Electronic Supplementary Material (ESI) for RSC Advances.

Supporting information for

Carbon Monolith with Embedded Mesopore and Nanoparticles as Novel Adsorbent for Water Treatment

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S1. Colorimetric Analysis

For colorimetric analysis, the solution after treatment (5.25 mL) were taken into test tubes, o-phosphoric acid (0.50 mL, 4.5 M) and 1,5-diphenyl carbazide (0.25 mL, 5.0 g L^{-1}) were then added. After incubation at room temperature for 30 minutes for color development, the absorbance of the samples was measured in a UV-Vis spectrophotometer (UV1601, Shimadzu). Peaks with varied intensities were observed in the spectrometer scans at 540 nm wavelength depending on the concentrations of the remaining Cr(VI) in the samples.

S2. Nanoparticle Size Analysis

The iron particle size is determined as 53.67±46.50 nm from TEM images in Fig. S1 based on 174 particle measurements. From the statistic histogram, the majority of iron carbide particles has a size smaller than 50 nm and very few over 150 nm.

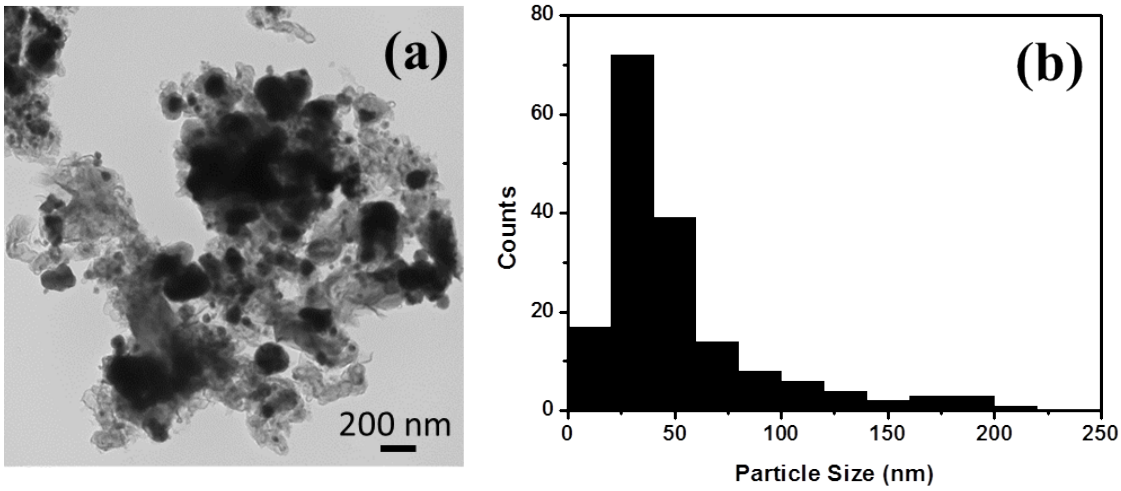

Fig. S1. (a) TEM images of c-WFe, (b) histogram shows the particle size distribution.

S3. Raman Analysis

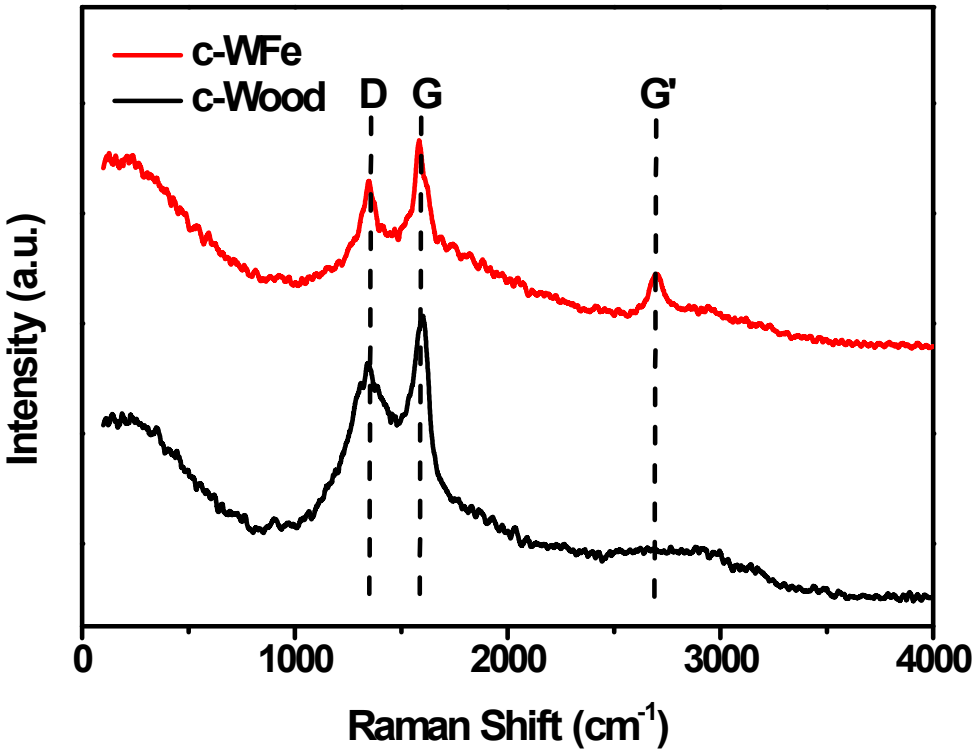

Fig. S2. Raman spectrum of c-Wood and c-WFe.

