Evaluation of Differences between Fe_3O_4 Micro- and Nanoparticles Properties

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Recently nano- and microsized powder materials based on Fe_3O_4, especially in combination with bioselective elements have been widely used. High chemical activity of Fe_3O_4 particles is caused by their higher ability to ion or atomic exchange, adsorption and formation of surface ligaments with other adsorbed particles. This guarantees the creation of bioparticles with their further use in biosensorics and in enzymatic reactions. Detailed characterization of Fe_3O_4 particles is therefore necessary in order to obtain accurate relationship between their size, electronic, magnetic and structural properties.

Nanoparticles by the sizes and mass occupy the intermediate place between single molecule and living cells. Still the main advantage of these materials is their ability to perform the preset functions under the effect of external magnetic field. However, nanoparticles synthesis has remained until now a complicated task. This is related with the difficulty of formation of homodispersive population of checked-size magnetic particles. Physical and chemical properties of magnetic Fe_3O_4 particles are determined by their size, structure and method of preparation. In particular, the process of synthesis of ferromagnetic iron oxide powders should be directed to obtaining the powder of specific fraction both as to the size and as to the shape. Size factor of powder particles affect their adsorption characteristics, which are determined by the surface energy level. Materials science approaches to the formation of the desired shape and character of the distribution as to the powder fractions will improve their functional properties.

To estimate the sizes of Fe_3O_4 atomic-force microscopy was used, which software products allowed the establishment of the scanned particles structure. Investigation data prove the results of microscopic investigations on the spherical nanoparticles accumulation. Two types of structural inhomogeneity can be distinguished on the investigated sample surface: conglomerates of conical-like nanoparticles and granular texture of substrate. Surface topography is characterized by a rough relief with morphological regions of blocked structure. Blocks are characterized by non-isometric round form with no surface faceting. Use of Fe_3O_4 nanoparticles with the aim of their functionalization application of shells, medical aids and markers on them) or introduction in a living organism for hyperthermia, foresees the application of surface coating. In this case the analysis of the dimensions and properties of nanoparticles using a simple method becomes more complex [1]. In such cases magnetic methods become one of the methods of particles categorization.

It is known that powder particles of Fe_3O_4 retain magnetization even if no external magnetic field is present, possessing own magnetic moment. However, remaining magnetization has a negative effect –a tendency of nanoparticles to agglomeration. Besides the technology of obtaining crystalline nanoparticles with high saturation magnetization needs further improvement. Moreover, nanoparticles lose their stability with time. This occurs due to the decrease of their free surface energy as a result of agglomeration. Therefore, for the effective use of such magnetic particles their chemical stability should be ensured by applying the corresponding coating on their surface.

[1] G. De Crozals, R. Bonnet, C. Farre, C. Chaix, Nanoparticles with multiple properties for biomedical applications: A strategic guide, *Nano Today* **11**(4) (2016) 435-463.