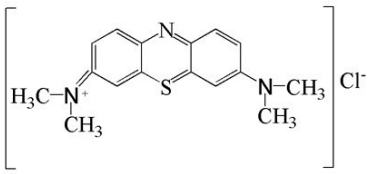# Supplementary Information

Removal of mercury (II) and methylene blue from water environment with magnetic graphene oxide: adsorption kinetics, isotherms and mechanism

Yongfu Guo,[*] Juan Deng, Junyan Zhu, Xiaoji Zhou and Renbi Bai

Table S1   The general data of MB and Hg(II) used in this work

Adsorbates	Chemical construction	Classification	Formula	Molecular volume (g mol^{-1})	λ_{max} (nm)
MB		Cationic	$C_{16}H_{18}ClN_3S$	319.9	664[a]
HgCl$_2$		Cationic		200.6	253.7[b]

[a] Determined by UV-vis spectrophotometer UV-3600.

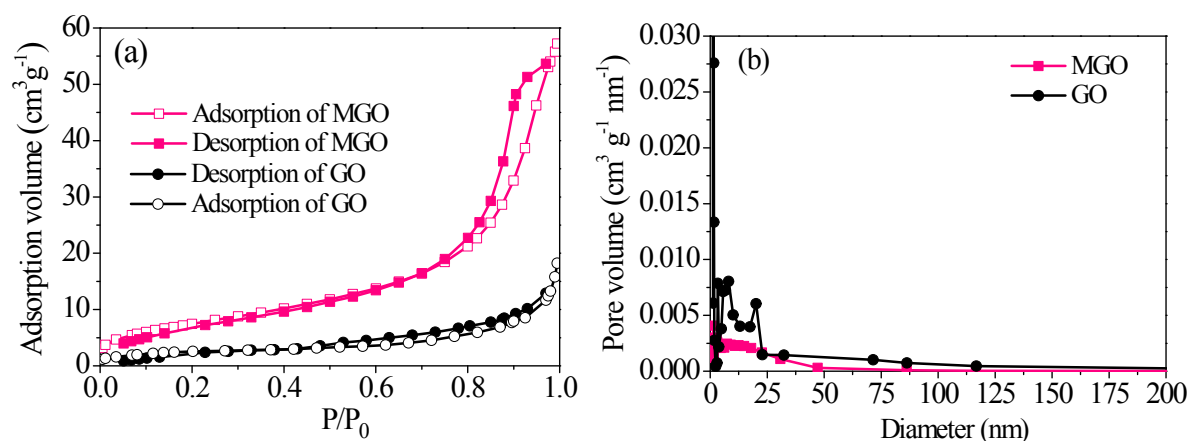[b] Determined by cold vapor atomic adsorption spectrophotometry F732-VJ.

Fig. S1 BET patterns (a) and particle size distribution (b) of GO and MGO.

The isotherms of MGO shown in Fig S1(a) exhibited obvious H4 hysteresis loops, suggesting mesoporous features in the range of 0.5-1.0 P/P_0.[1] The pore size distributions (shown in Fig. S1(b)) calculated by BJH method showed main pore sizes around 5 - 50 nm for MGO, as shown in Table S2.

Table S2 The characteristics of GO and MGO used in this work

| Adsorbents | Surface area ($m^2\ g^{-1}$) | | Pore volume ($cm^3\ g^{-1}$) | Average pore size (nm) | Range of particle diameter (nm) | Average pore diameter (nm) |
	BET	Langmuir				
GO	9.2	80.6	0.028	6.5	10 - 150	652.2
MGO	58.6	1, 259.9	0.088	10.8	5 - 50	225.9

Table S3　EDS data of GO and MGO

GO		MGO	
Elements	Weight (%)	Elements	Weight (%)
C	66.4	C	32.2
O	31.4	O	40.6
Fe	0	Fe	25.6

Adsorption kinetics study:

Pseudo-first-order equation:

$$\ln (q_e - q_t) = lnq_e - k_1 t \tag{1}$$

Pseudo-second-order equation:

$$\frac{t}{q_t} = \frac{1}{q_e^2 k_2} + \frac{t}{q_e} \tag{2}$$

Intra-particle diffusion equation:

$$q_t = k_{di} t^{0.5} + C_i \tag{3}$$

where k_1 (min^{-1}) and k_2 (g·mg^{-1}·min^{-1}) are the pseudo-first-order and pseudo-second-order adsorption rate coefficients, respectively. k_{di} (mg·g^{-1}·min$^{-0.5}$) is the intra-particle diffusion rate coefficient at stage i. C_i (mg g^{-1}) is the thickness of the boundary layer at stage i.

Adsorption isotherms study:

The Langmuir empirical equation is given below:

$$\frac{C_e}{q_e} = \frac{C_e}{Q_m} + \frac{1}{Q_m K_L}$$

(4)

The Freundlich isotherm is expressed as:

$$\ln q_e = \ln K_F + \frac{1}{n} \ln C_e$$

(5)

where Q_m is the maximum monolayer covered adsorption capacities (mg g^{-1}), and K_L and K_F are the Langmuir adsorption constant (L mg^{-1}) and Freundlich isotherm constant (mg^{1-n} L^n g^{-1}). The n is the indicators of adsorption intensity. The slope of 1/n is a measure of adsorption intensity or surface heterogeneity, becoming more heterogeneous as its value gets closer to zero. Whereas, a value below unity implies chemisorption process where 1/n above one is an indicative of cooperative adsorption.[2]

The separation factor R_L used to describe the adsorption characteristics can be calculated with K_L which is derived from Eq. (6):

$$R_L = \frac{1}{1 + K_L C_0}$$

(6)

Generally, the values of R_L mean the favorable adsorption in the interaction of adsorbent-adsorbate pair ($0 < R_L < 1$), linear ($R_L = 1$), irreversible ($R_L = 0$) or unfavorable ($R_L > 1$).[3,4]

Table S4   Characteristics of raw chloralkali wastewater after pre-treated

Characteristics	Values
pH	5.1-7.7
Hg^{2+}	0.1-0.6 mg L^{-1}
Mg^{2+}	15-50 mg L^{-1}
Cl^-	722-1205 mg L^{-1}
Fe^{2+}	0.7-1.2 mg L^{-1}
Na^+	5200-8900 mg L^{-1}
Fe^{3+}	0.1-0.2 mg L^{-1}
COD_{cr}	20-45 mg L^{-1}

References

1   L. Cui, Y. Wang, L. Hu, L. Gao, B. Du and Q. Wei, *RSC Adv.*, 2015, **5**, 9759.

2   K. Y. Foo and B. H. Hameed, *Chem. Eng. J.*, 2010, **156**, 2.

3   Y. F. Guo, J. Deng, J. Y. Zhu, C. Zhou, C. Y. Zhou, X. J. Zhou and R. B. Bai, *RSC Adv.*, 2016, **6**, 39762.

4   B. Henriques, G. Goncalves, N. Emami, E. Pereira, M. Vila and P. Marques, *J. Hazard. Mater.*, 2016, **301**, 453.