

Article

Continuous Fixed-Bed Column Studies on Congo Red Dye Adsorption-Desorption Using Free and Immobilized *Nelumbo nucifera* Leaf Adsorbent

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Supplementary Materials

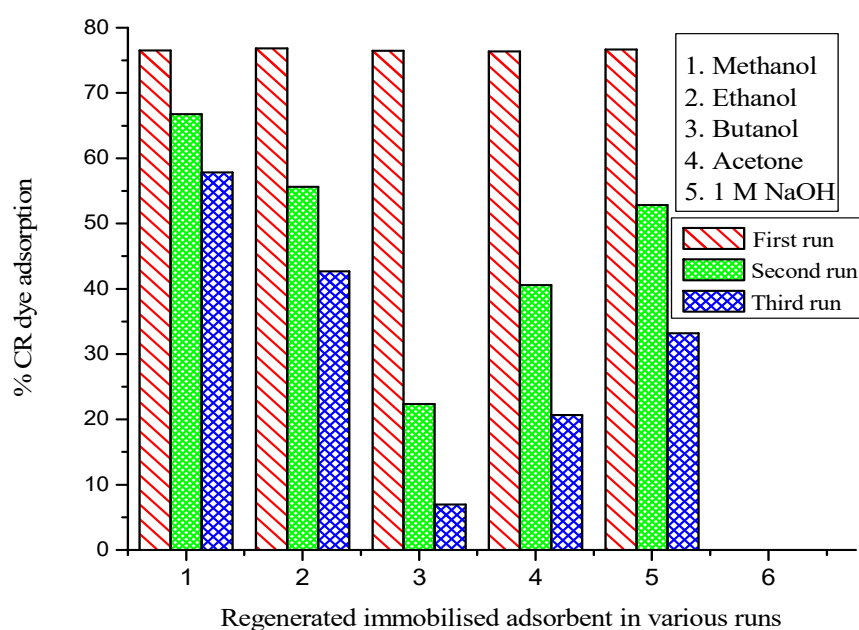


Figure S1. Reusability of immobilized NNLP adsorbent for the adsorption of CR dye in various runs. (Initial pH: 6; initial dye concentration: 200 mg L⁻¹; volume of dye solution: 100 mL; agitation speed: 150 rpm; temperature: 301 K; contact time: 24 h).

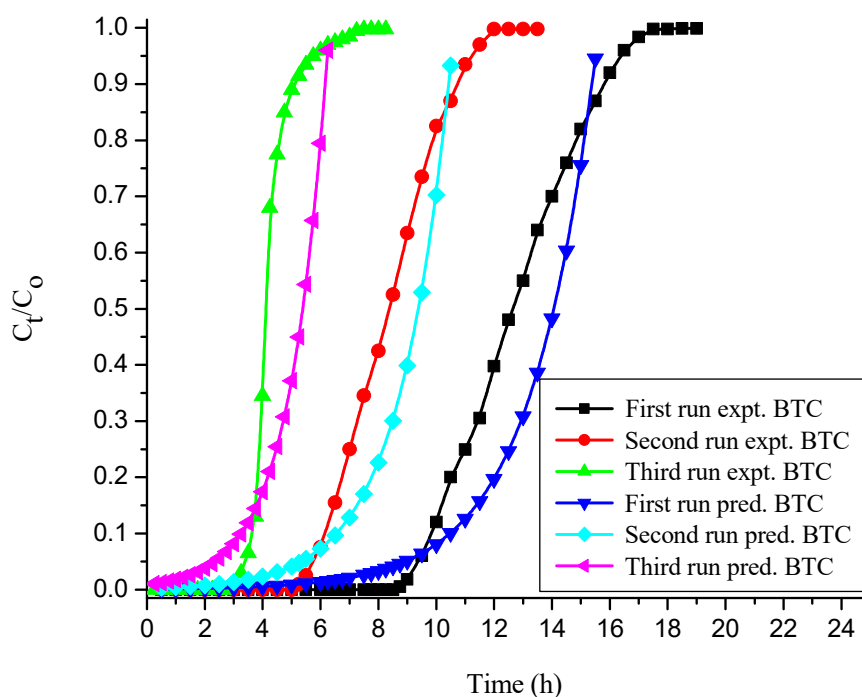


Figure S2. BTCs for experimental vs. simulated Adams-Bohart model for the decolorization of CR by free NNLP adsorbent in various runs (Initial pH: 6; flow rate: 1 mL min^{-1} ; inlet dye concentration: 15 mg L^{-1} ; temperature: 301 K).

