JOURNAL OF NANO- AND ELECTRONIC PHYSICS
Vol. **8** No 3, 03053(3pp) (2016)
ЖУРНАЛ НАНО- ТА ЕЛЕКТРОННОЇ ФІЗИКИ
Том **8** № 3, 03053(3cc) (2016)

Short Communication

Method of Obtaining a Composite Material Based on Small-Dispersed Particles

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(Received 04 May 2016; published online 03 October 2016)

In this work a method of obtaining a composite material based on small-dispersed particles is considered. Proposed method consists of two steps of separation, mechanical – rough separation and plasma – soft separation, and also of step of deposition a catalytic nanolayer by wet impregnation of separated particles in an aqueous solution of nickel nitrate. During such procedure a composite powder of small-dispersed zeolite particles with average diameter of 5 μm and catalytic nickel layer was obtained. All obtained samples were studied on a Quanta 3D 200i scanning electron microscope. Microscopic analysis and obtained experimental results show, that increasing of dispersion of separated powder allows for increasing a mass of catalyst in the composite, and the used separation method in plasma for obtaining of particles with high dispersion do not erode a catalytic layer.

Keywords: Composite material, Small-dispersed particles, Plasma, Catalyst, RF discharge.

DOI: 10.21272/jnep.8(3).03053 PACS numbers: 52.27.Lw, 52.77._j

1. INTRODUCTION

The composite material is a multi-component solid material with a clear boundary between the components. If the average size of one of the components is in a nanometer range (up to 100 nm) then in this case, the size effect appears and such nanocomposite material has specific physical and chemical properties. Nanocomposite materials are widely used in various fields: in electronics [1-3] (transistors, diodes, displays, etc.), in medicine [4-7] (functional microcapsules and biomarkers, stands with nano-layer for the treatment of atherosclerosis), in energy [8-10] (creation of monocrystalline solar panels), etc. However, in some situations, control of the value of the physical and chemical properties of the composite material is required. For example, in cancer treatment a technology of selective internal radiotherapy is often used, this procedure allows for destruction of cancer cells by internal source of radiation, delivered directly to the afflicted organ. A composite material, such as YAS particles (Y_2O_3-Al_2O_3-SiO_2) are used in radiotherapy. In such therapy the dispersion of particles plays an important role. Therefore the production of composite materials based on small-dispersed or monodisperse particles is actual task for many application, not only for medicine, due to their more uniform properties (size and/or weight of the particle, surface area, surface chemistry, chemical composition, surface activation duration agents, etc.). In this work a simple method of obtaining a composite material based on small-dispersed particles is considered.

2. OBTAINING A COMPOSITE MATERIAL BASED ON SMALL-DISPERSED PARTICLES

The method of producing a composite material based on small-dispersed particles consists of several stages. The first stage is a mechanical separation of solid material (pressing and sieving) for obtaining a rough fraction (polydisperse particles). The second stage is a deposition of catalytic nano-layer on the surface of polydisperse particles. The third stage is a plasma separation [11-13] of obtained composite powder for extraction of fine fractions (small-dispersed particles with catalytic nano-layer). Thus, a mineral zeolite, due to the porosity structure and good absorption characteristics, was used as catalyst carrier and object of separation. Also such characteristics allows for qualitative coating the surface and pores of zeolite by catalytic nano-layer.

Zeolite minerals originally were in the form of granules with dimensions of 3.6 ± 0.4 mm (Figure 1 a). At the first stage of experiment, these granules were subjected to mechanical separation, which consists of pressing procedure - grinding the granules (Figure 1 b) and sieving procedure through a two-layer mesh with pore size of 0.3 mm (Figure 1 c).

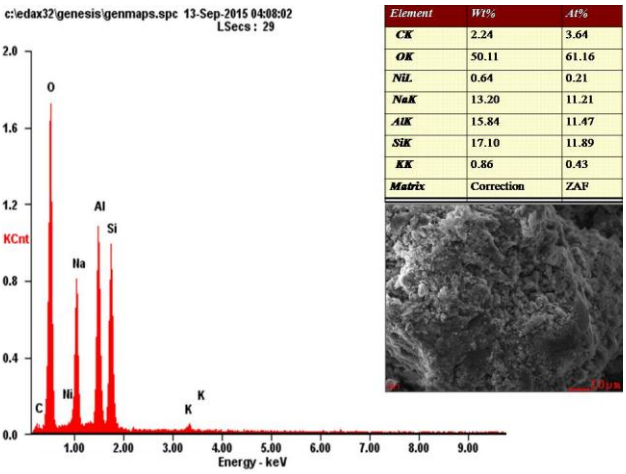
Scanning electron microscopy (SEM) analysis shows that zeolite powder size after pressing procedure is in a range of 1 μm up to 1 mm, and after sieving procedure is about from 1 to 250 microns (particles with low dispersity).