From Raman, I_D/I_G has been used to qualitatively compare the degree of graphitization. However, quantitative determination has not been well established. Raman spectrum of c-Wood and c-WFe were also used to qualitatively compare the degree of graphitization, as shown in Fig. S2. Compared to c-Wood (I_D/I_G=0.895), c-WFe shows lower I_D/I_G ratio of 0.889. The lower I_D/I_G ratio indicates fewer edge defects on graphite edges for c-WFe. Besides, G' band at 2700 cm^{-1}, which corresponds to the interactions between the stacked graphene layers, was detected for c-WFe, the existence of stacked graphene layers further confirmed the fact that catalytic graphitization can be induced by iron carbide.

S4. Carbon Yield Calculation

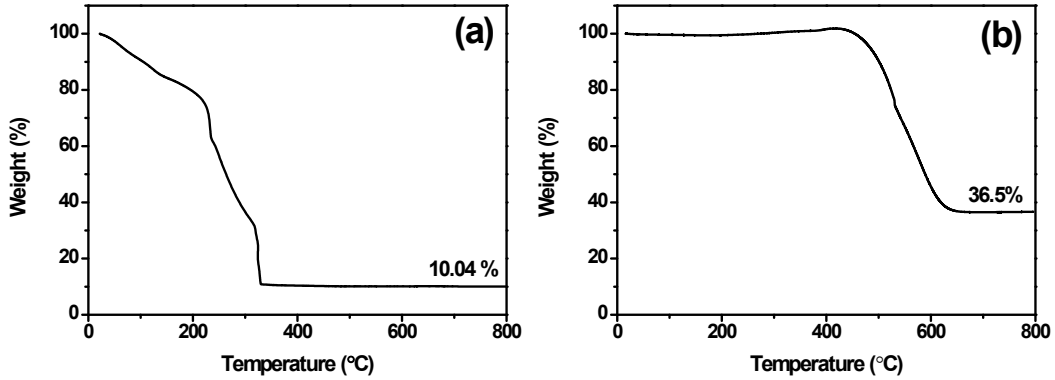

Fig. S3. TGA of (a) iron nitrite doped wood (b) c-WFe.

To determine the carbon yield, mass of c-Wood, c-WFe before ($m_{all\text{-}before}$) and after ($m_{all\text{-}after}$) annealing at 800 °C were carefully weighed, and the mass of carbon ($m_{c\text{-}before}$) in soaked wood and produced char ($m_{c\text{-}after}$) after annealing can be calculated since the carbon loading in dried soaked wood and c-WFe has been determined as 49.30 and 74.90 wt% from TGA results, Fig. S3. The carbon yield of c-Wood and c-WFe are 27.45 and 37.48%, respectively. The calculation is shown in Table S1. During annealing, iron carbide can induce catalytic graphitization, which will promote the reorganization and stabilization of carbon, thus contributing to the 10.03 % increase in carbon yield for c-WFe, compared to c-Wood. The 10.04 wt% residue for wood impregnated with iron nitrite is Fe_2O_3, corresponds to 50.70 wt% of $Fe(NO_3)_3 \bullet 9H_2O$, thus wood loading is determined as 49.30 wt%. Similarly, the final residue is 35.90 wt% which corresponds to a 25.10 wt% iron elements in c-WFe and the wood mass percentage is determined as 74.90 wt%.

Table S1. Calculation of carbon yield for c-Wood and c-WFe.

Sample	$m_{all\text{-}before}$	$m_{c\text{-}before}$	$m_{all\text{-}after}$	$m_{c\text{-}after}$	Yield (%)
c-Wood	1.0078	1.0018	0.275	0.275	27.45
c-WFe	0.4903	0.2417	0.121	0.0906	37.48