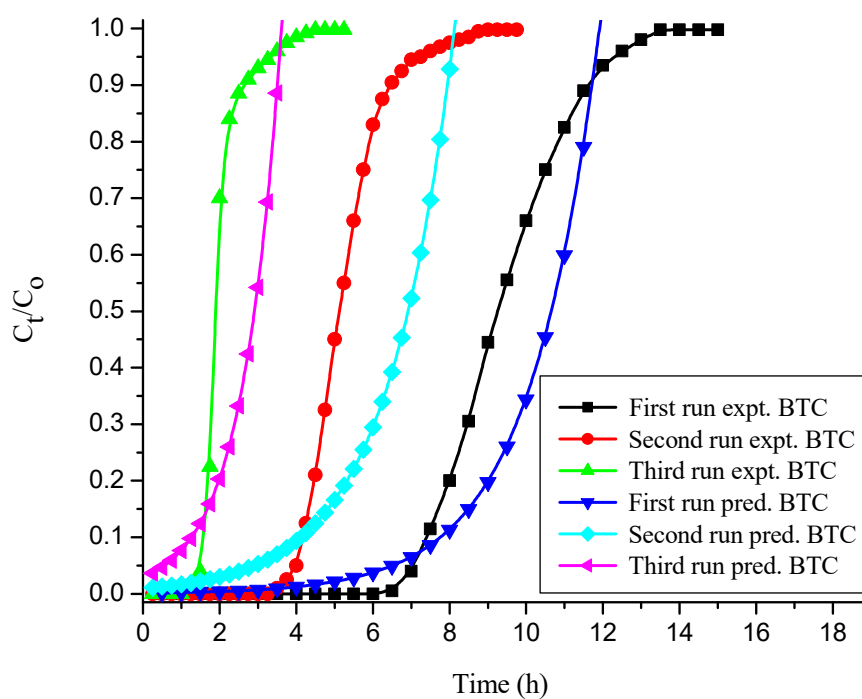


Figure S3. BTCs for experimental vs. simulated Adams-Bohart model for the decolorization of CR dye by sodium silicate gel immobilized NNLP adsorbent in various runs (Initial pH: 6; flow rate: 1 mL min^{-1} ; inlet dye concentration: 15 mg L^{-1} ; temperature: 301 K).

