Synthesis of nickel-graphite nano- and micro-sized powders by liquid-phase arc discharge

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INTRODUCTION

The synthesis of metals encapsulated in a carbon nanoshell by the method of electric arc synthesis in a liquid medium will allow not only to obtain a wider range of materials than a similar process in the gas phase, but will also allow to give the material additional physical and chemical properties.[1] In obtaining the composite material, different electrode materials and composition of liquid medium can be used, it will contribute to the ability to control the necessary material parameters. The relevance of this topic is the possibility of remote control of composite ferromagnetic particles in the liquid, which will allow high-quality separation, as well as for the use of the obtained nano- and micro-powders in alternative energy, including the production of hydrogen.

EXPERIMENTAL STUDY

The liquid-phase electric arc synthesis unit consists of a reaction chamber, two electrodes arranged vertically along the chamber axis, an alternator, and a liquid-phase medium that acts not only as a coolant but also as an additional chemical reagent [2]. The materials of the upper and lower electrodes consist of nickel and graphite, respectively. The upper electrode is movable and oscillates relative to the lower electrode. Thus, the electric circuit between the electrodes closes and opens, forming an arc discharge plasma.

RESULTS AND DISCUSSION

The synthesis of encapsulated nickel nanoparticles was performed in three different liquids (distilled water, alcohol, and toluene) under the same conditions. The obtained solutions with microparticles were subjected to separation and examined on analytical instruments. The sizes of the obtained nanostructures were determined using a scanning electron microscope (Fig. 1); the results showed that the nanostructures range in size from 100 nm to several microns. The phase composition of nickel particles immobilized in a carbon nanoshell was investigated by X-ray phase analysis. The analysis was performed using a Rigaku MiniFlex 600 X-ray spectrometer. To remove the amorphous carbon and the resulting nickel carbide, an annealing in an inert environment was performed.

CONCLUSION

According to the results of the experiments, it was found that, regardless of the liquid medium, the particles have a spherical shape, the particles synthesized in toluene were more homogeneous in size. The composition of the carbon shell was determined by X-ray analysis. In the liquid phases
distilled water and alcohol the shell had graphite composition, in toluene the shell composition was graphene.

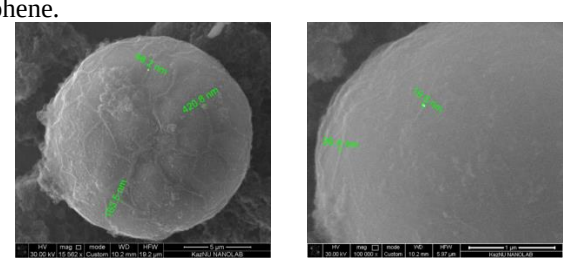

Fig. 1 Micrographs of microstructures of nickel particles in a carbon shell

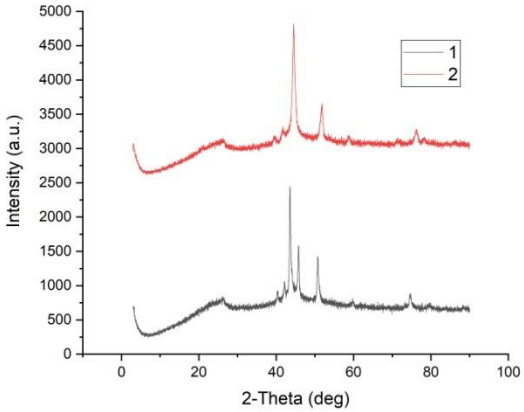

Fig. 2 X-ray phase analysis of encapsulated nickel particles obtained in toluene before annealing (1) and after (2)

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