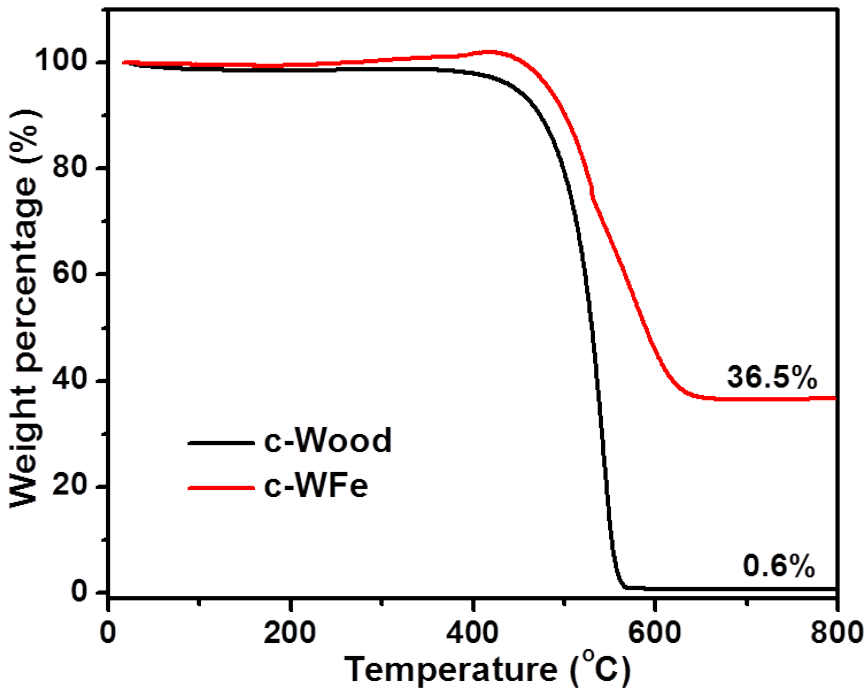

Fig. S4. TGA curves of c-Wood and c-WFe.

To quantify the weigh percentage of nanoparticles in c-WFe, TGA is performed on both c-Wood and c-WFe up to 800 °C in air, Fig. S4. The c-Wood shows fast weight loss starting from 400 °C and completely burned out at 570 °C. The 0.6 wt% residue is probably from the non-degradable inorganics. c-WFe shows a 2.5 wt% weigh increase at 420 °C due to the oxidation of Fe→Fe_2O_3 and then loses weight slowly until the temperature reaches ~670 °C. Operated in the air condition, iron acts as oxygen trap and thus reduces the oxidation effect of oxygen on the carbon matrix, which well explains the slower weight loss of c-WFe. The final residue of Fe_2O_3 is 35.9 wt% after subtracting the 0.6 wt% residue, which corresponds to a 25.1 wt% of iron elements.

S5. UV-Vis Spectra of Standard Curve

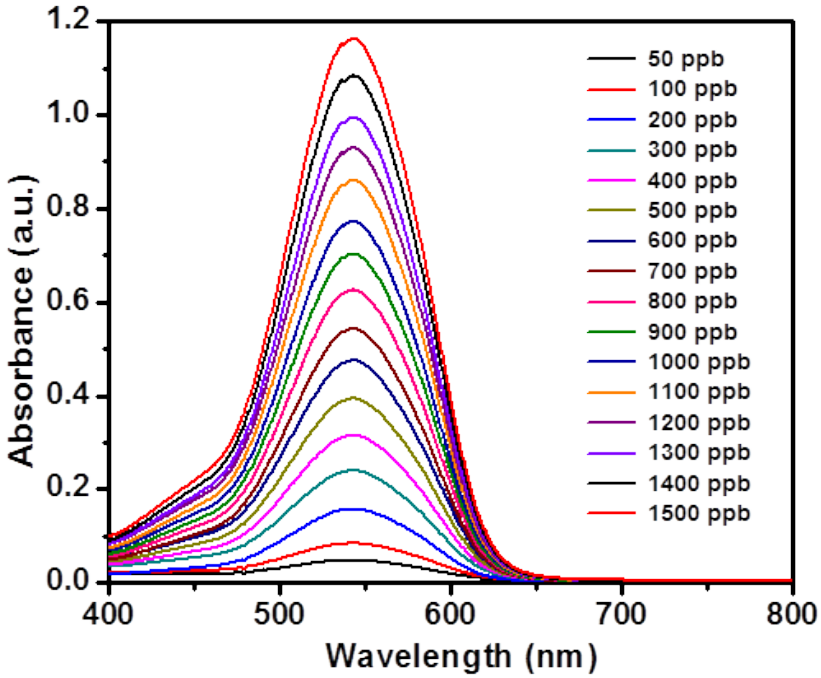

Fig. S5. UV-Vis spectra with increasing Cr(VI) concentration from 50 to 1500 ppb.

