the obtained nanoparticles was determined by X-ray Photoelectron Spectroscopy (XPS) on a complex photoelectron spectrometer Escalab 250Xi (Thermo Fisher Scientific Inc.) with the energy of incident photons Al Kα = 1486.6 eV. The studies were carried out under ultrahigh vacuum conditions of the order of 10^{-7} Pa at room temperature. It was possible to clean the sample surface with a beam of Ar+ ions. In the analysis, a library of standard XPS spectra of the equipment manufacturer was used, atomic sensitivity factors were taken into account. For the study, nanoparticles were deposited on a silicon substrate.

Result and Discussion

SEM images are shown in figure 1.

Analysis of SEM images allowed us to estimate the size of synthesized agglomerated particles from 10 μm to 50 μm. After ultrasonic separation of particle agglomerates, the size range of individual particles ranged from 40 nm to 200 nm.

The results of the studies are shown in figure 2.

As a result of the XPS research, Ni, Si and O atoms, C, S contamination atoms and insignificant amounts of N, Na were detected. The energy position of Ni2p maximum before purification was 856 eV, and after purification 853.5 eV. The position of Ni2p3/2 (856 eV) corresponds to compounds of Ni or nickel oxide (Ni_2O_3), it may also be an unreacted part of the nickel salt. The position Ni2p3/2 (853.5 eV) corresponds to metallic nickel or slightly oxidized nickel.

There is also a large amount of carbon – about 80%, which indicates the presence of organic precursor residues. It is noted that there is a porous, insular surface coating, which is confirmed by the results of the SEM study.

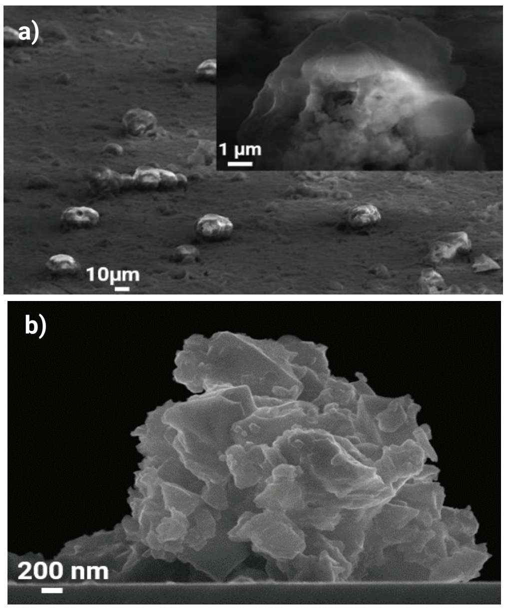

Figure 1 SEM images of the obtained particles:
a) In agglomerated form
b) After ultrasonic treatment.

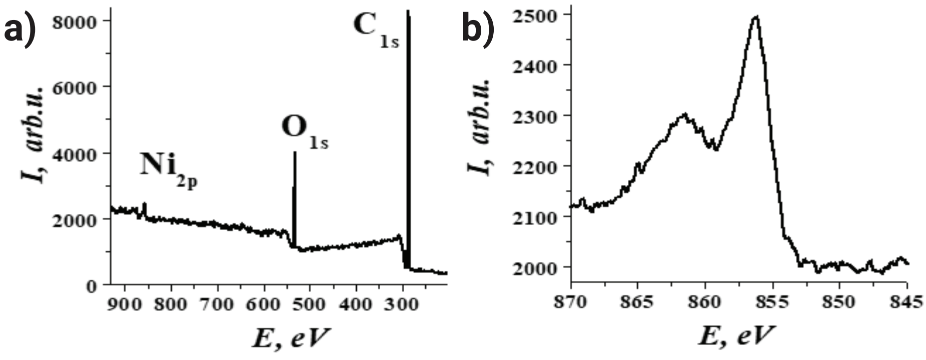

Figure 2 a) Overview XPS spectrum of the surface of the obtained particles; b) XPS spectrum of the 2p-electrons of nickel after argon purification.

Conclusion

In this work, nickel particles were obtained by the method of green synthesis and investigated. The composition of the studied nanoparticles was determined by the XPS method, and the morphology by the SEM method.

It can be noted that the use of alcohol in synthesis leads to agglomeration of particles. This effect may be related to the magnetic dipole interaction between neighboring particles, which increases in the presence of a less coordinating solvent, such as alcohol.

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