

Supplementary material for

Adsorption of Methylene Blue onto clay/carbon composite: Kinetics and isotherms study

Freeman Madhau^{a,c}, Zhenjun Wu^{a,b}, Yahui Shi^{a, b}, Dongjin Wan^{a, b, *}, Shepherd Tichapondwa^d,
Yangyang Wang^a, Jiekai Wang^a, Heyu Wan^a

^a College of Environmental Engineering, Henan University of Technology, Zhengzhou, Henan
450001, China

^b Zhengzhou Key Laboratory of Water Safety and Water Ecology Technology, Zhengzhou, Henan
450001, China

^c Department of Water Resources Engineering, Bulawayo Polytechnic, P.O. Box 1392, Bulawayo,
Zimbabwe

^d Water Utilization and Environmental Engineering Division, Department of Chemical
Engineering, University of Pretoria, Pretoria 0002, South Africa

* Corresponding author: djwan@haut.edu.cn

Supplementary material (Text)

Text 1. Analysis methods.

All experiments were at least performed in triplicates and average values were used. Values in the column chart are the standard deviation. The one-way ANOVA was utilized to test whether there was a significant difference among different groups. Identical letters represent no significant differences at a significance level of $P < 0.05$ in the column charts.

MB concentrations were measured at 664 *nm* using a UV-visible spectrophotometer (TU-1900, China). All samples were filtered before analysis using a 0.45 μm membrane supplied by Shanghai Xin Ya Purification Equipment Co., Ltd China. A ZEISS GeminiSEM 300 (Germany) instrument was used for both Energy-Dispersive X-ray spectroscopy (EDS) analysis and Scanning Electron Microscopy (SEM) imaging. The elements C, H, O, and N were measured using a vario MICRO select elemental analyzer (Elementar, Germany). The specific surface area and other physical properties of the samples were determined using the Brunauer-Emmet-Teller (BET) method with a Micrometrics ASAP 2460 (China) instrument. Fourier transform infrared (FTIR) spectra of 4,000-400 cm^{-1} were obtained using a Nexus 670 (USA) spectrometer. X-ray diffraction (XRD) spectra were acquired on a D8 Advanced diffractometer (USA) using Cu $K\alpha$ radiation. X-ray photoelectron spectroscopy (XPS) analysis was performed using Thermo Escalab 250SXI (USA). Dissolved organic carbon (DOC) amounts were determined by a total organic carbon analyzer (TOC-LCPN, Japan).

Supplementary material (tables)

Table S1. Characteristic of MB dye

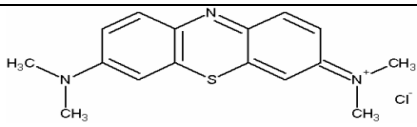
Parameter	Value
Chemical structure	
Chemical formula	C ₁₆ H ₁₈ ClN ₃ S
Molecular weight (g/mol)	319.85
Solubility in water (25 °C)	10%

Table S2. The comparison of maximum adsorption capacities of different activated materials for MB adsorption.

Adsorbent	Activation process	Activating Temperature (°C)	Adsorbent dosage (g/L)	C _o (mg/L)	Q _m (mg/g)	Reference
Rosa canina seeds	Chemical	500	2	20-100	47.20	(Jawad <i>et al.</i> , 2016)
Coconut leaves	Chemical	-	0.5-2.5	30-400	126.6	(El-Sayed, Yehia and Asaad, 2014)
Corn cob	Chemical	400	2	5-50	28.65	(Ren <i>et al.</i> , 2011)
Corn cob	Chemical	500	2	5-50	17.57	(Zhang, Zhang and Li, 2018)
SBE@C(500 °C)	Physical	500	0.6	10-60	29.54	<i>This study</i>
SBE	Physical	25	0.6	10-60	10.62	<i>This study</i>

Table S3: Thermodynamic parameters for MB adsorption onto SBE@C (500 °C).

Adsorbent	T(°C)	ΔG° (kJ/mol)	ΔH° (kJ/mol)	ΔS° (J/mol)
SBE@C(500 °C)	25	-9.96	26.39	121.00
	35	-10.30		
	45	-12.38		

Table S4. EDS of SBE, SBE@C (500 °C), SBE after adsorption, and SBE@C (500 °C) after adsorption.

