Magnetic Fe_3O_4@SiO_2 study on adsorption of MO on nanoparticles

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Research Status

Status of organic dye wastewater treatment in water

Many treatment methods and treatment processes have been used for the treatment of various types of pollutants in water, and the main methods include chemical precipitation, membrane separation, oxidation reduction, adsorption, and so on.

Chemical precipitation

The safety of post-flocculation by-product sludge cannot be properly addressed

Membrane treatment

Intercepts pollutants, but faces membrane contamination challenges

Oxidation-reduction method

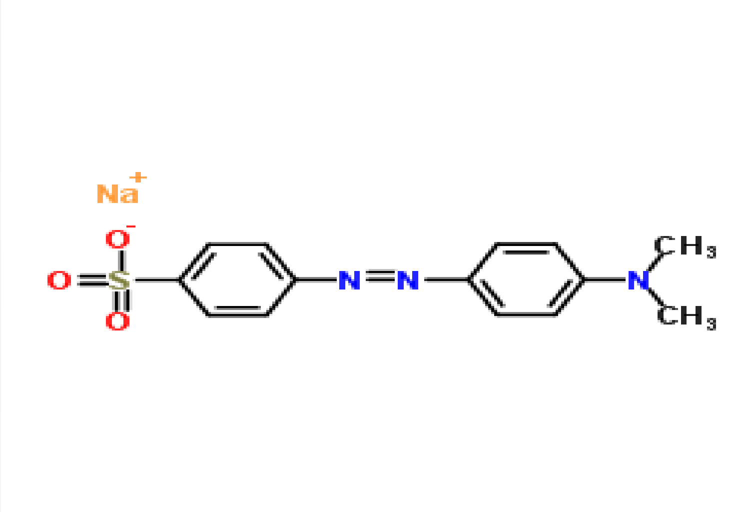
Higher operating costs and complex installations with limited treatment capacity

Adsorption

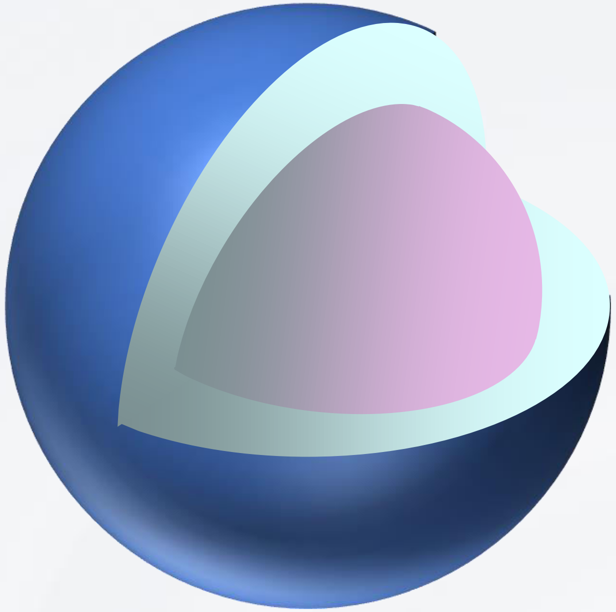
For an efficient, practical, convenient and economical water pollution treatment method

Research contents

Target contaminant MO and adsorbent $Fe_3O_4@SiO_2$



MO solution is one of the typical anionic dyes , and the need for reasonable wastewater treatment processes is particularly important because of the complex structure of MO dyes, which are not easily biodegradable or photodegradable.



The adsorbent has a large surface area and small particle size and easy separation characteristics, can be effectively removed by hydrogen bonding and electrostatic interactions with the MO dye molecules to remove the adsorbent, it is an ideal adsorbent with high efficiency, safety and reusability.

