THE STRUCTURE AND MORPHOLOGY OF Pt–Re(Rh)–CARBON NANOCOMPOSITES

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Introduction

The development of methods for the preparation of nanoparticles with the required properties is one of priority directions in modern materials science. The physical properties of nanodisperse systems are substantially different from those of massive samples of the same materials. The ratio between the total area of the surface of particles and their total volume increases as the size of particles decreases. Quantum size effects begin to strongly influence the properties of the system when the number of atoms in a particle decreases to hundreds or even dozens. All this results in fundamental differences between the properties of fine-dispersity systems and massive samples.

Metal-carbon nanocomposites containing platinum family metal nanoparticles attract attention due to possibililty of using them as heterogeneous catalysts of many chemical reactions such as hydrocarbon dehydrogenation, electrooxidation of methanol and hydrogen etc.

Results and discussion

Metal–carbon composites were prepared under the conditions of IR pyrolysis of a precursor based on polyacrylonitrile (PAN) and the $PtCl_4$ and $NH_4ReO_4(RhCl_3)$ platinum family metal compounds.

Carbonization occurs in polyacrylonitrile under IR pyrolysis conditions at temperatures above 400°C. This causes the formation of a graphite-like structure; the degree of its ordering depends on the intensity of IR pyrolysis [1]. Simultaneously, the reduction of metals occurs with the participation of hydrogen released in the dehydrogenation of the main PAN polymer chain [2].

The TEM image of sample IR-PAN/Pt–Re obtained at 700°C is shown in Fig. 1. We clearly see dark inclusions, which are metallic nanoparticles distributed in a lighter semitransparent carbon matrix. Separate metal particles are round-shaped. Presumably, large dark regions are aggregated metal particles.

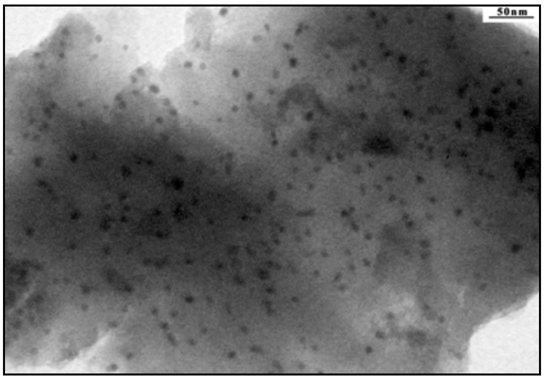

Fig. 1. TEM image of sample IR-PAN/Pt–Re obtained at 700°C.

The histogram of particle size distributions for sample IR-PAN/Pt–Re obtained at annealing temperature of 700°C is shown in Fig. 2.

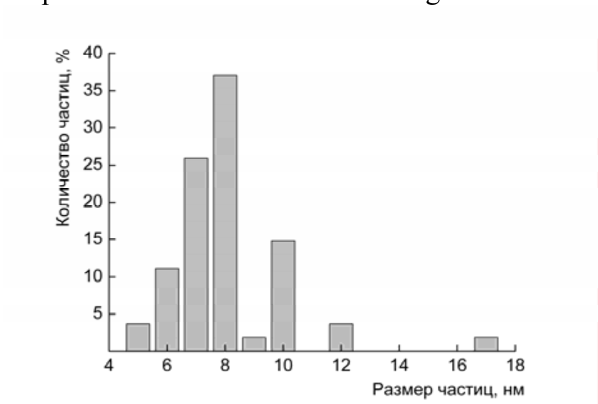

Fig. 2. The histogram of particle size distributions for sample IR-PAN/Pt–Re obtained at annealing temperature of 700°C.

92% of nanoparticles had sizes 5 nm < d < 10 nm. The mean site was 8 nm.

Thus, metallic nanoparticles in IR-PAN/Pt–Re had a narrow particle-size distribution, which did not depend on temperature of IR annealing.

It was shown there is formation of Pt–Re alloy in IR-PAN/Pt–Re nanocomposites. The X-ray powder pattern of IR-PAN/Pt–Re obtained at 1000°C is shown in Fig. 3.

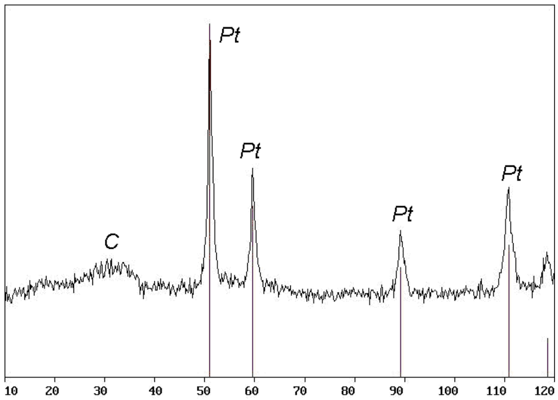

Fig. 3. The X-ray powder pattern of IR-PAN/Pt–Re obtained at 1000°C.

According to the X-ray powder pattern of IR-PAN/Pt–Re, formation of intermetallic compound Pt_7Re_3 occurs in the nanocomposites. The lattice parameter in IR-PAN/Pt–Re is $a = 3{,}888$ Å, and $a = 3{,}902$ Å for the massive Pt_7Re_3.

The samples of IR-PAN/Pt–Rh were also synthesized and investigated by the X-ray analysis. The formation of solid solution based on Pt and Rh was shown. It's structure with increased lattice parameter ($a = 3{,}8728$) similar to the structure of intermetallic compound $Rh_{0,57}Pt_{0,43}$ ($a = 3{,}856$).

Conclusions

To summarize, metal-carbon nanocomposites containing nanoparticles of alloy Pt–Re (or Pt–Rh) and intermetallic compounds Pt_3Re_7 (or $Rh_{0,57}Pt_{0,43}$) were prepared. The alloying of Pt and Ru particles occurred at IR pyrolysis. intensities corresponding to temperatures above 700°C. Metallic nanoparticles had a narrow particle-size distribution. The mean size is 8 nm.

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References

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2. Zemtsov L.M., Karpacheva G.P., Efimov M.N., Muratov D.G., Bagdasarova K.A. Carbon nanostructures based on IR-pyrolyzed polyacrylonitrile. Polymer Science. 2006; 48(6).A: 633–637.