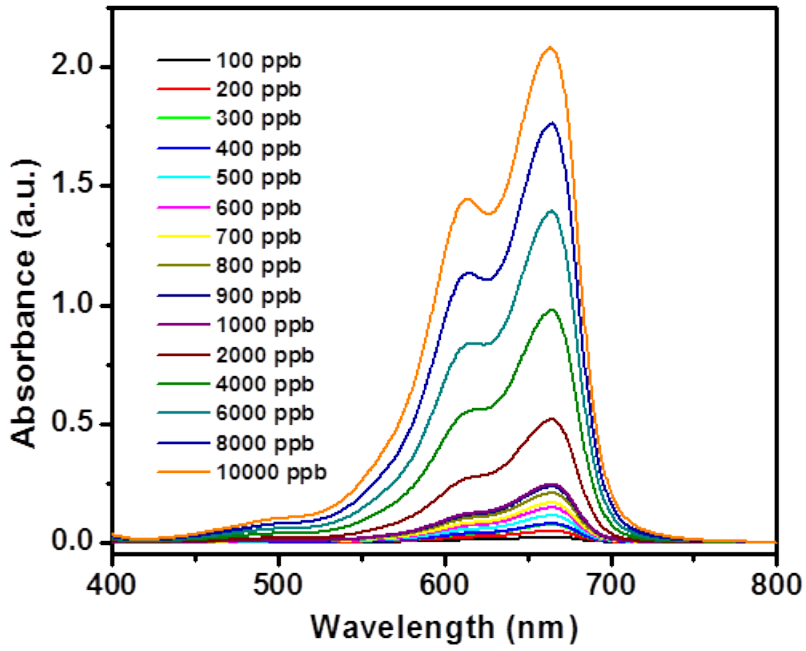

Fig. S6. UV-Vis spectra with increasing MB concentration from 100 to 10000 ppb.

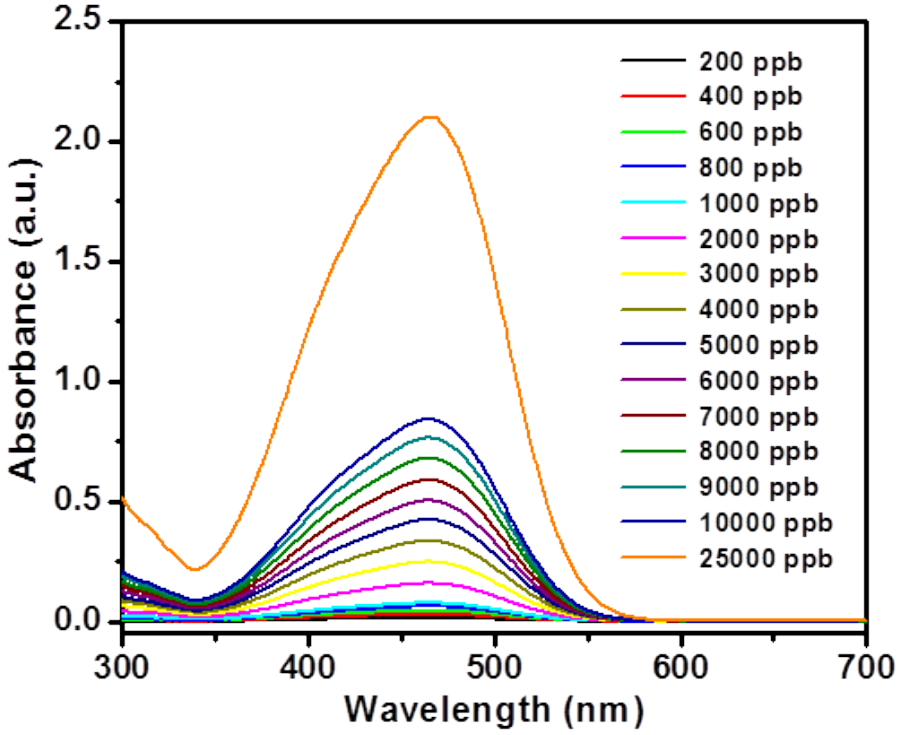

Fig. S7. UV-Vis spectra with increasing MO concentration from 200 to 25000 ppb.