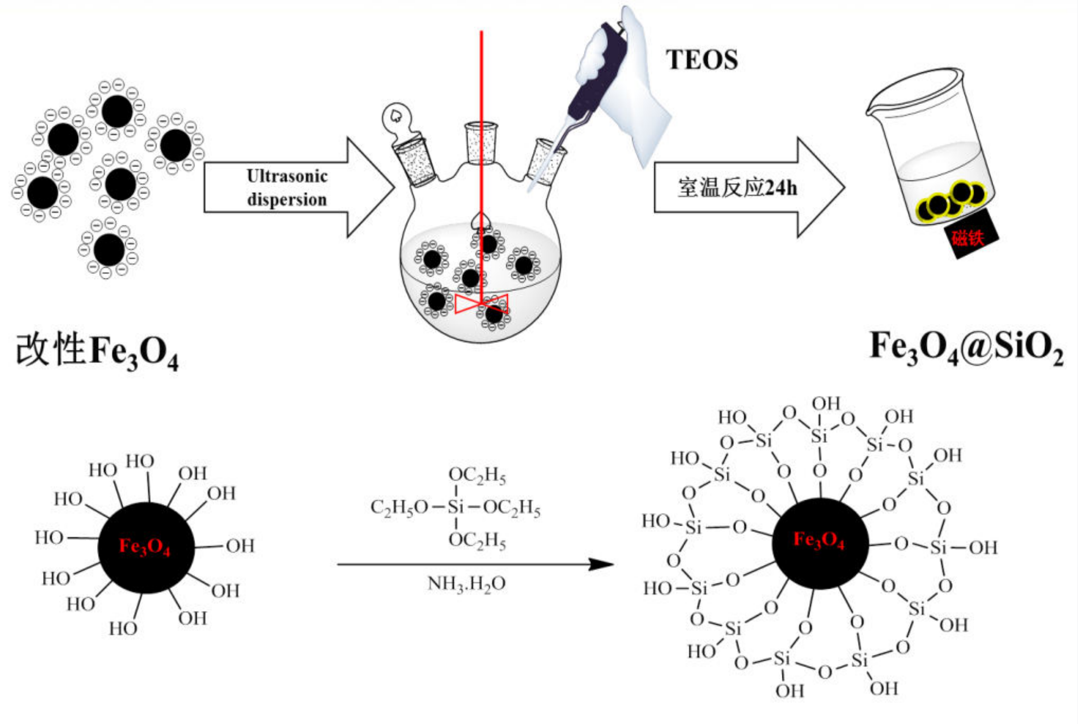
Research contents

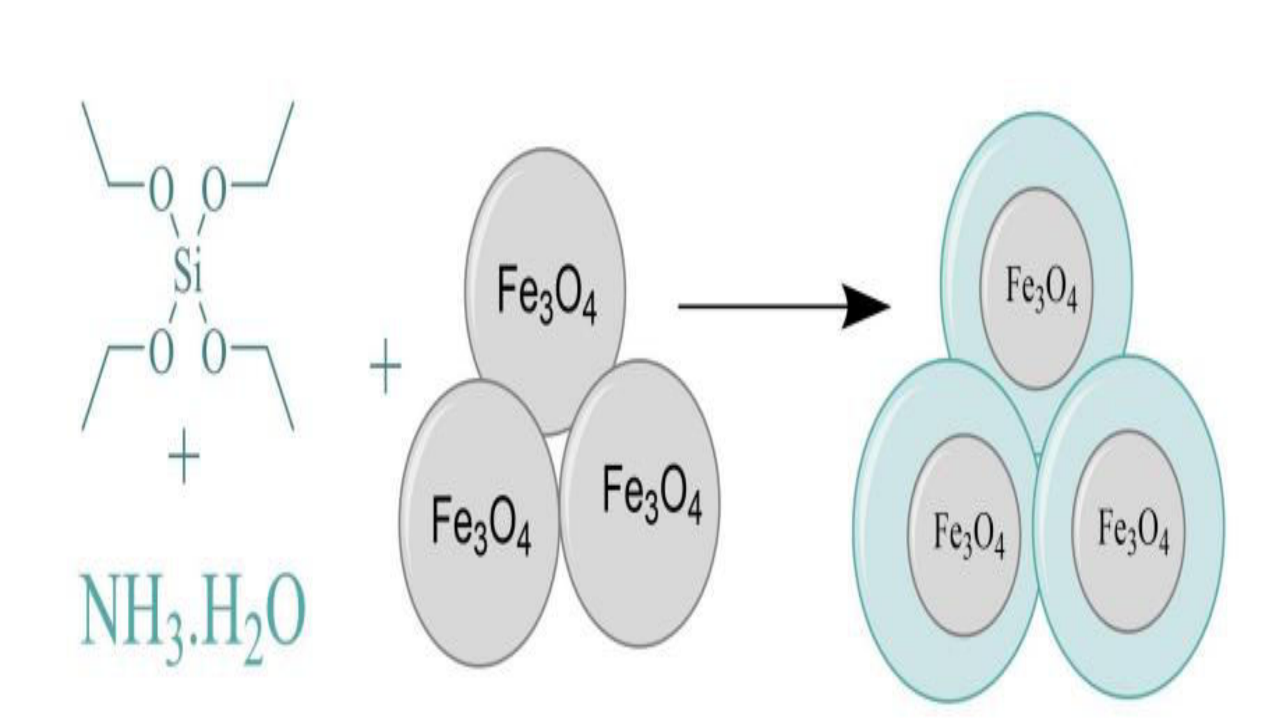
Preparation of adsorbent $Fe_3O_4@SiO_2$

