Features of epirubicin immobilisation on the surface of the composite Fe_3O_4/DMSA

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The use of multiple models allows not only the identification of the most suitable equations, but also a deeper understanding of the underlying adsorption mechanism. A comprehensive analysis of the adsorption equilibrium Epirubicin (EPI) on the surface of nanosized composite Fe_3O_4/DMSA was carried out using both two-parameter (Langmuir, Freundlich, Temkin, Dubinin–Radushkevich, BET, Hols) and three-parameter (Hill, Sips, Toth, Redlich–Peterson) isotherm models. This combined approach enabled a detailed assessment of the adsorption capacity, surface heterogeneity and interaction energetics in the Fe_3O_4/DMSA-epirubicin system.

The obtained nanoparticle samples had D_{av} = 7.64 ±2.22 nm, S_{sp} = 103 m^2/g, total pore volume of 0.44 $cm^3 \cdot g^{-1}$ and average pore size of 5.7 nm. The adsorption of EPI on the surface of nanosized Fe_3O_4/DMSA was studied at a concentration of C_0 = 0.006-0.6 mg/ml (m = 0.03 g, V = 5 ml, 3 h in static mode at room temperature). The change in EPI concentration was determined spectrophotometrically (λ = 480 nm).

The adsorption of EPI on the Fe_3O_4/DMSA composite is governed by a complex and heterogeneous mechanism. The Langmuir model demonstrated an optimal fit between the two-parameter models, indicating the formation of a monolayer at certain active sites at the initial stages. At the same time, the parameter values of the three-parameter models (Sips, Toth, Hill) clearly demonstrate the energy heterogeneity of the surface. The Dubinin-Radushkevich and Temkin models indicate the inclusion of ion-exchange interactions in the process in addition to physical adsorption, which is consistent with the chemical nature of the Fe_3O_4/DMSA surface.

In addition, the applicability of the BET model indicates intermolecular interactions, not limited to π–π stacking and hydrogen bonds between EPI molecules. The Redlich-Peterson model (n_{RP} ≈0.85) confirms the intermediate nature of the system between ideal homogeneous and heterogeneous adsorption. This result demonstrates the multifunctional and energetically diverse nature of the Fe_3O_4/DMSA surface, which provides effective immobilization of EPI.