

*Supplementary Materials*

# Fabrication and Application of Zeolite/Acanthophora Spicifera Nanoporous Composite for Adsorption of Congo Red Dye from Wastewater

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## 1. Adsorption isotherms

Langmuir, Freundlich, and Tempkin isotherms have been applied to explain the reaction isotherm of the designed Z, AS, and ZAS nanocomposite for the tested CR. The three models can be represented by equations 1, 2, and 3, respectively [1-4]:

$$\frac{C_e}{q_e} = \frac{1}{K_L Q_o} + \frac{C_e}{Q_o} \quad (1)$$

$$\log q_e = \log K_F + \frac{1}{n} \log C_e \quad (2)$$

$$q_e = B \ln K_T + B \ln C_e \quad (3)$$

Here,  $Q_o$  is the maximum amount of dye removed by Z, AS, and ZAS adsorbents (mg/g);  $K_L$ ,  $K_F$ , and  $K_T$  indicate to Langmuir constant, Freundlich constant, and Tempkin binding constant, respectively.  $B(=RT/b)$  is a constant associated with the adsorbed heat,  $n$  is the adsorption density,  $T$  is the absolute temperature, and  $R$  is the universal gas constant.

## 1. Adsorption kinetics and mechanism

Different adsorption mechanisms and kinetics models such as intra-particle diffusion, pseudo-first-order, pseudo-second-order, and simple Elovich kinetic model are used for identifying the adsorption mechanisms and kinetics models that best match with the adsorption of CR onto Z, AS, and ZAS adsorbents.

Equations 4 to 7 are used to represent the pseudo-first-order, pseudo-second-order, simple Elovich kinetic, and Intra-particle diffusion models, respectively [5-11].

$$\ln (q_e - q_t) = \ln(q_e) - k_1 t \quad (4)$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \quad (5)$$

$$q_t = \frac{1}{\beta} \ln \alpha \beta + \frac{1}{\beta} \ln t \quad (6)$$

$$q_t = k_3 t^{\frac{1}{2}} + I \quad (7)$$

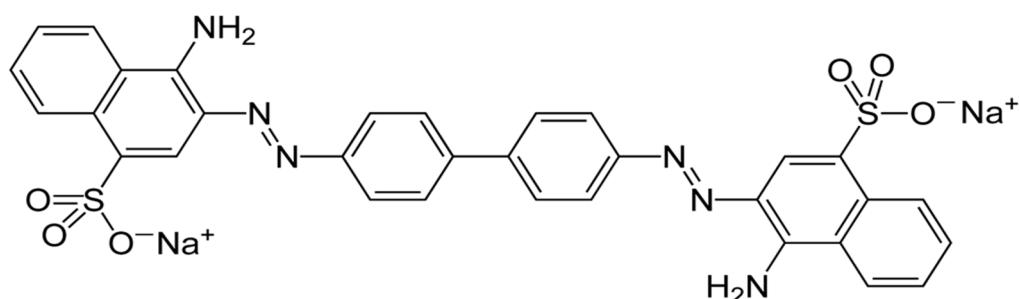
Where  $k_1$ ,  $k_2$ , and  $k_3$  represent rate constants of the pseudo-first-order, pseudo-second-order, and Intra-particle propagation models.  $I$  refers to a constant related to the boundary thickness.  $\alpha$  implies the adsorption rate at time = 0 min(mg/min) and  $\beta$  represents the extent of surface coverage (g/mg).

**Table S1.** Conditions of experimental adsorption tests.

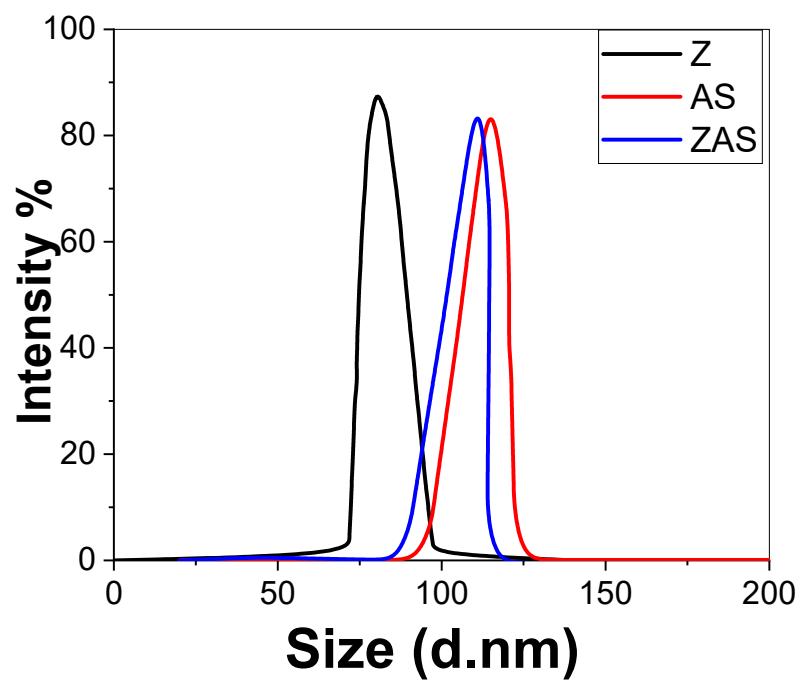
Scheme .	Dye concentration, ppm	Z, AS and ZAS weight, g	Temperature, °C	pH value
1	5, 10, 15, 20 and 25	0.02	25	7
2	10	0.01, 0.02, 0.03, 0.04 and 0.05	25	7
3	10	0.02	40, 50, 60, 70, 80 and 90	7
4	10	0.02	25	3, 4, 5, 7, 8 and 10