S6. c-WFe Loading and Pollutants Concentration Effect

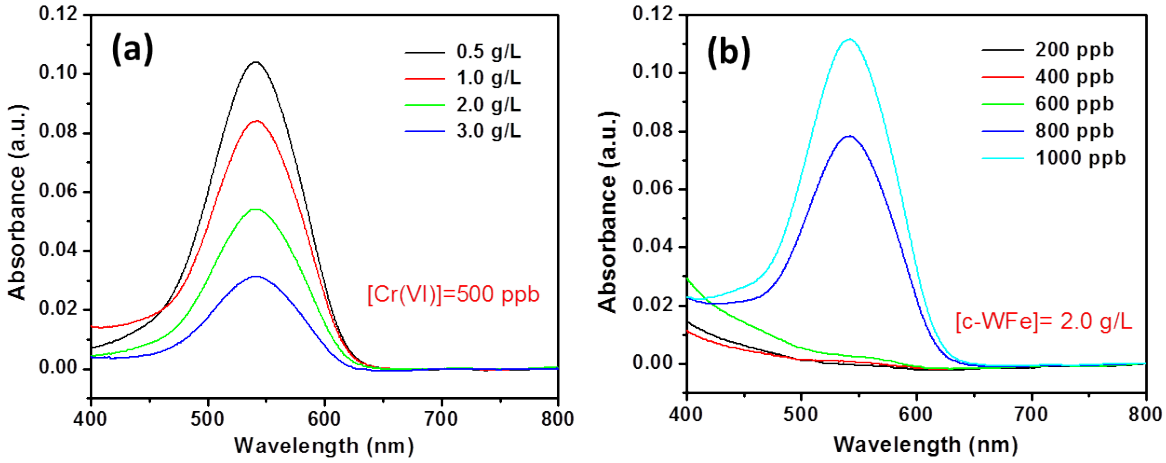

Fig. S8. (a) c-WFe loading and (b) Cr(VI) concentration effect on Cr(VI) removal property.

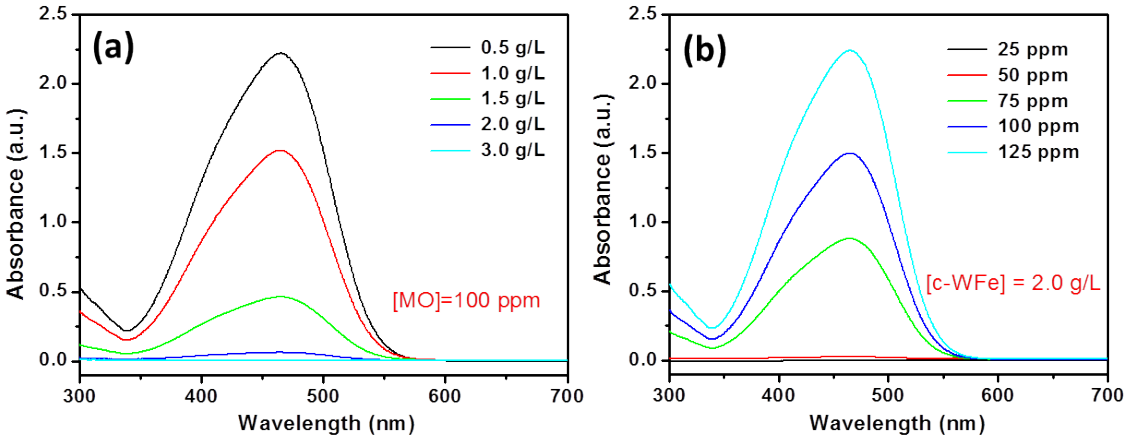

Fig. S9. (a) c-WFe loading and (b) MO concentration effect on MO removal property.

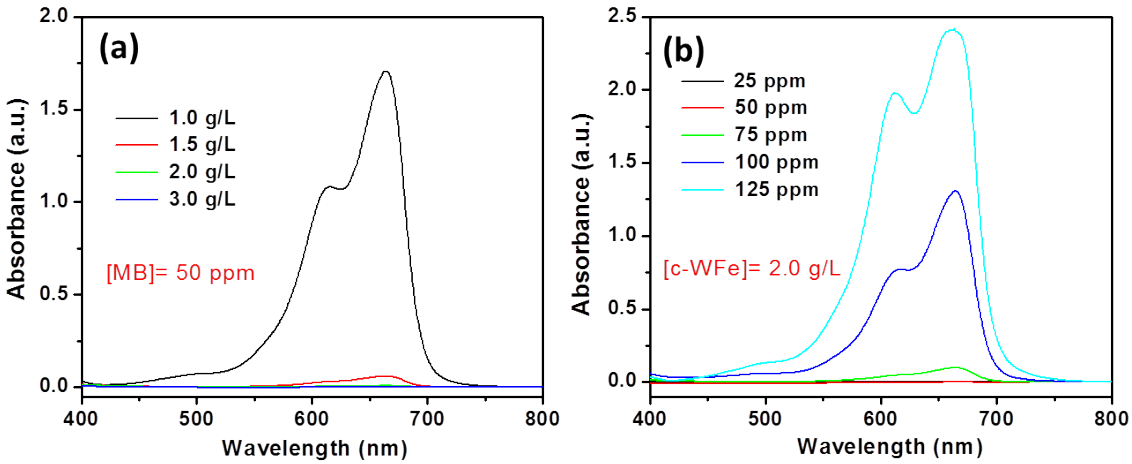

Fig. S10. (a) c-WFe loading and (b) MB concentration effect on MB removal property.