Then the second stage of experiment was carried out. Obtained zeolite particles with low dispersity were coated with catalytic nano-layer by wet impregnation method in aqueous solution of 0.1 M nickel nitrate. To achieve quality absorption and coating the obtained solution with zeolite powder was stirred in a magnetic stirrer for 2 hours, then filtered and dried naturally.

After drying the obtained samples were studied by SEM analysis. SEM images and chemical compositions of zeolite particle before and after catalyst nano-layer coating are shown in Figures 2 and 3, respectively.

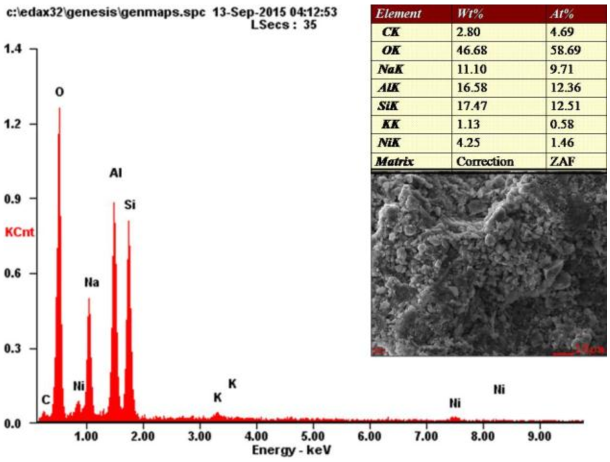
Figure 3 shows, that chemical composition of the sample, obtained after mechanical separation and cata-

Fig. 1 – Mechanical separation of zeolite:
a) zeolite granules before separation, size ~ 3.6 mm; b) zeolite particles after grinding, sizes from 1 micron to 1 mm; c) zeolite particles after sieving, sizes 1 to 250 microns



Element	Wt%	At%
CK	2.24	3.64
OK	50.11	61.16
NiL	0.64	0.21
NaK	13.20	11.21
AlK	15.84	11.47
SiK	17.10	11.89
KK	0.86	0.43
Matrix	Correction	ZAF

Fig. 2 – Chemical composition of zeolite particle before catalytic coating



Element	Wt%	At%
CK	2.80	4.69
OK	46.68	58.69
NaK	11.10	9.71
AlK	16.58	12.36
SiK	17.47	12.51
KK	1.13	0.58
NiK	4.25	1.46
Matrix	Correction	ZAF

Fig. 3 – The chemical composition of zeolite particle after catalytic coating

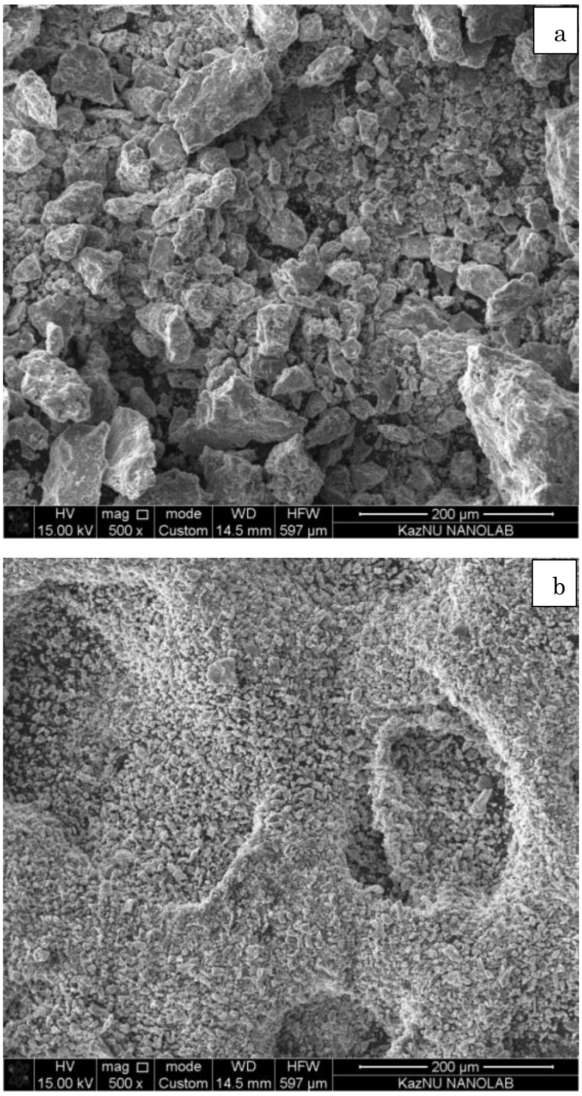


Fig. 4 – SEM images of the composite particles of zeolite/Ni before (a) and after (b) plasma separation

