Electronic Supplementary Material (ESI) for RSC Advances.

Effective retention of cesium ions from aqueous environment using morphologically modified kaolinite nanostructures: experimental and theoretical studies

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Table.S1. Nonlinear equations of kinetic, classic isotherm, and advanced isotherm models

Kinetic models		
Model	**Equation**	**Parameters**
Pseudo-first-order	$Q_t = Q_e\,(1 - e^{-k_1 \cdot t})$	Q_t (mg/g) is the adsorbed ions at time (t), and K_1 is the rate constant of the first-order adsorption (1/min)
Pseudo-second-order	$Q_t = \frac{Q_e^2 k_2 t}{1 + Q_e k_2 t}$	Qe is the quantity of adsorbed ions after equilibration (mg/g), and K_2 is the model rate constant (g/mg min).
Classic Isotherm models		
Model	**Equation**	**Parameters**
Langmuir	$Q_e = \frac{Q_{max}\, bC_e}{(1 + bC_e)}$	C_e is the rest ions concentrations (mg/L), Q_{max} is the theoritical maximum adsorption capacity (mg/g), and *b* is the Langmuir constant (L/mg)
Freundlich	$Q_e = K_f C_e^{1/n}$	K_F (mg/g) is the constant of Freundlich model related to the adsorption capacity and n is the constant of Freundlich model related to the adsorption intensities
Dubinin–Radushkevich	$Q_e = Q_m e^{-\beta\varepsilon^2}$	β (mol²/KJ²) is the D-R constant, ε (KJ²/mol²) is the polanyil potential, and Q_m is the adsorption capacity (mg/g)
Advanced isotherm models		
Model	**Equation**	**Parameters**
Monolayer model with one energy site (Model 1)	$Q = nN_o = \frac{nN_M}{1 + (\frac{C1/2}{C})^n} = \frac{Q_o}{1 + (\frac{C1/2}{C})^n}$	Q is the adsorbed quantities in mg/g n is the number of adsorbed ion per site Nm is the density of the effective receptor sites (mg/g) Q_o is the adsorption capacity at the saturation state in mg/g C1/2 is the concentration of the ions at half saturation stage in mg/L C1 and C2 are the concentrations of the ions at the half saturation stage for the first active sites and the second active sites, respectively n1 and n2 are the adsorbed ions per site for the first active sites and the second active sites, respectively
Monolayer model with two energy sites (Model 2)	$Q = \frac{n_1 N_{1M}}{1 + (\frac{C_1}{C})^{n_1}} + \frac{n_2 N_{2M}}{1 + (\frac{C_2}{C})^{n_2}}$	
Double layer model with one energy site (Model 3)	$Q = Q_o \frac{(\frac{C}{C1/2})^n + 2(\frac{C}{C1/2})^{2n}}{1 + (\frac{C}{C1/2})^n + (\frac{C}{C1/2})^{2n}}$	
Double layer model with two energy sites (Model 3)	$Q = Q_o \frac{(\frac{C}{C1})^n + 2(\frac{C}{C2})^{2n}}{1 + (\frac{C}{C1})^n + (\frac{C}{C2})^{2n}}$	

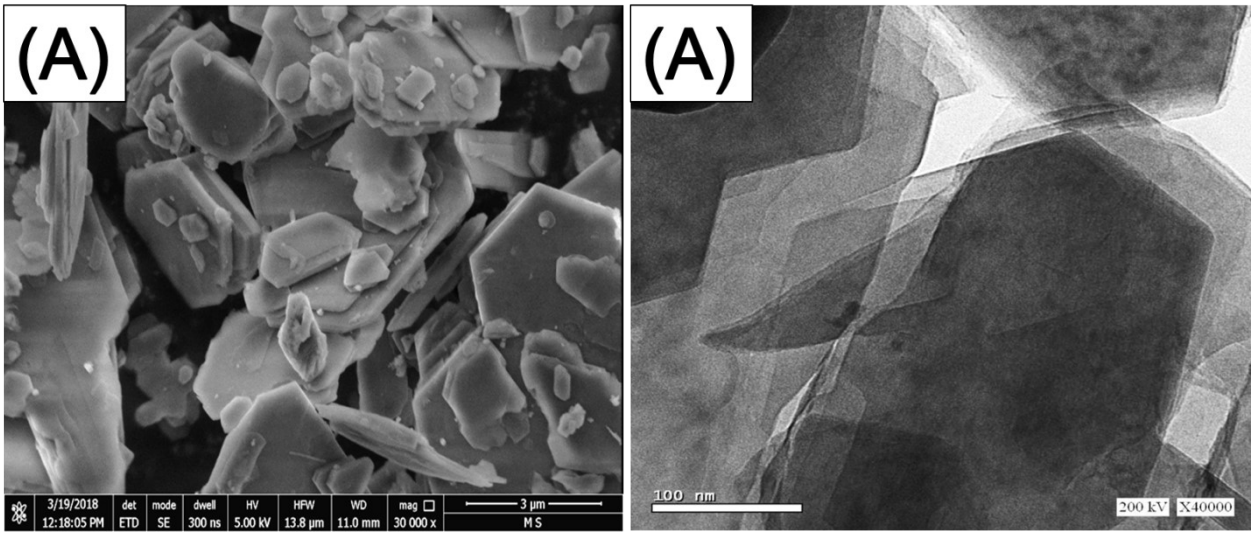

Fig.S1. SEM image (A) and HRTEM image (B) of the used raw kaolinite