1 Synthesis of Fe_3O_4 nanoparticles by chemical precipitation method， The reaction equation is as follow :

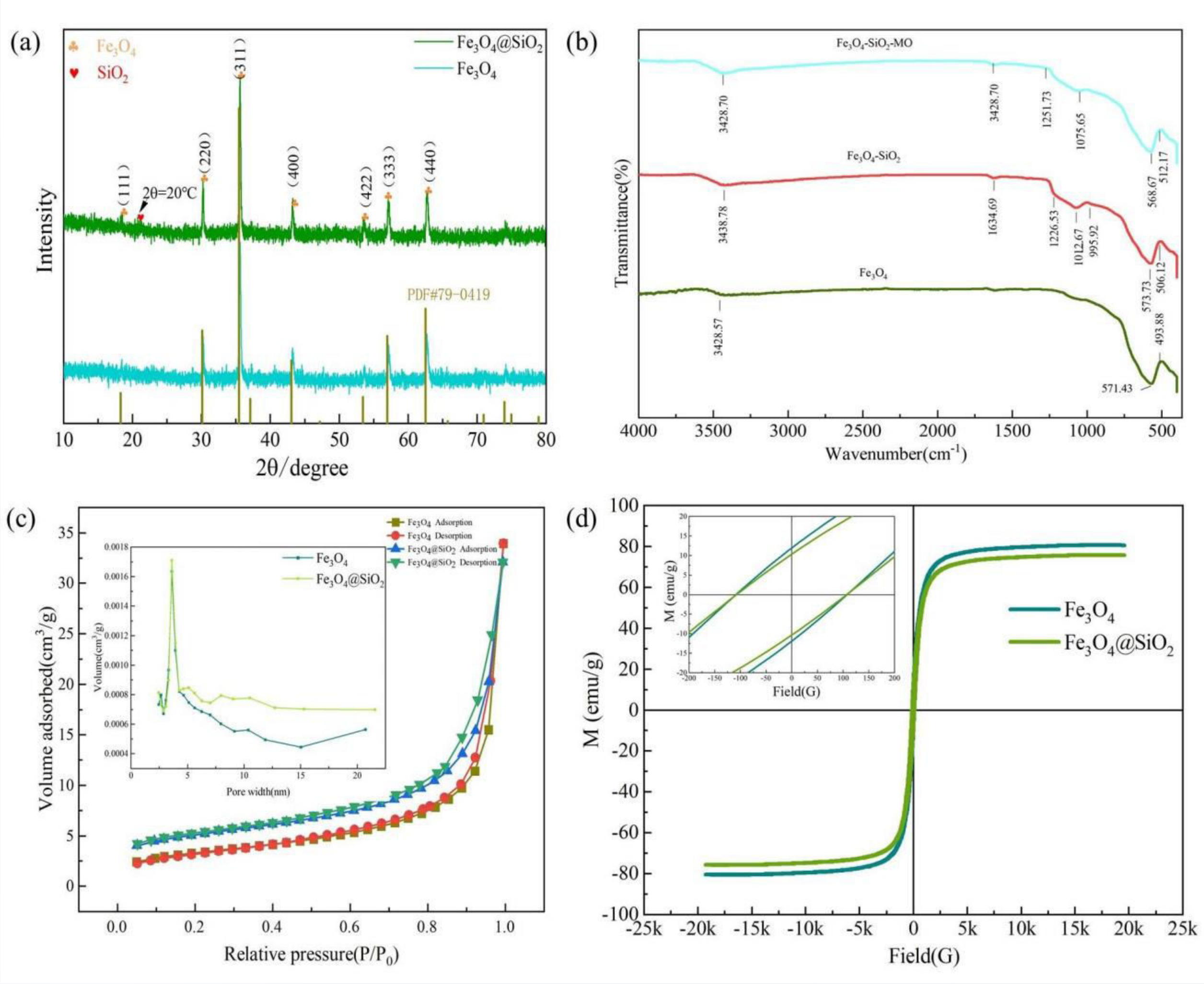
$$Fe^{2+}+2Fe^{3+}+8OH^{-}=Fe_3O_4+4H_2O$$

