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Features of adsorption human Ig on the surface of magnetically sensitive nanocomposites

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Introduction

The coating of nanoparticles with a protein shell allows the creation of sites of specific binding of NPs to cell membranes, and the protein can play the role of a vector for nanomaterials in the biological environment.

The peculiarities of the interaction of protein substances with the surface of NPs are influenced by a number of factors: chemical nature, physico-chemical properties of NPs, reaction of the environment, nature of the protein, etc.

Therefore, it is relevant to study the possible mechanisms of interaction of nanoparticles for medical and biological purposes with blood plasma proteins.

In this work, the adsorption interaction of normal human immunoglobulin with Fe_3O_4 and Fe_3O_4/SiO_2 nanoparticles in saline (Natrii chloridi Solutio 0.9%) was investigated [1-3].

Methods

- The specific surface area measured by the method of nitrogen desorption, (KELVIN 1042 Sorptometer).
- The size and shape of the MNPs were determined by transmission electron microscopy (JEOL 1200 EX, Japan) with a tungsten filament operating at a 120 kV acceleration voltage
- The acid-base properties of the surface of the samples were investigated by the method of pH-metry
- Surface studies of nanodispersed samples were performed by FTIR spectroscopy (Perkin Elmer Fourier Spectrometer, model 1720X).
- Spectrophotometric studies of the absorption spectra, measurement of optical density and Ig concentration in solutions (Lambda 35 UV / Vis Perkin Elmer Instruments spectrometer).

Results

Nanodispersed magnetite was synthesized by the co-precipitation of iron salts by the Elmore reaction

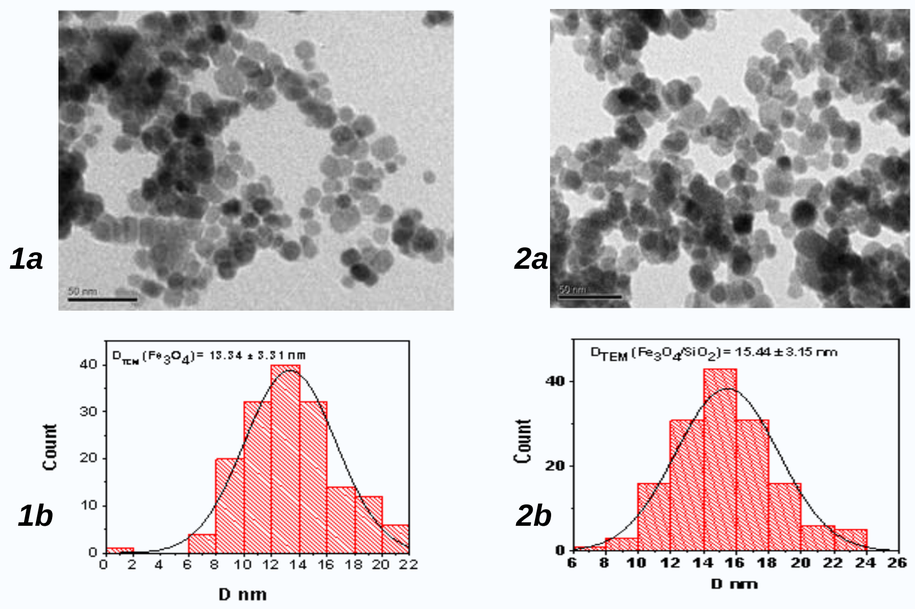
$$Fe^{2+} + 2Fe^{3+} + 8NH_4OH \rightarrow Fe_3O_4 + 4H_2O + 8NH_4^+$$

The synthesis of Fe_3O_4/SiO_2 was carried out by the method of adsorption modification (tetraethoxysilane (TEOS) was selected as a modifier)

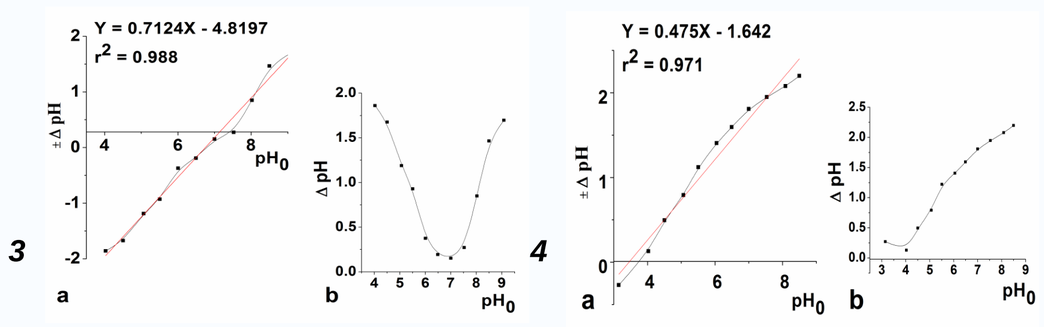
As a result of the addition of the modifier occurs the formation of hydrogen bonds between the silanol group of the modifier and the hydroxyl group of the Fe_3O_4 surface with subsequent molecular condensation with the formation of a siloxane coating Si-O-Si by the mechanism of polymolecular condensation. The content of the SiO_2 was 0.2 g per 1 g of magnetite.