Element	Atomic percent (%)			
	SBE	SBE@C(500 °C)	SBE after adsorption	SBE@C(500 °C) after adsorption
C	49.56	58.25	50.66	59.64
O	42.33	35.21	40.25	35.04
Al	1.97	1.79	2.17	1.14
Si	6.01	4.65	6.83	4.11
S	0.10	0.08	0.02	0.07
Cl	0.03	0.01	0.07	0

Table S5. BET analysis results for SBE and SBE@C (500 °C).

Sample	Specific surface area (m ² /g)	Mesopore Volume (cm ³ /g)	Average Pore diameter (nm)
SBE	0.17	5.82×10^{-4}	13.83
SBE@C (500 °C)	68.28	3.40×10^{-1}	19.93

Supplementary material (Figures)

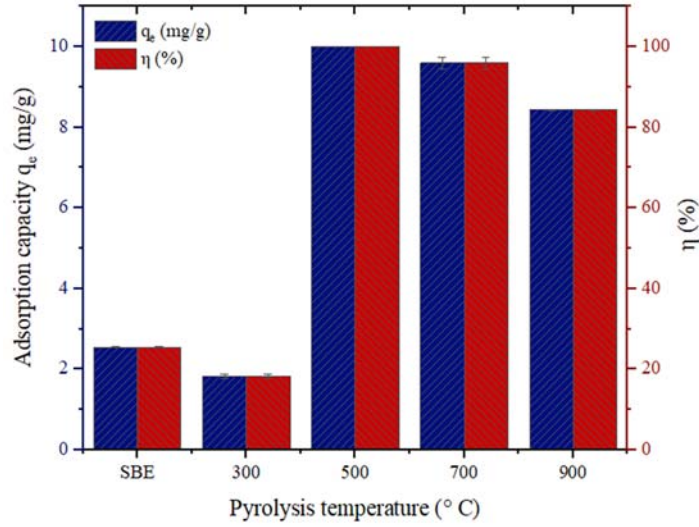


Figure S1. Adsorption capacity of MB in solution by SBE@C at different pyrolysis temperatures ($C_0 = 10$ mg/L, dosage = 1 g/L, solution volume = 100 mL, rotation speed = 150 rpm, temperature = 25 $^{\circ}$ C, 120 minutes).

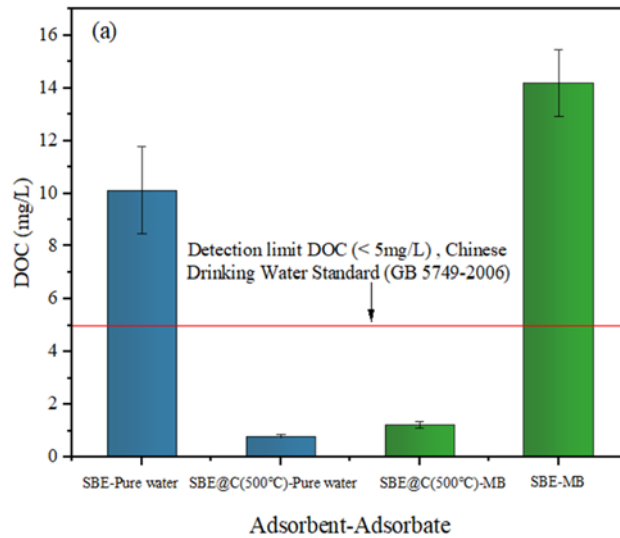


Figure S2. (a) DOC of pure water and MB solution ($C_0 = 10$ mg/L, dosage = 0.6 g/L and $V = 100$ mL) after adsorption by SBE and SBE@C (500 $^{\circ}$ C) at 25 $^{\circ}$ C.

