"SHELL MODEL" FOR ANALYSIS BARIUM HEXAFERRITE NANOPARTICLES

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High dispersive particles of ferrite that with common technical use are now studied actively as objects for creating drugs with magnetic properties. Particles of barium hexaferrite have a complete potential as a magnetic material for pharmaceutical drugs has.

This ferrite belongs to the class of hard magnetic material. It has a rather large value of the coercive force and residual induction, after magnetization it can act as a permanent magnet. In industry ferrites are obtained by conducting a solid phase ferritization reaction at high temperatures followed by grinding in ball mills, so by a mechanochemical synthesis method.

The study of the reaction mechanisms that are the basis of the formation of ferrites points to the complex nature of this process. For the mechanochemical method of synthesis, the passage of the ferritization process depends significantly on the diffusion constraints, therefore, the methods of "wet" or "soft" chemistry, which are associated with the use of solutions and amorphous co-precipitated and dehydrated hydroxides are increasingly used to produce oxide powders. It is a method of chemical condensation.

The question of near-surface magnetism is important in the study of the basic properties of magnetic nanoparticles. Considering that the particles are three-dimensional objects, surface atoms, depending on the particle size, can occupy a sagnificantlly large fraction of the total volume of particles. Not only contribution of the exposed surface belongs to it, but also the adjacent structurally defective layers. The effect of the exposed surface is larger if proportion of the crystal is smaller. According to the postulates of the "shell model", it is necessary to specify such parameters of particle size as the total diameter of the solid particle (d) and the thickness of the near-surface layer (δ) with a "canted" magnetic structure. The thickness of the near-surface layer depends on many parameters.

In the experimental work, particles of barium hexaferrite ($BaO \cdot 6Fe_2O_3$) have been synthesized by chemical condensation method. Taking into account the known fact that the thickness of the structurally defective near-surface layer with distorted magnetic structure for the particles of barium hexaferrite exceeds two parameters of the crystal lattice, the contribution of the near-surface layer in the particles of the experimental system is significant (40-10% of the volume of the particle) to obtain significant results. The determined value of the saturation magnetization of the synthesized sample of barium hexafferite is $\sigma_s = 64$ Am^2/kg and differs from the macro-analogue by 11%.

The mentioned correlation $\sigma_S(d)$ (Figure) clearly demonstrates the general tendency of magnetization reduction with a decrease in the average particle size. This dependence was established for particles of barium hexaferrite synthesized by various methods and can be used for the attestation of particles of barium hexaferrite with a known one parameter (size or magnetization). The experimental sample completely corresponds in its parameters to the established correlation. In accordance with its size, the synthesized barium hexaferrite system has satisfactory magnetic properties.

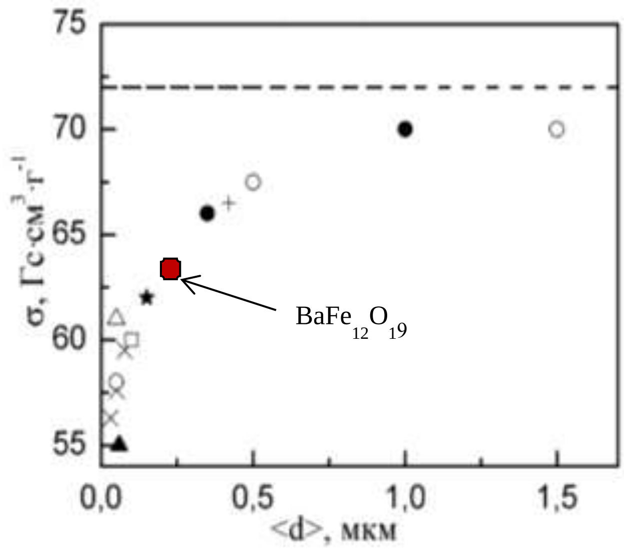

Figure. Magnetization of saturation of particles of barium hexaferrite of various
dispersity relatively to the macro-analog (*T* = 300 K, *H* = 18 kOe)

The main role in this question belongs to the method and conditions for the synthesis of particles. For nanoparticles of barium hexaferrite (d = 14 nm) obtained by the mechanochemical method, $\delta = 2\ nm$. Therefore, the volume fraction of the structure-defective surface is almost 64% of the total volume of the particle. In this case, the saturation magnetization of the nanoparticles of hexaferrite is reduced compared to its single crystal analogue by 61.5%.

The chemical condensation method makes possible to obtain barium hexaferrite nanoparticles with a saturation magnetization value 5.6 times higher than for particles obtained by the mechanochemical method. The thickness of the near-surface layer of synthesized particles of barium hexaferrite is only δ~0.84 nm. The method of chemical condensation allows to accurately dosing the initial materials, which are used in the form of solutions. Under conditions of mixing and co-precipitation of the components in the liquid phase, a high dispersion and close contact is achieved, a uniform distribution of components of the ferrite is ensured.

Using the synthesized particles of barium hexaferrite, an X-ray contrast medium with magnetically controlled properties has been developed to diagnose diseases of the hollow organs of the digestive system (patent of Ukraine No. 90577). Its X-ray contrast properties are 1.55 times greater than in traditional nonmagnatic analogues (30% aqueous suspension of barium sulfate). Controlling the medium with an external magnetic field opens up new possibilities in diagnostics to improve its quality.