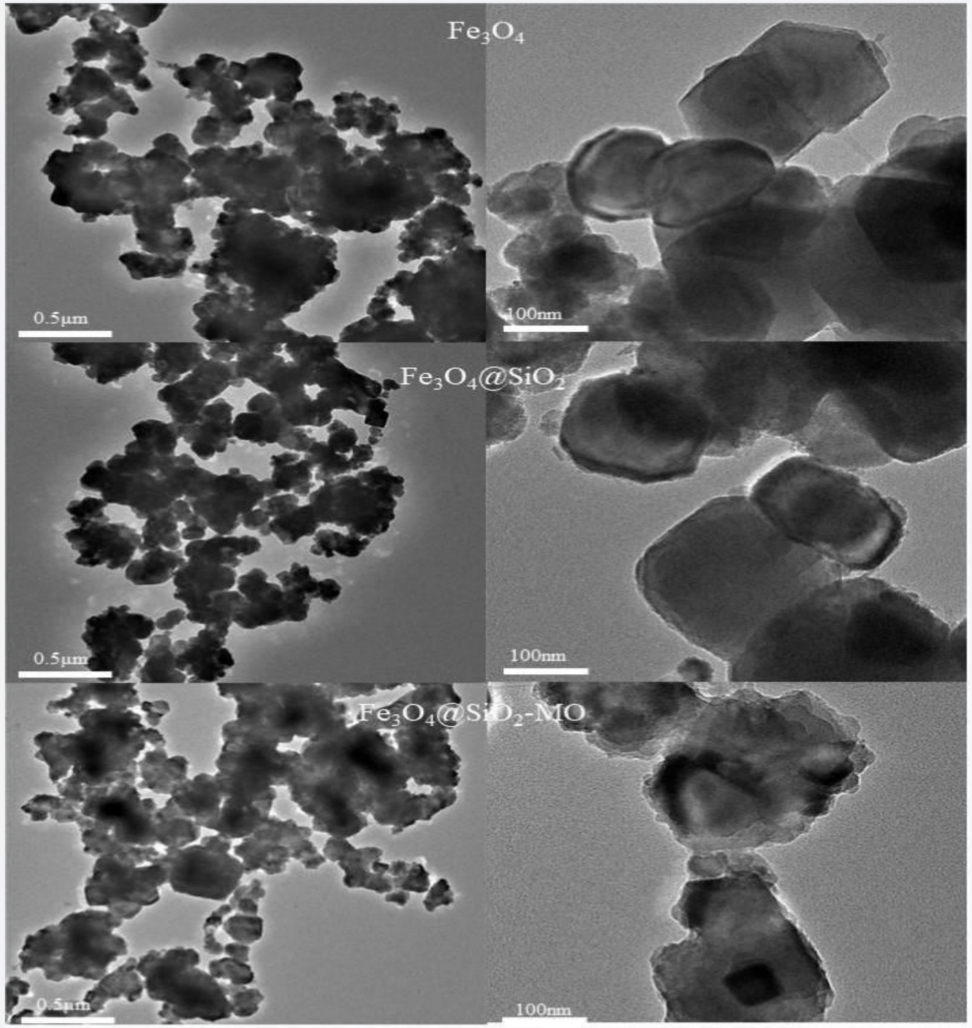
2 In this experiment, the $Fe_3O_4@SiO_2$ material was prepared by Sol-Gel method





