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Adsorption of Doxorubicin on the surface of magnetically sensitive nanocomposite $Fe_3O_4/Al_2O_3/C$

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Introduction / Objectives / Aims

Magnetically sensitive nanocomposites with carbon components are promising in the development of new types of carriers for targeted delivery of drugs, contrast agents for magnetic resonance imaging, medical hyperthermia, magnetically controlled adsorbents for various functional purposes.

The aim of this work is to study the adsorption activity of promising for practical use of magnetic-sensitive nanocomposites of the core-shell type based on single-domain magnetite and carbon against the chemotherapeutic drug Doxorubicin (DOX).

Metods

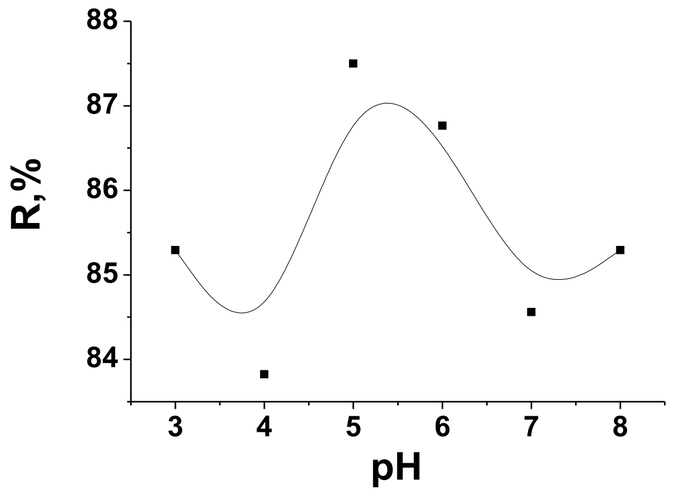
- The crystal structure of NPs was determinated by powder X-ray diffraction method (XRD). XRD measurements were perfomed using DRON-4-07 diffractometer with CoKα radiation and Fe filter, focusing on Bragg-Brentano.
- The completeness of carbonization of the surface layer of the carbohydrate was evaluated by the method of TPD MS (MX-7304A (Sumy, Ukraine)) with electron impact ionization.
- The magnetization of the samples was measured using a vibrating magnetometer at a frequency of 228 Hz at room temperaure.
- Investigation of morphology and size distribution of NPs were performed in water solutions (Transmission Electron Microscope JEOL 1200 EX (Tokyo, Japan)).
- The specific surface area of the samples was determined by the method of adsorption-desorption of nitrogen (KELVIN 1042 Sorptometer "COSTECH Instruments").

Synthesis of NCs Fe3O4/Al2O3

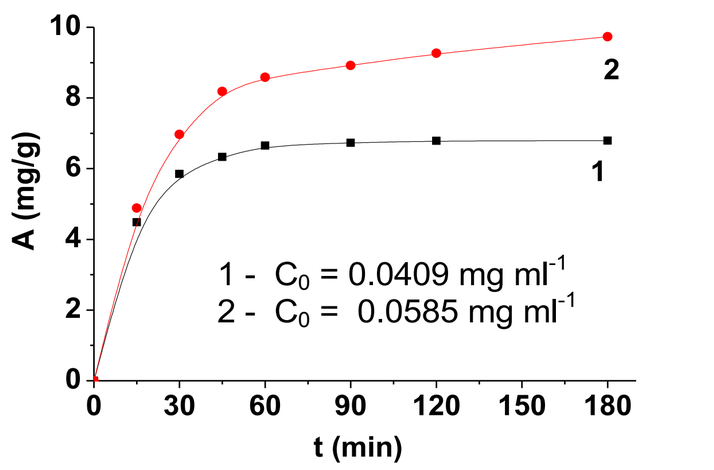
- Nanodisperse mafgnetite in the single-domain state was synthesized by the Elmore reaction.
- The synthesized NPs Fe_3O_4 in the original ensemble were characterized by sizes 3–23 nm and a single-domain state. The average size (D_{XRD}), determined by Scherrer's formula, was 10.5 nm. The specific surface area of the synthesized magnetite was S_{sp} = 105 m^2/g. Magnetite was characterized by a coercive force H_c = 55.0 E, specific saturation magnetization σ_s = 56.2 Gs×cm^3/g, relative residual magnetization M_r/M_s = 0.2.
- The synthesis of aluminum-containing coating on the surface of Fe_3O_4 was carried out by double chemical modification with aluminum isopropylate with subsequent polycondensation of the products of hydrolysis of aluminum isopropylate on the surface of the carrier.
- The obtained NCs Fe_3O_4/Al_2O_3 was impregnated using a rotary evaporator with sucrose solutions at the rate of 0.45 g of carbohydrate per 1 g NCs. Carbonization of the carbohydrate shell of NCs was carried out in argon at 500 ºC for 2 hours in a furnace with programmable heating (heating rate 10 deg min^{-1}).