**Table S2.** Characteristic wavenumbers and function groups of FTIR bands for Z, AS, and ZAS adsorbents.

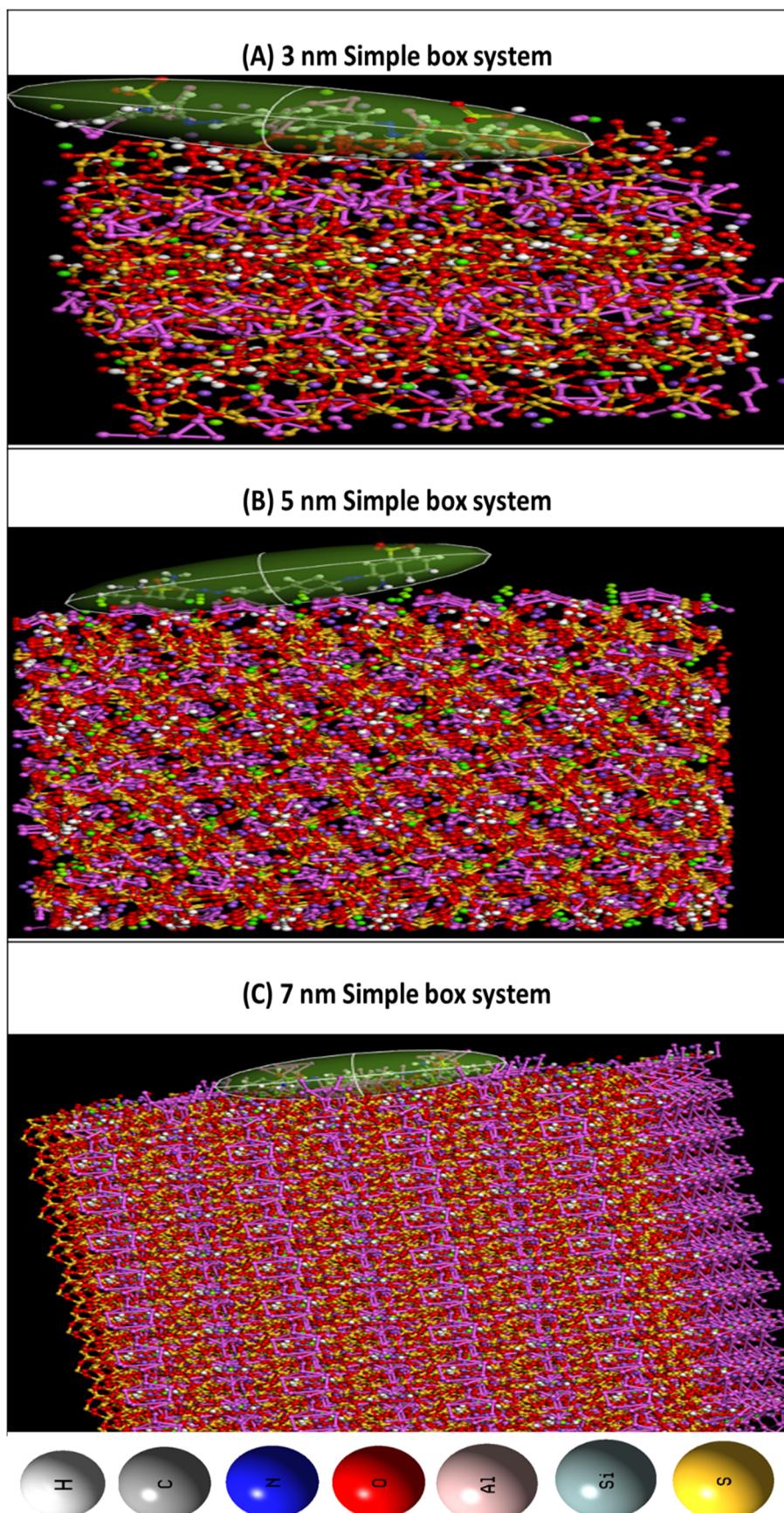
FT-IR peaks (cm <sup>-1</sup> )			Assignment	References
Z	AS	ZAS		
-	3787	3300 – 3500	amine group (-NH) stretching	[12]
3452, 3432, and 3442	3432	2915	hydroxyl group (-OH)	[13-15]
-	2915	1425	(-CH) group	[16, 17]
-	1627	1019	(-C=O) group	[18]
1029	-	1039	Si-O-Al	[19]
464	-	461	Si-O-Si bending	[20]
400 - 800	-	400 - 800	metal oxides	[21]



**Figure S1.** Structure of Congo red.



**Figure S2.** DLS spectra of Z, AS, and ZAS adsorbents.



**Figure S3.** The adsorption configurations of adsorbed CR on zeolite clinoptilolite of 3, 5, and 7 nm simple box systems for clarity purposes.

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