Magnetite nanoparticles and their hybrid nanocomposites with chloramphenicol: low temperature synthesis and physico-chemical properties

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Magnetic nanoparticles with a size of less than one hundred nm have attracted the increasing interest in science and technology in recent decades. These particles have unique properties, such as a large specific surface area, a high proportion of surface and near-surface atoms, and a large number of surface defects. Magnetite nanoparticles possess also the unique magnetic and thermal properties, low toxicity, and high biocompatibility. Magnetic iron oxide nanoparticles currently reveal high potential as magnetic vectors for targeted drug delivery and magnetic agents for MRI, and magnetic hyperthermia. They are used for magnetic cell labeling separation and tracking in tissue engineering and clinical diagnostic. If the size of these particles decreases below the critical size of the magnetic domain, they transfer into a superparamagnetic state. Superparamagnetic nanoparticles are characterized by a high value of saturation magnetization, the absence of residual magnetism and a high magnetocaloric effect. In addition, superparamagnetic particles smaller than 10 nm are optimal agents for MRI, as they are T1 contrast agents, unlike magnetic particles of larger size.

The use of cryochemical technologies in the production of nanomaterials makes it possible to obtain materials with different dimensional and structural characteristics. In the course of this work, by varying the conditions of cryochemical synthesis, particles of magnetic iron oxides of various sizes and structures were obtained. Spray freeze-drying method were used for aqueous solutions of iron salts (iron III acetylacetonate, iron II formate, iron III citrate, iron II glucognate). The subsequent stage included thermal decomposition of the resulting precursors. Varying the nature of the precursor maghemite particles of tens nanometers in size were obtained in the case of iron II formate and iron III acetylacetonate, and up to micron lamellar for the case of iron III citrate and porous structures for the case of iron II gluconate.

Cryochemical coprecipitation of divalent and trivalent iron salts led to reducing of the average size of the resulting magnetic iron oxide nanoparticles from 17 for classical coprecipitation method down to 6 nm for cryochemical one. However, for the last case in addition to the main metal oxide products, goethite phase with undesirable magnetic properties is also formed. The deposition of iron II sulfate from the surface of cryo-granules allowed us to obtain nanopowder of magnetic iron oxide, free of the admixture of undesirable goethite particles.

Low-temperature technologies allowed to obtain not only magnetic oxide nanoparticles, but also their hybrid materials. Nanocomposites of magnetite dopped with drug substance chloramphenicol were obtained by cryochemical approach. The resulting hybrid particles had an average size of 50-400 nm. They included magnetite nanoparticles with an average size of less than 10 nm, as in the precursor used. The resulting systems showed higher dissolution rates and saturation solubility than the original pharmacopoeia bulk preparation. For the obtained nanosystems the antibacterial activity against *E. coli* and *S. aureus* was determined by minimal inhibition concentration (MIC) and by kinetic inhibition constants/ It has been established that the simultaneous presence of magnetite nanoparticles and chloramphenicol in the formulation led to a synergistic increase in their antibacterial activity.