S7. Isothermal Adsorption

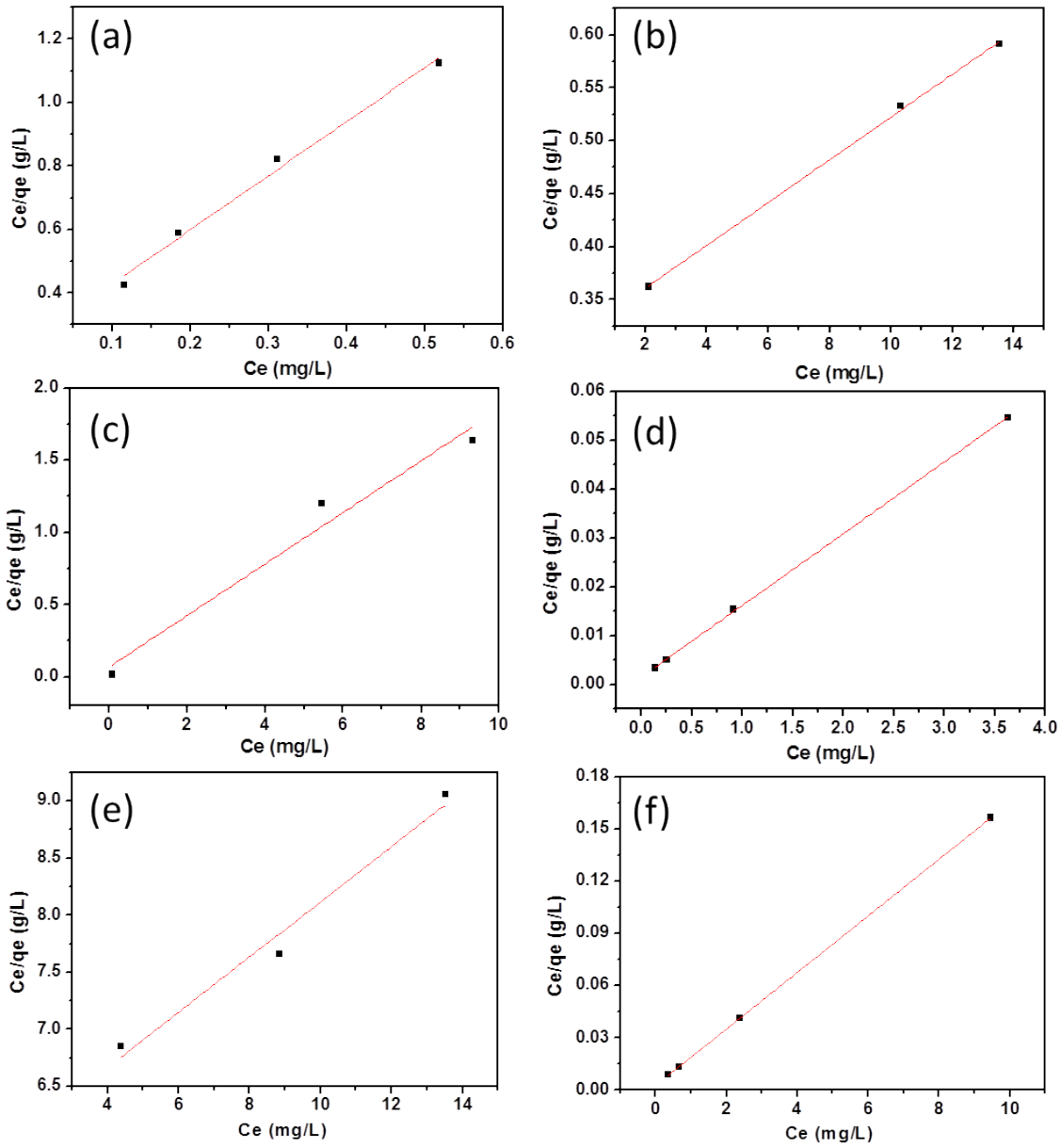

Fig. S11. adsorption isotherm of (a) c-Wood in removing MB (b) c-Wood in removing MO (c) c-WFe removing MB (d) c-WFe in removing MO (e) activated charcoal in removing MB (f) activated charcoal in removing MO.