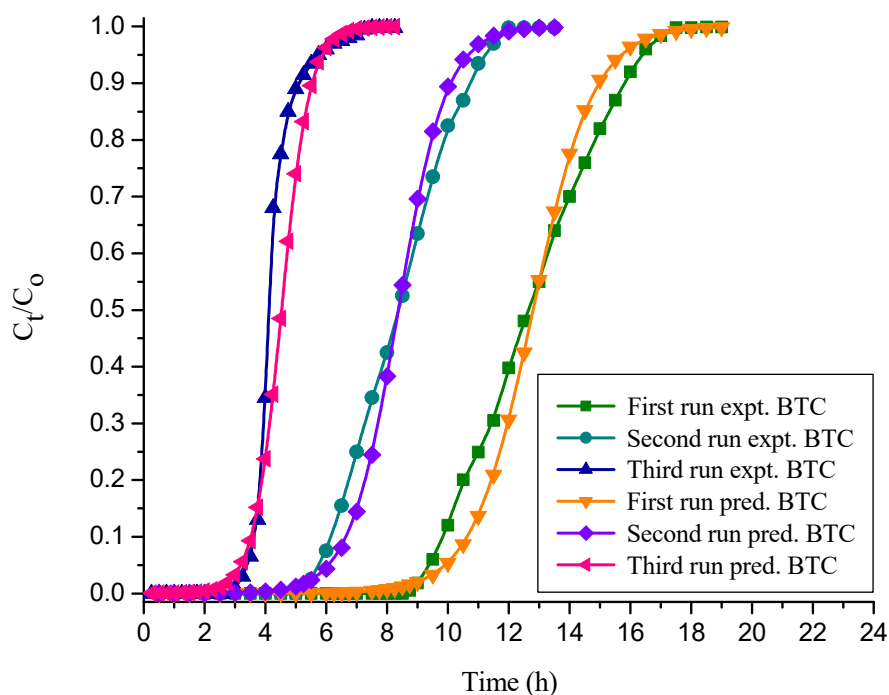


Figure S4. BTCs for experimental vs. simulated BDST model for the decolorization of CR by free NNLP adsorbent in various runs (Initial pH: 6; flow rate: 1 mL min^{-1} ; inlet dye concentration: 15 mg L^{-1} ; temperature: 301 K).

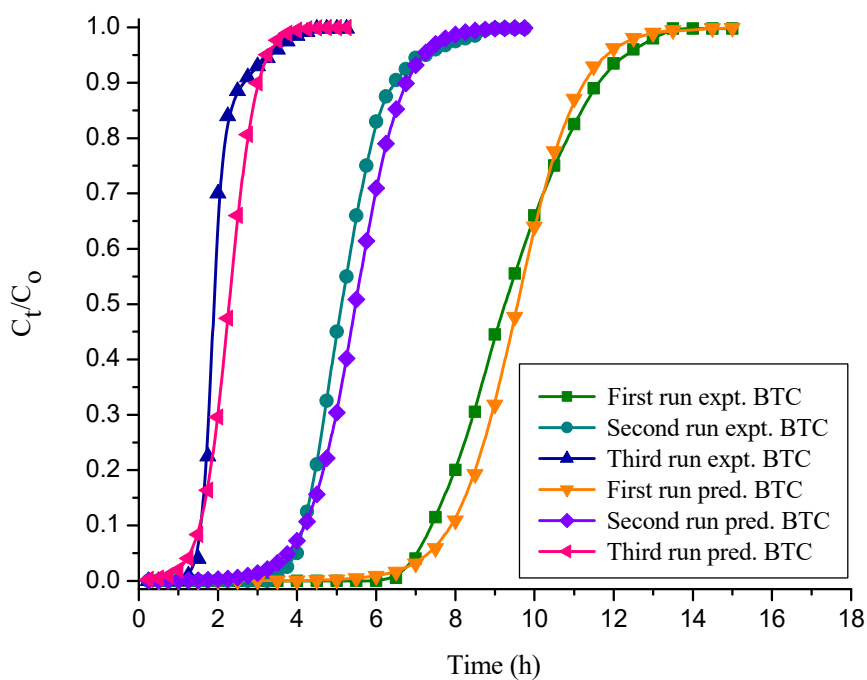


Figure S5. BTCs for experimental vs. simulated BDST model for the decolorization of CR dye by sodium silicate gel immobilized NNLP adsorbent in various runs (Initial pH: 6; flow rate: 1 mL min^{-1} ; inlet dye concentration: 15 mg L^{-1} ; temperature: 301 K).