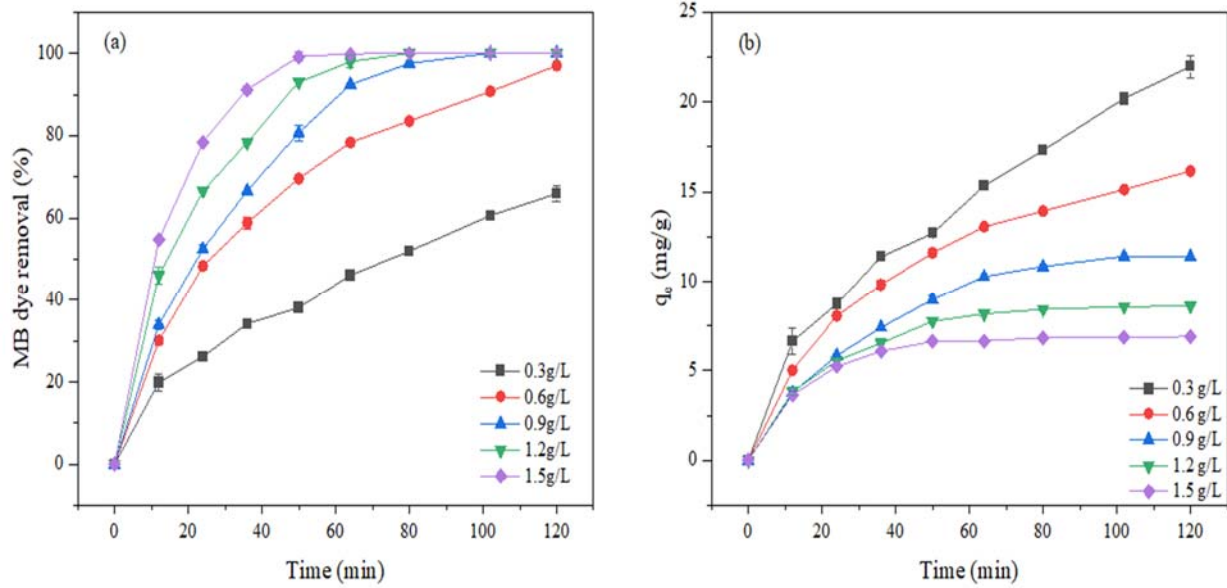


Figure S3. Effects of SBE@C (500 °C) dosage on (a) removal efficiency (%) and (b) adsorption capacity (mg/g), ($C_0= 10$ mg/L, rotation speed = 150 rpm and $V= 100$ mL).

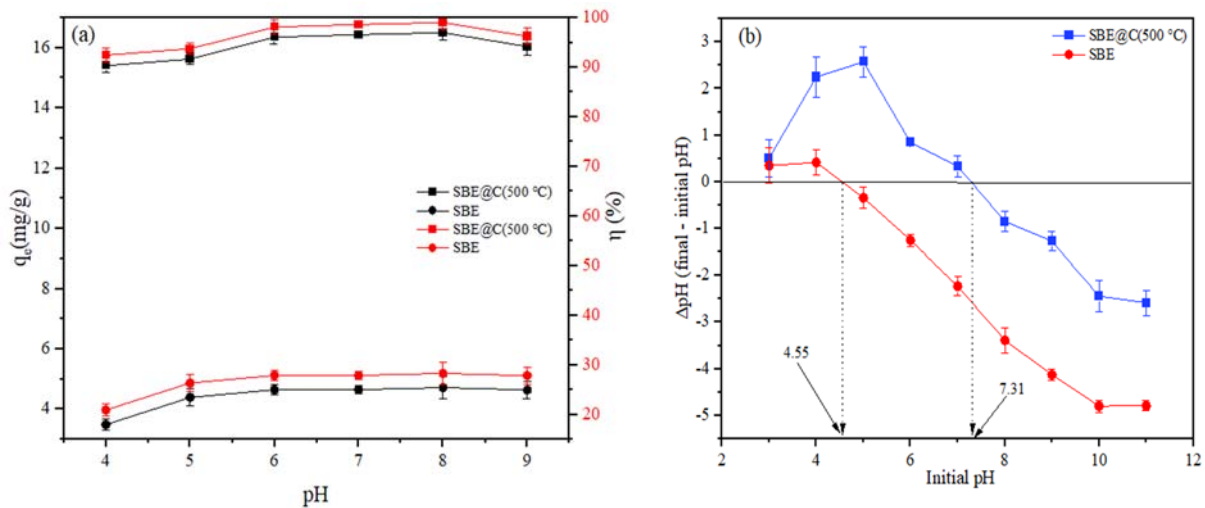


Figure S4. (a) Effect of pH on the adsorption of MB by SBE and SBE@C (500 °C), and (b) pH of zero point charge (pH_{pzc}) plots of SBE and SBE@C (500 °C).