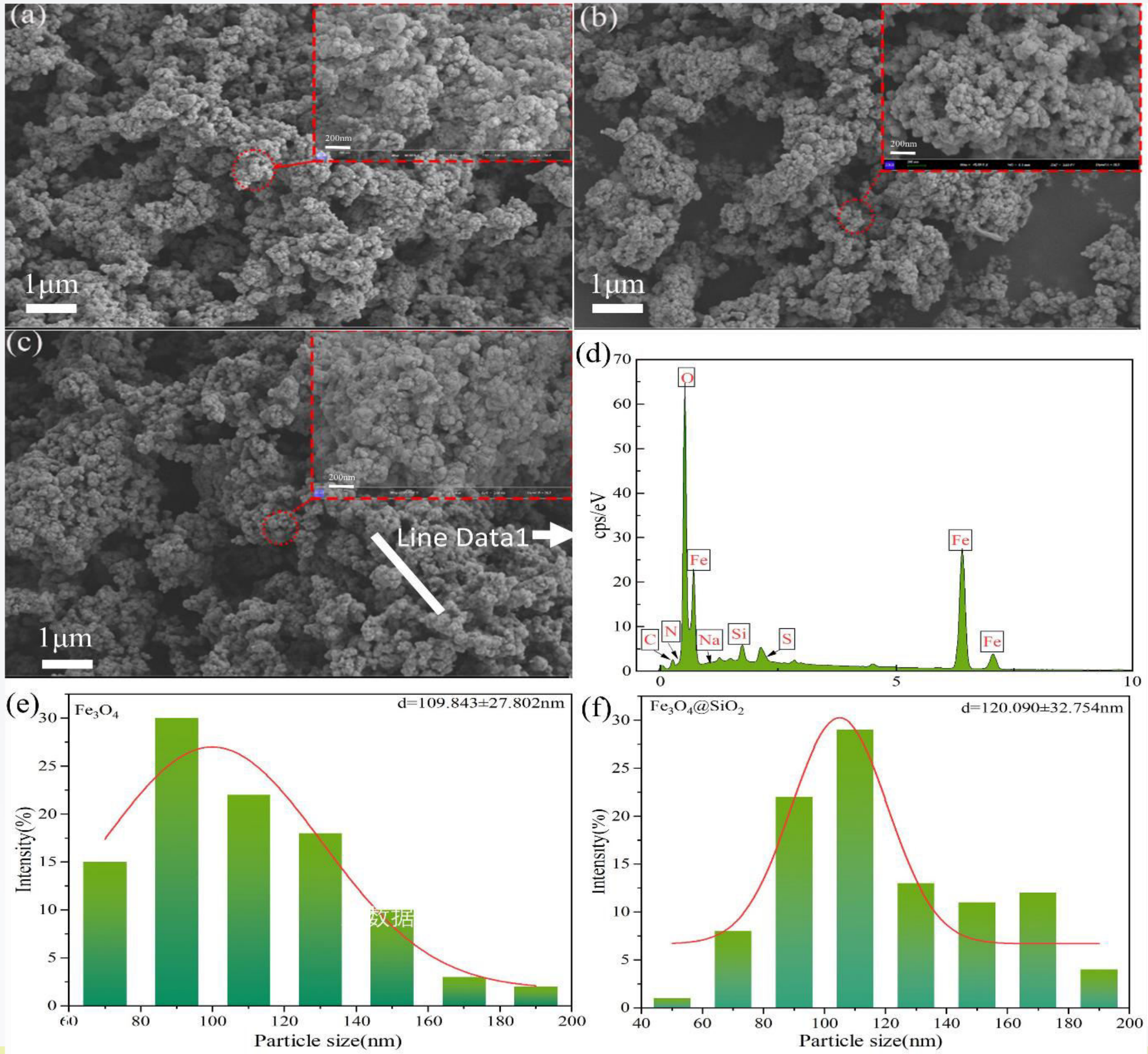
1 Characterization

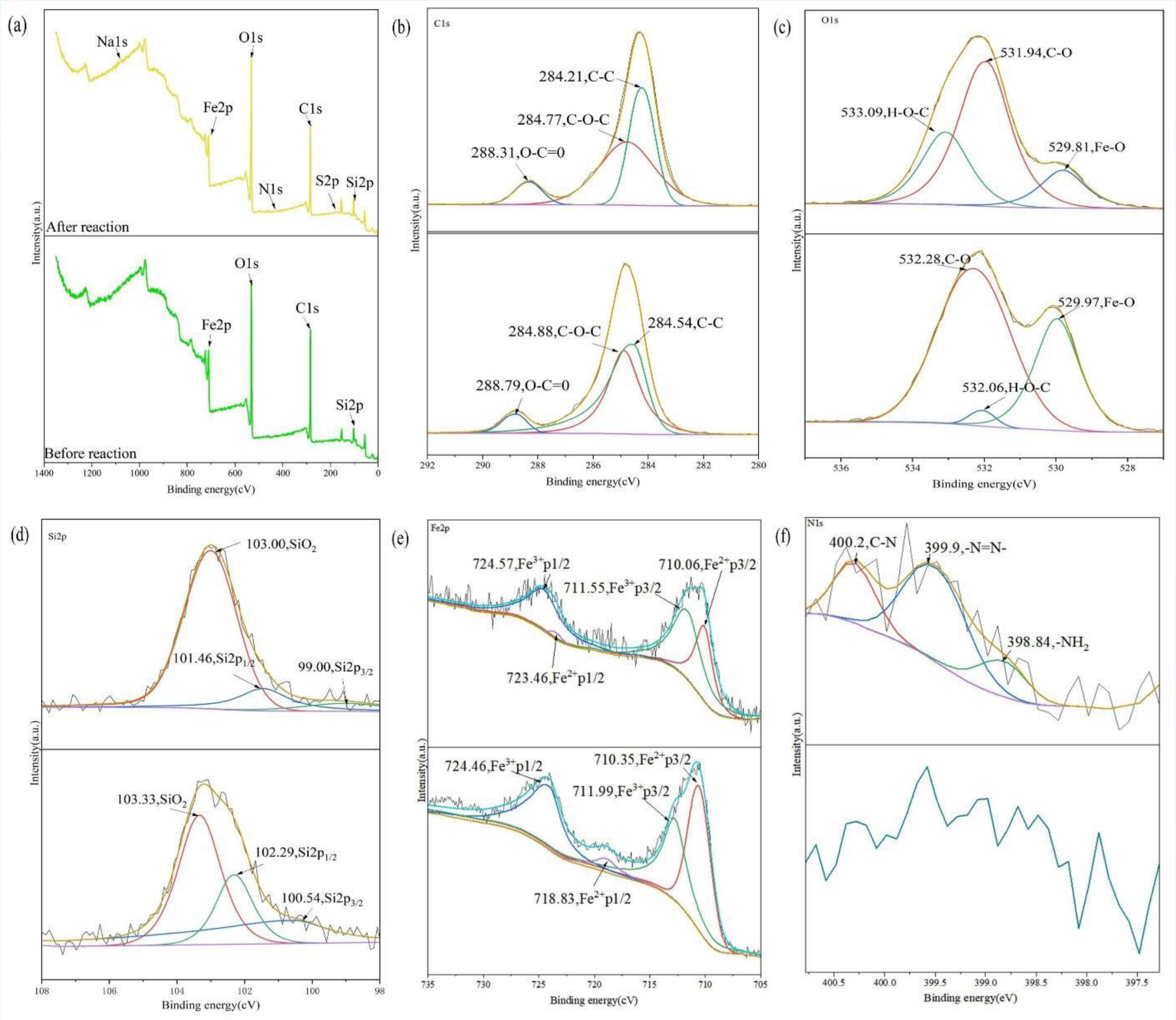




Results and discussion

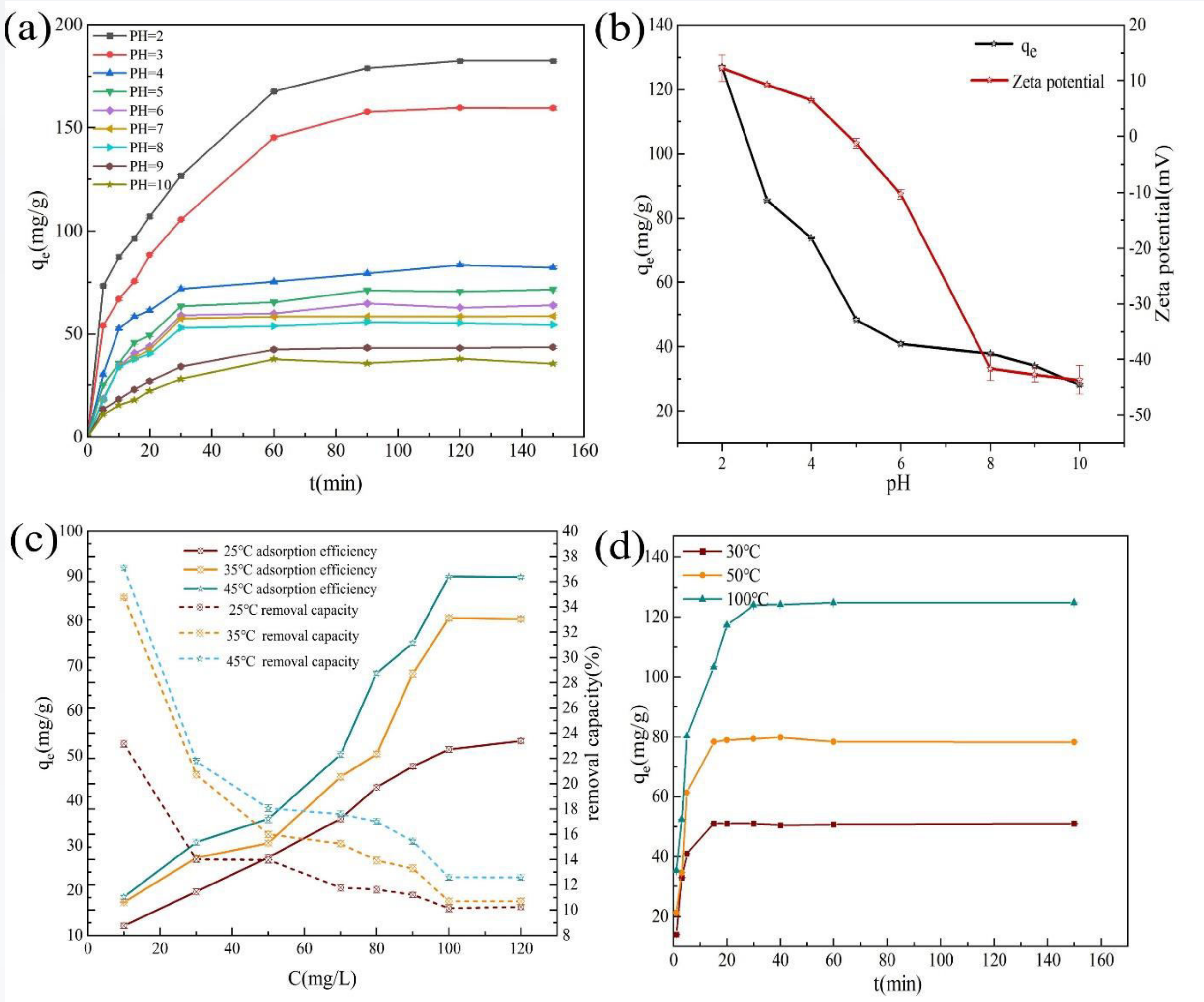