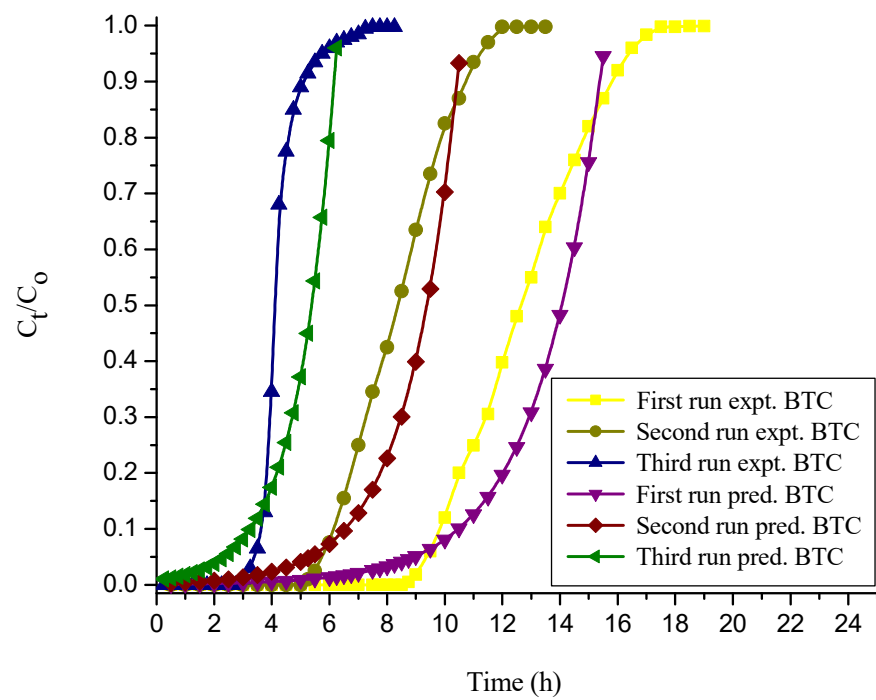


Figure S6. BTCs for experimental vs. simulated Wolborska model for the decolorization of CR by free NNLP adsorbent in various runs (Initial pH: 6; flow rate: 1 mL min^{-1} ; inlet dye concentration: 15 mg L^{-1} ; temperature: 301 K).

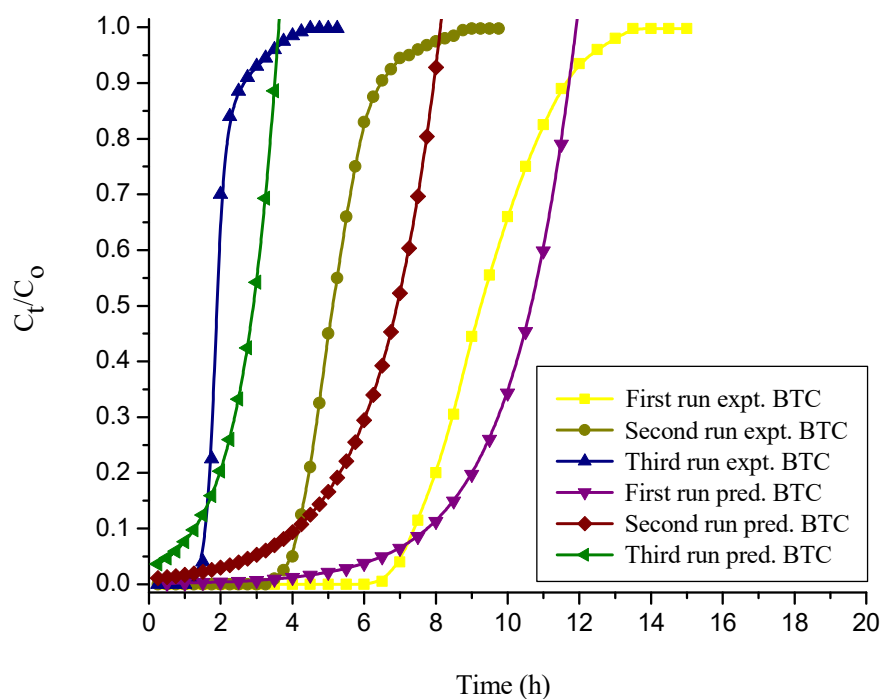


Figure S7. BTCs for experimental vs. simulated Wolborska model for the decolorization of CR dye by sodium silicate gel immobilized NNLP adsorbent in various runs (Initial pH:6; flow rate: 1 mL min⁻¹; inlet dye concentration: 15 mg L⁻¹; temperature: 301 K).