S8. Kinetic Study at Different Temperatures

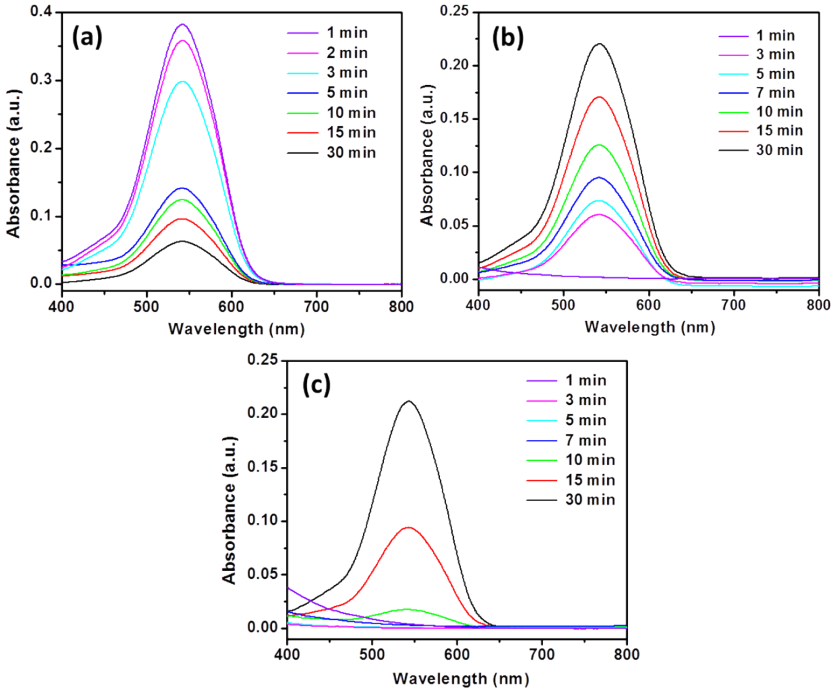

Fig. S12. Kinetic adsorption of Cr(VI) with c-WFe at (a) 20 °C, (b) 40 °C, and (c) 60 °C. [c-WFe]= 2.0 g/L.

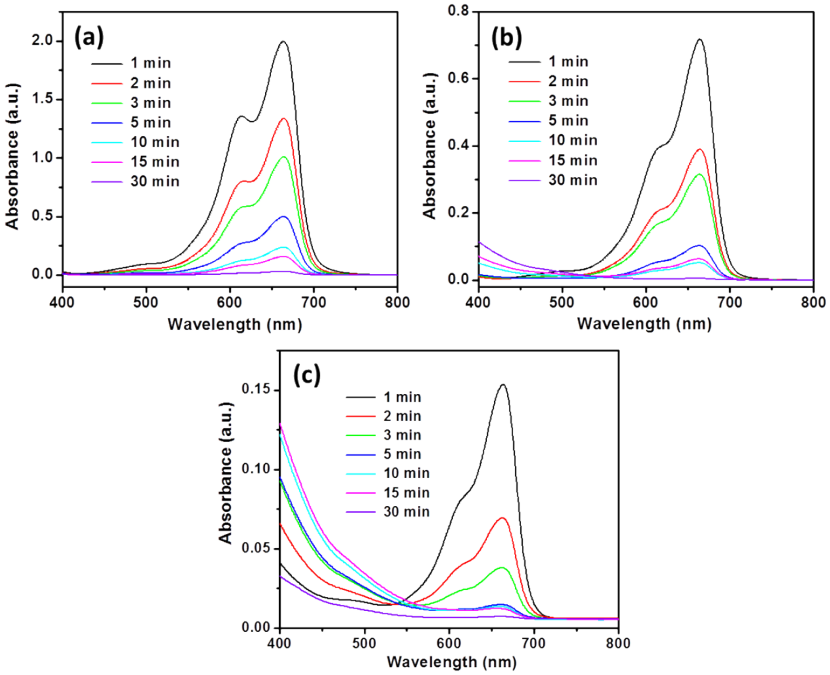

Fig. S13. Kinetic adsorption of MB with c-WFe at (a) 20 °C, (b) 40 °C, and (c) 60 °C. [c-WFe]= 2.0 g/L.

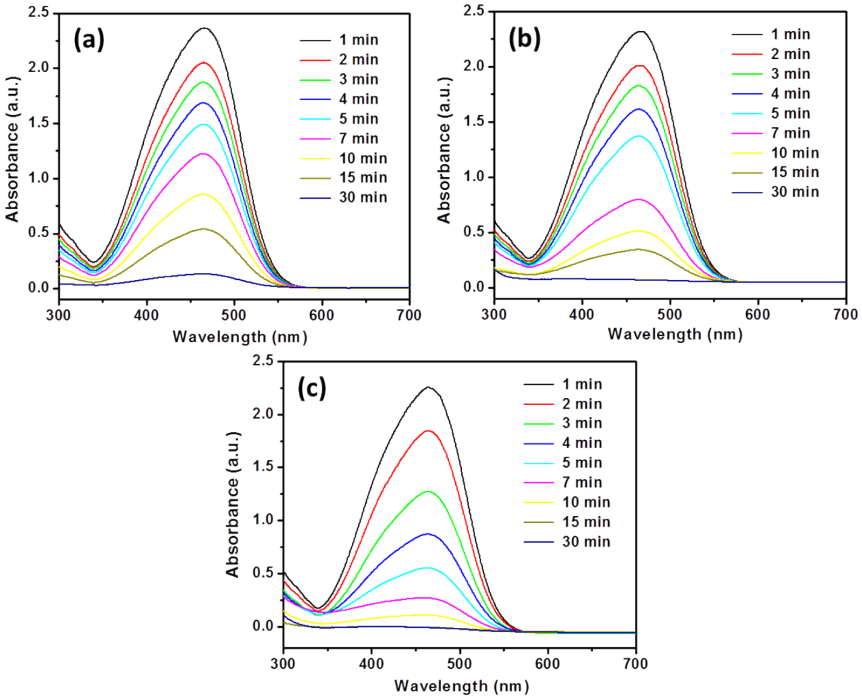

Fig. S14. Kinetic adsorption of MO with c-WFe at (a) 20 °C, (b) 40 °C, and (c) 60 °C. [c-WFe]= 2.0 g/L.