1 Characterization

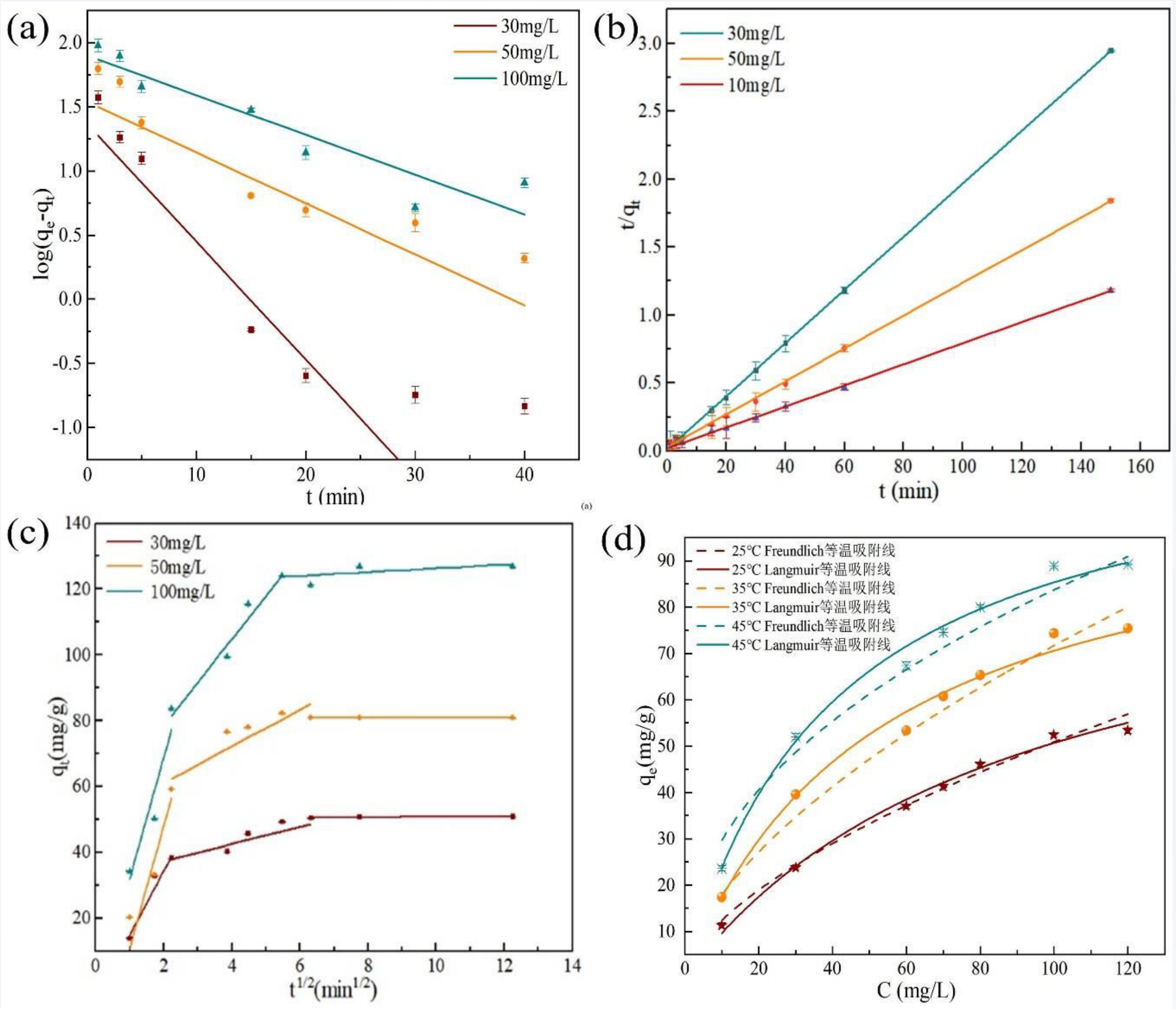




Results and discussion

2 Adsorption experiment results





Results and discussion

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2 Adsorption experiment results

Kinetic model fitting parameters for the adsorption of MO by $Fe_3O_4@SiO_2$ nanomaterials