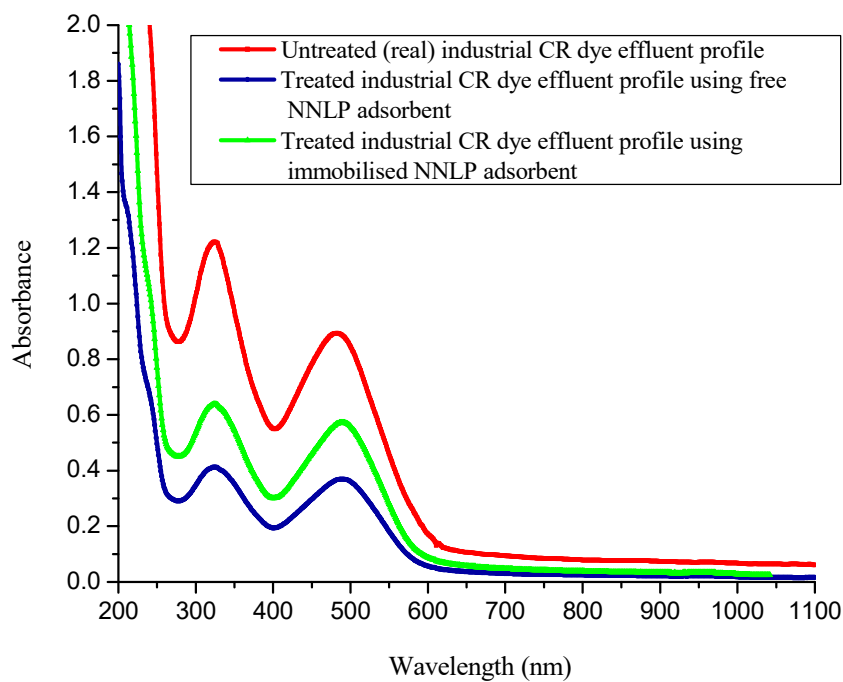


Figure S8. Industrial CR dye effluent decolorization profile obtained in column studies using free and immobilized NNLP adsorbents with untreated effluent profile (Initial pH: 6; bed height: 2.5 cm; flow rate: 1 mL min⁻¹; inlet adsorbate concentration: 215 mg L⁻¹; temperature: 301 K).

Table S1. Effect of adsorbent composition in various polymeric matrices for CR dye adsorption (Initial pH:6; initial dye concentration: 250 mg L⁻¹; free NNLP adsorbent particle size: 94 µm; immobilized NNLP adsorbent dosage: 6 g L⁻¹; agitation speed: 150 rpm; temperature: 301 K; contact time: 24 h).

NNLP adsorbent loading % (w/v)	% color removal of CR dye in various immobilized polymeric matrices			
	Calcium alginate	Polyvinyl alcohol	Polysulfone	Sodium silicate
1	70.39	62.24	69.84	75.48
2	71.65	65.38	72.35	80.26
3	73.47	68.54	74.16	83.64
4	75.58	69.48	75.90	81.28
5	76.83	67.82	77.24	78.34
6	74.92	65.16	78.56	74.12
7	72.67	62.98	75.62	69.76
8	70.29	60.35	71.18	65.52
9	68.04	58.08	66.45	60.34
10	65.24	56.34	62.58	54.26

Table S2. Desorption studies for the removal of CR dye from sodium silicate gel immobilized NNLP adsorbent in various runs.

Sl. No	Desorbing reagent	% desorption of CR dye from NNLP adsorbent		
		1 st run	2 nd run	3 rd run
1	Methanol	72.870	61.243	52.670
2	Ethanol	63.961	47.655	34.822
3	Butanol	35.479	15.836	1.548
4	Acetone	49.660	33.258	11.367
5	1 M NaOH	58.148	43.912	25.784

Table S3. Reusability of sodium silicate gel immobilized NNLP adsorbent for the decolorization of CR dye in various runs.

Sl. No	Desorbing reagent	% color removal by regenerated immobilized NNLP adsorbent		
		1 st run	2 nd run	3 rd run
1	Methanol	76.542	66.753	57.840
2	Ethanol	76.822	55.637	42.765
3	Butanol	76.485	22.342	6.978
4	Acetone	76.394	40.564	20.652
5	1 M NaOH	76.652	52.845	33.184