Experimental data on the specific surface area indicate an increase in the value of the specific surface area of Fe_3O_4/SiO_2 nanocomposites to 130 $m^2 \cdot g^{-1}$, compared with unmodified magnetite (99 $m^2 \cdot g^{-1}$)

Fe_3O_4 (Fig. *1a,1b*) NPs obtained by the Elmore method, which have a spherical shape with an average diameter of 13.34 nm without significant aggregation. As a result of modification, there is an increase in size (an average diameter of Fe_3O_4/SiO_2 NPs (Fig. *2a, 2b*) of 15.44 nm).



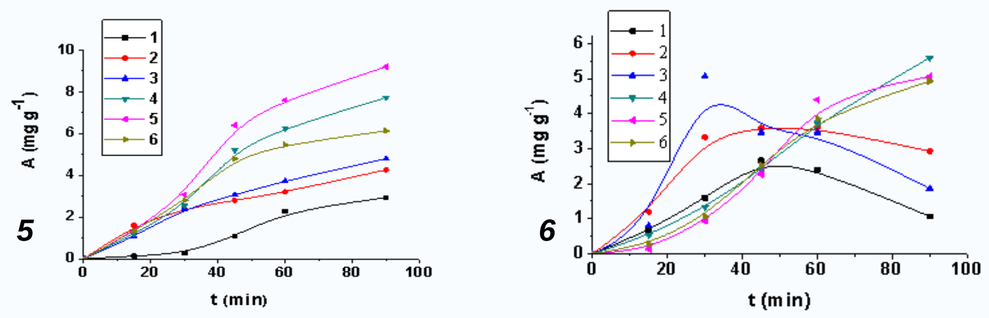
TEM images of NPs. Scale bar 50 nm (Fig. 1a, 2a);
the corresponding particle size distribution (Fig. 1b, 2b).



Determining the value pH_{IIP} (*a*) and hydrolytic adsorption curve (*b*) for the surface of NPs Fe_3O_4 (Fig. 3); Fe_3O_4/SiO_2 (Fig. 4) (0.9% NaCl).

Conclusion

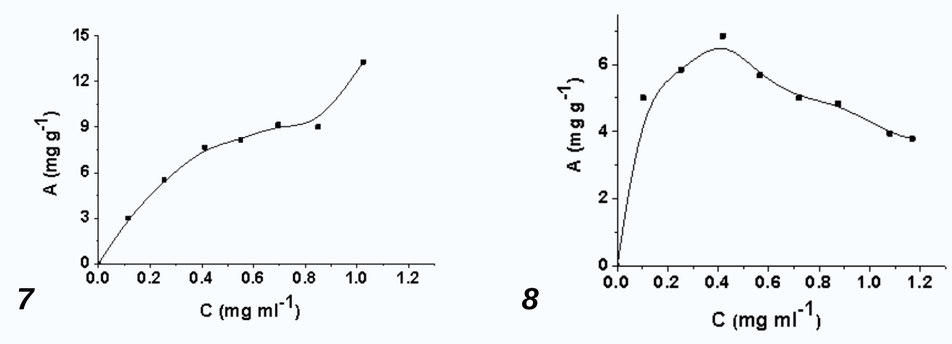
The experimental results of kinetics studies were analyzed and the adsorption isotherm was constructed. The experimental kinetic adsorption curves have been analyzed using kinetic equations that take into account the properties of the sorption processes involving protein molecules.



Kinetic curves of Ig sorption on the surface of Fe_3O_4 (Fig. 5);
Fe_3O_4/SiO_2 (Fig. 6) (C (Ig) - 1) 0.15; 2) 0.3; 3) 0.45; 4) 0.6; 5) 0.75; 6) 0.9 mg ml^{-1}; saline medium - 0.9% NaCl; T - 22^0 C; pH - 7.2).

The experimentally obtained results of kinetic dependences testify to the correspondence of the nature of adsorption kinetics to the peculiarities of the interaction of proteins with hydrophilic surfaces without changing the conformation of the protein. Within the investigated concentrations and the time range of the establishment of adsorption equilibrium is not observed. Mathematical analysis of kinetic curves indicates the correspondence of the Freundlich model (for the whole range of concentrations).

The adsorption curve of isotherm (Fig. 7, 8) has been analyzed by means of using Lengmuir, Freundlich, BET adsorption models, by Lengmuir's modify model for the adsorption of low molecular weight polymeric compounds as well by the Dubinin-Radushcevych model.



Isotherm of nonspecific adsorption of human Ig on the surface of Fe_3O_4 (Fig. 7) and Fe_3O_4/SiO_2 (Fig. 8) medium of saline NaCl; pH = 7.2

Based on the results of mathematical processing of the experimental curves, a conclusion was made about the conformity of Ig adsorption processes on the NPs surface to the Lengmuir's modify model for the adsorption of polymeric compounds (monolayer adsorption). This corresponds to the properties of protein molecules that are able to form agglomerates that exhibit the properties of independent kinetic and structural units.

Found that the adsorption capacity of NPs Fe_3O_4 for Ig is significantly higher than for Fe_3O_4/SiO_2.

References

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