Nanocomposites and nanomaterials

Study of kinetic models for doxorubicin adsorption on the surface of hollow magnetite nanoparticles

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Hollow structures possess a large surface area and internal voids, which facilitate the loading of more substances and increase the number of active sites. Among the chemical methods for obtaining monodisperse hollow or mesoporous Fe_3O_4 nanoparticles, the solvothermal method is particularly important, as it enables the synthesis of particles with favorable magnetic properties, morphology, and size suitable for biomedical applications.

Monodisperse magnetite (Fe_3O_4) nanospheres with hollow or porous internal structures were synthesized via a one-pot solvothermal method. The synthesis was performed using iron(III) chloride ($FeCl_3$) as the iron ion source and sodium acetate trihydrate ($NaAc{\cdot}3H_2O$) as a structure-directing agent in an ethylene glycol solution, without the use of any templates or surfactants. A Fe^{3+}/Ac^- salt mixture in a 1:4 molar ratio was transferred into a Teflon-lined stainless-steel autoclave and subjected to hydrothermal treatment at 200 °C for 10 hours. After cooling to room temperature, the precipitate was collected by magnetic separation and washed several times with water and ethanol. The size and structure of the hollow Fe_3O_4 nanoparticles were characterized using IR spectroscopy and TEM. The specific surface area (S_{sp}) was 73 m^2/g, and the pore diameter (d_p) was 215 nm, consistent with the material's hollow structure. The kinetics of doxorubicin (DOX) adsorption on the surface of hollow Fe_3O_4 nanoparticles was studied at an initial concentration of C_0 = 0.0758 mg/mL (m = 0.03 g, V = 5 mL, saline, τ = 3 h). The change in DOX concentration was determined spectrophotometrically at λ = 480 nm. The adsorption kinetics data were fitted using pseudo-first-order and pseudo-second-order models, commonly employed to describe single-component adsorption at the adsorbent–adsorbate interface. Additionally, the Avrami and Elovich models, as well as external and internal diffusion models (Boyd, Bangham, and Weber–Morris), were applied to further analyze the adsorption mechanism.