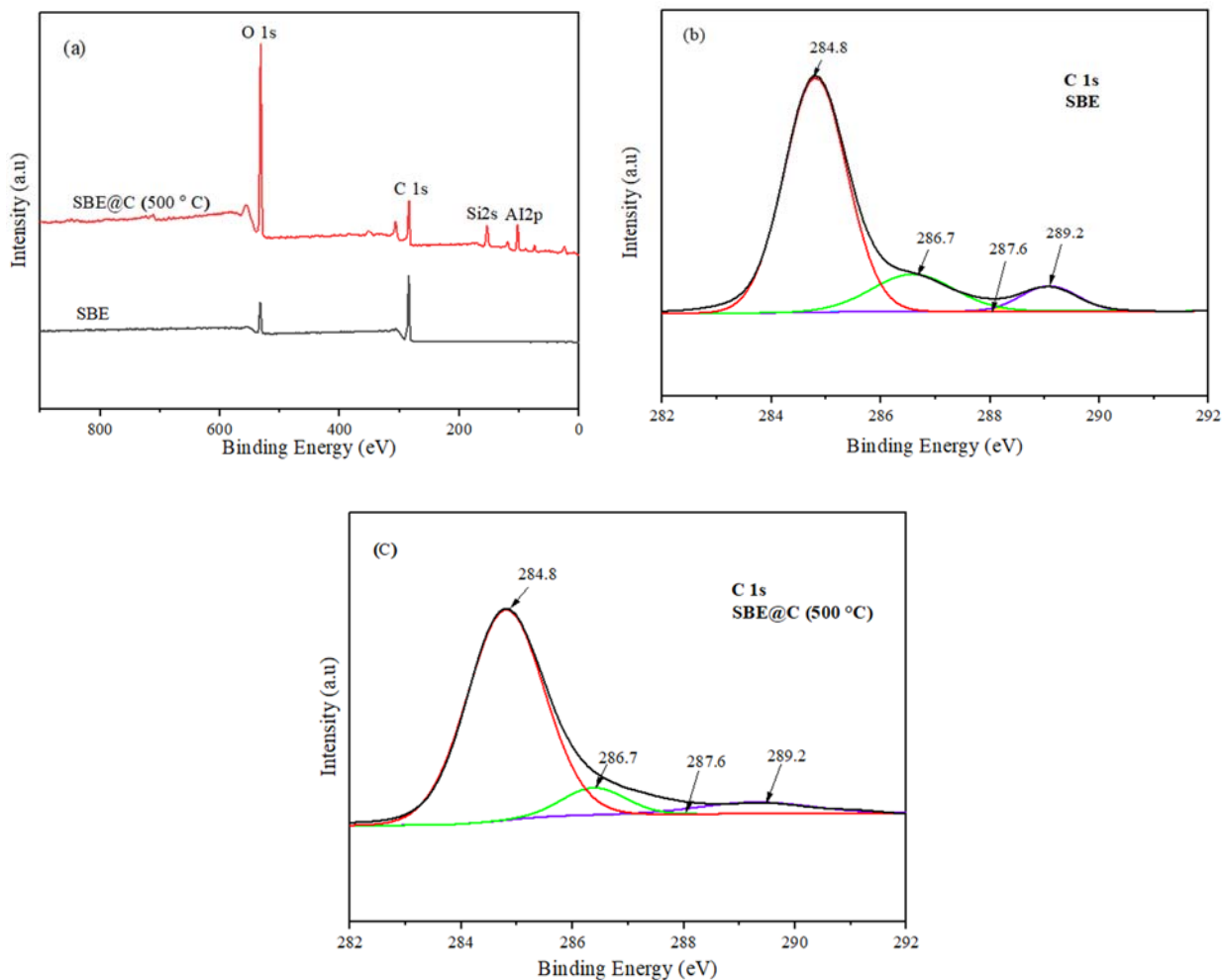


Figure S5. (a) Survey scan, C1s XPS spectra of (b) SBE, and (c) SBE@C (500 °C).

References

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