RESULTS

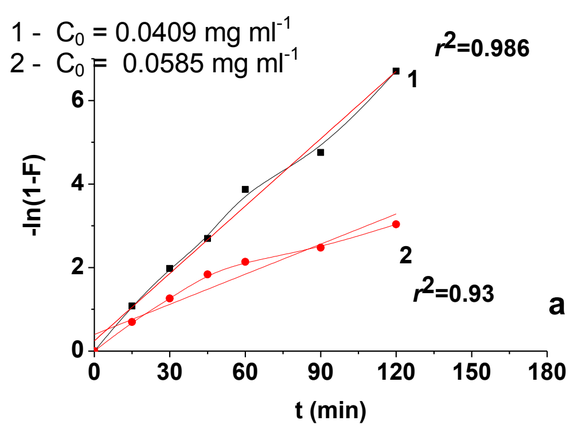
According to the results of mathematical processing of kinetic dependences and isotherms, it is established that the adsorption kinetics of DOX corresponds to the pseudo-second order model (A_{exp}= 6.79mg/g, A_{calc}= 6.96, k g/(mg·min) = 0.0352, V_0, mg/(g·min) = 1.62, r^2=0,99) with a limiting stage of external diffusion (r^2=0.99) and the isotherm corresponds to the Freundlich model (r^2=0.97).

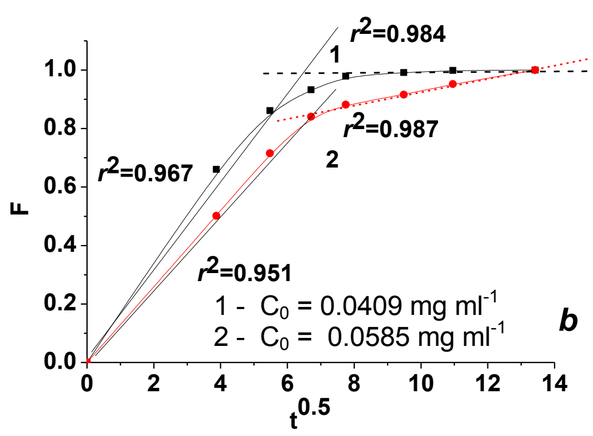


Dependence of the degree of extraction on pH

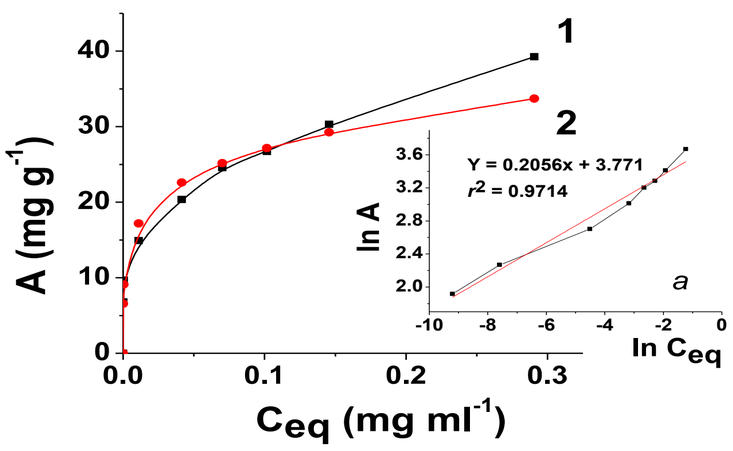


Experimental dependence of the value of DOX adsorption on the contact time on samples of $Fe_3O_4/Al_2O_3/C$ nanocomposite





Experimental kinetic dependences of DOX adsorption in the coordinates --ln(1-F) – t (a) and F – $t^{0.5}$ (b)



Isoterms of DOX adsorption on NCs $Fe_3O_4/Al_2O_3/C$ obtained from adsorption experiment (1); calculated from the parameters of the Freindlich equation (2); linearized form of Freindlich isotherm (a)