S9. Correlation Factor with Different Kinetic Models

Table S1 The formula and parameters of different kinetic models.

Models	Equation	Parameters	
Pseudo-first-order	$\log(Q_e - Q_t) = \log Q_e - \frac{k_1}{2.303}t$	k_1 (min^{-1})	rate constant
		Q_e (mg g^{-1})	adsorption capacity at equilibrium
Pseudo-second-order	$\frac{t}{q_t} = \frac{1}{k_{ad}q_e^2} + \frac{t}{q_e}$	k_{ad} (g mg^{-1} min^{-1})	rate constant
		Q_e (mg g^{-1})	adsorption capacity at equilibrium
		h (mg g^{-1} min^{-1})	the initial adsorption rate at t approaching zero
Elovich	$Q_t = \frac{1}{\beta}\ln(\alpha\beta) + \frac{1}{\beta}\ln(t)$	α (mg g^{-1} min^{-1})	initial adsorption rate
		β (g mg^{-1})	desorption constant
		Q_t (mg g^{-1})	solid-phase loading of adsorbate in the adsorbent at time t
Intraparticle diffusion	$Q_t = k_{dif}t^{0.5} + C$	k_{dif} (mg g^{-1} min$^{-0.5}$)	rate constant
		C (mg g^{-1})	the thickness of the boundary layer

S10. Desorption of Dye from c-WFe

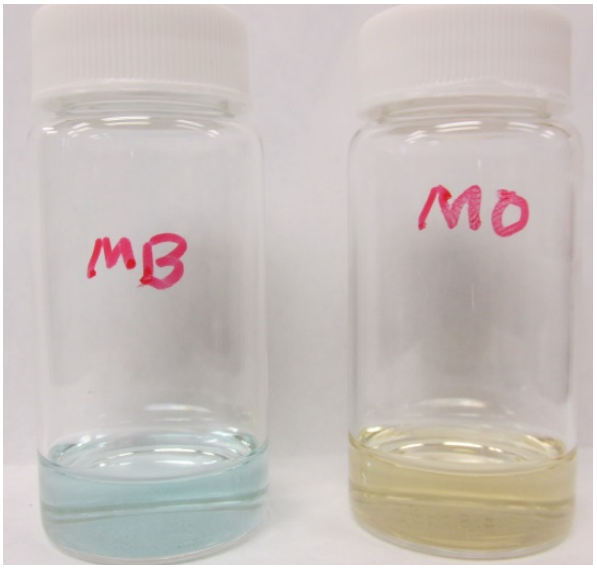

Fig. S15. The MB and MO adsorbed on c-WFe can be easily washed out by ethanol. Light blue color indicates the MB dissolved in ethanol (left, 3.8 ppm) and light orange color indicates the MO dissolved in ethanol (right, 2.9 ppm).

S11. Magnetic Property of c-WFe

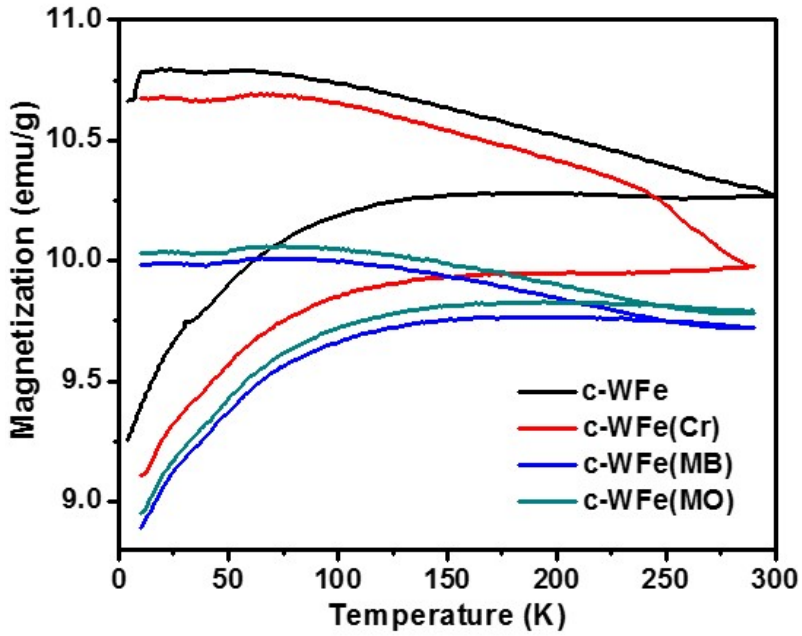

Fig. S16. FC-ZFC curves of c-WFe before and after pollutants adsorption.