lytic nano-layer deposition on its surface, indicates the presence of a nickel catalyst 4,25 (Wt %).

The next and final stage of experiment was a plasma separation method of composite particles with low dispersity for extraction a small-dispersed composite particles. This method is a well described in previous works [11-13], where a special configuration of radio-frequency (RF) electrode and trap has been used as separation tool. This method allow for extracting a small-dispersed or monodisperse particles from plasma dust structure in size range of 1 to 100 μm by varying a plasma parameters. The mechanism of plasma separation is capture and control of plasma dust structure. Thus, after plasma separation procedure the obtained samples were examined by SEM analysis. Figure 4 shows SEM images of samples (zeolite particles with Ni) before and after plasma separation.

Estimation of obtained SEM images shows that the separated composite particles in RF plasma have higher dispersion. This can be seen from size distribution of those particles before and after plasma separation, which is shown in Figure 5.

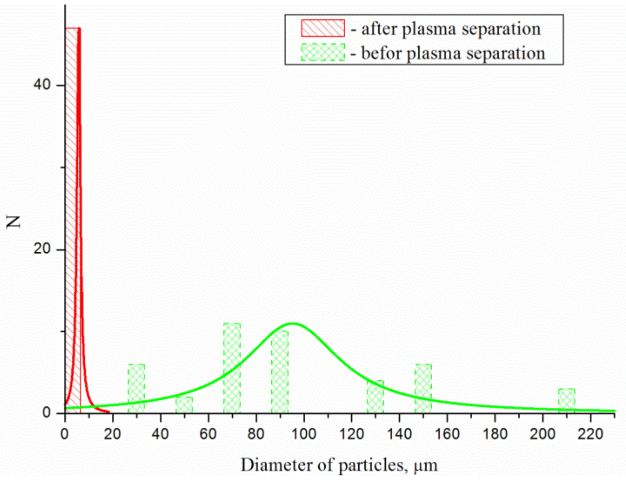


Fig. 5 – Size distribution of zeolite/Ni particles before and after plasma separation

It was also found that the plasma separation method does not destroy the catalytic layer on the surface of separated particles (Figure 6). Moreover, catalyst percentage in zeolite/Ni particles after plasma separation is higher than before.

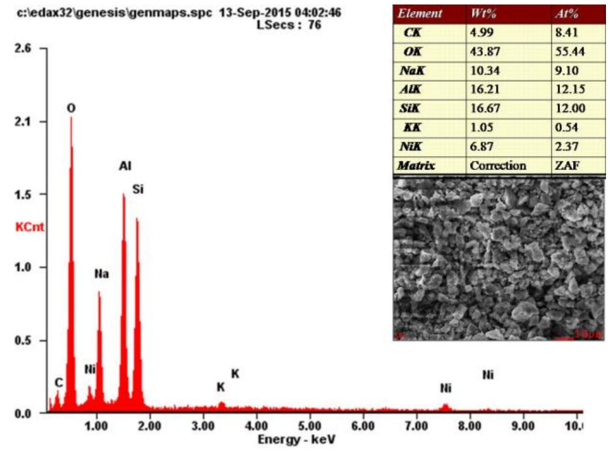


Fig. 6 – The chemical composition of zeolite/Ni particles after plasma separation

3. CONCLUSIONS

In this work a full cycle of mechanical and plasma separation and catalytic deposition methods for obtaining of composite material based on small-dispersed particles were shown. The proposed method is very simple and composite material, especially small-dispersed particles can be obtained from any solids. Energy dispersive spectroscopy analysis shows that plasma separation does not destroy catalytic nanolayer on the surface of separated particles, conversely catalyst percentage in zeolite/Ni particles after plasma separation is higher.

This work was supported by the Ministry of Education and Science of the Republic of Kazakhstan under the grant 3214/GF4.

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