C_0(mg/L)	pseudo-first-order			pseudo-second-order		
	K_1 (mg/(g/h))	q_e (mg/g)	R_1^2	K_2 (mg/(g/h))	q_e (mg/g)	R_2^2
30	0.714	76.207	0.86443	0.0994	51.18	0.99996
50	0.219	77.983	0.8632	0.0654	82.85	0.99982
100	0.184	114.024	0.84846	0.0396	129.19	0.99986

Intraparticle diffusion model for MO adsorption by $Fe_3O_4@SiO_2$ nanomaterials

C_0(mg/L)	Intraparticle diffusion model								
	K_{d1} (mg/g.min$^{1/2}$)	C (mg/g)	R^2	K_{d2} (mg/g.min$^{1/2}$)	C (mg/g)	R^2	K_{d3} (mg/g.min$^{1/2}$)	C (mg/g)	R^2
30	19.357	4.424	0.946	2.525	32.449	0.903	0.064	50.144	0.911
50	37.016	26.113	0.843	9.521	30.368	0.809	4.108	80.768	0.963
100	36.752	4.717	0.889	10.017	64.371	0.719	0.652	120.572	0.905

Results and discussion

2 Adsorption experiment results

Adsorption isotherm parameters

T(℃)	Langmuir			Freundlich		
	q_m (mg/g)	b (L/mg)	R^2	K_F	n	R^2
25℃	96.484	0.011	0.989	2.992	2.615	0.985
35℃	107.467	0.0191	0.997	4.445	2.604	0.990
45℃	119.873	0.0246	0.994	10.483	2.451	0.974

Thermodynamic parameters of MO adsorption by $Fe_3O_4@SiO_2$ nanomaterials

T(K)	Kc (ml/g)	△G^0 (KJ/mol)	△H^0 (KJ/mol)	△S^0 (J/(mol.K))
298	1.006	-0.01482	1.2417	4.2065
308	1.0187	-0.04744		
318	1.0383	-0.09937		

Results and discussion

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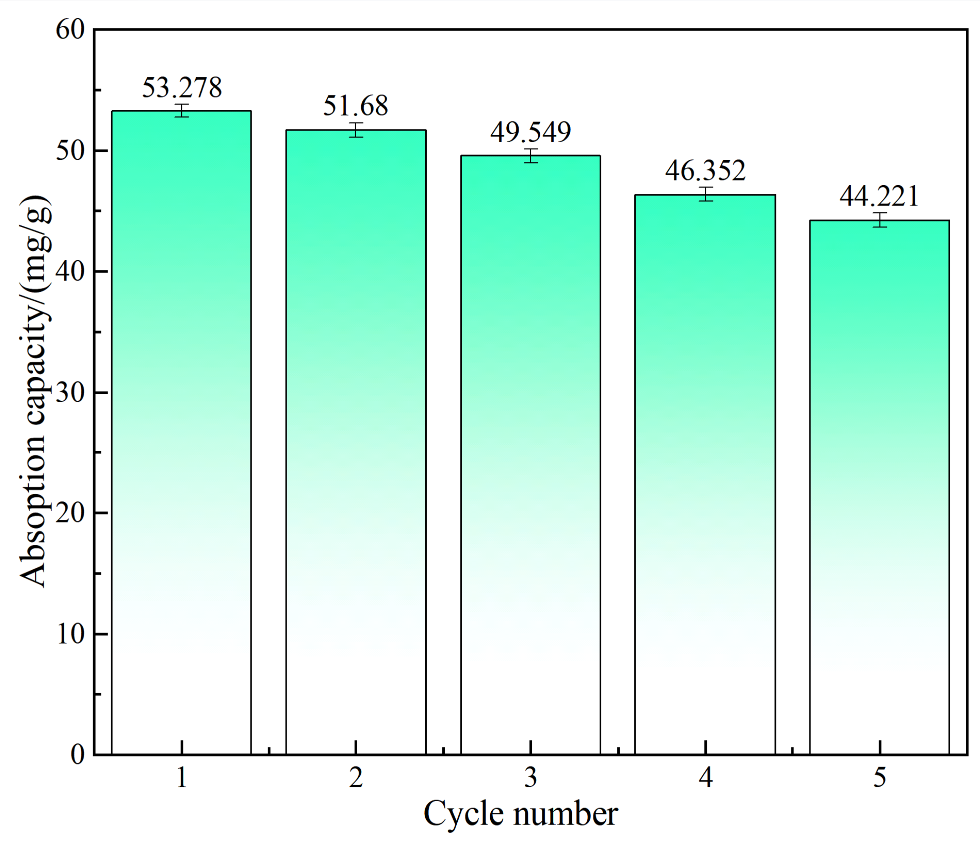
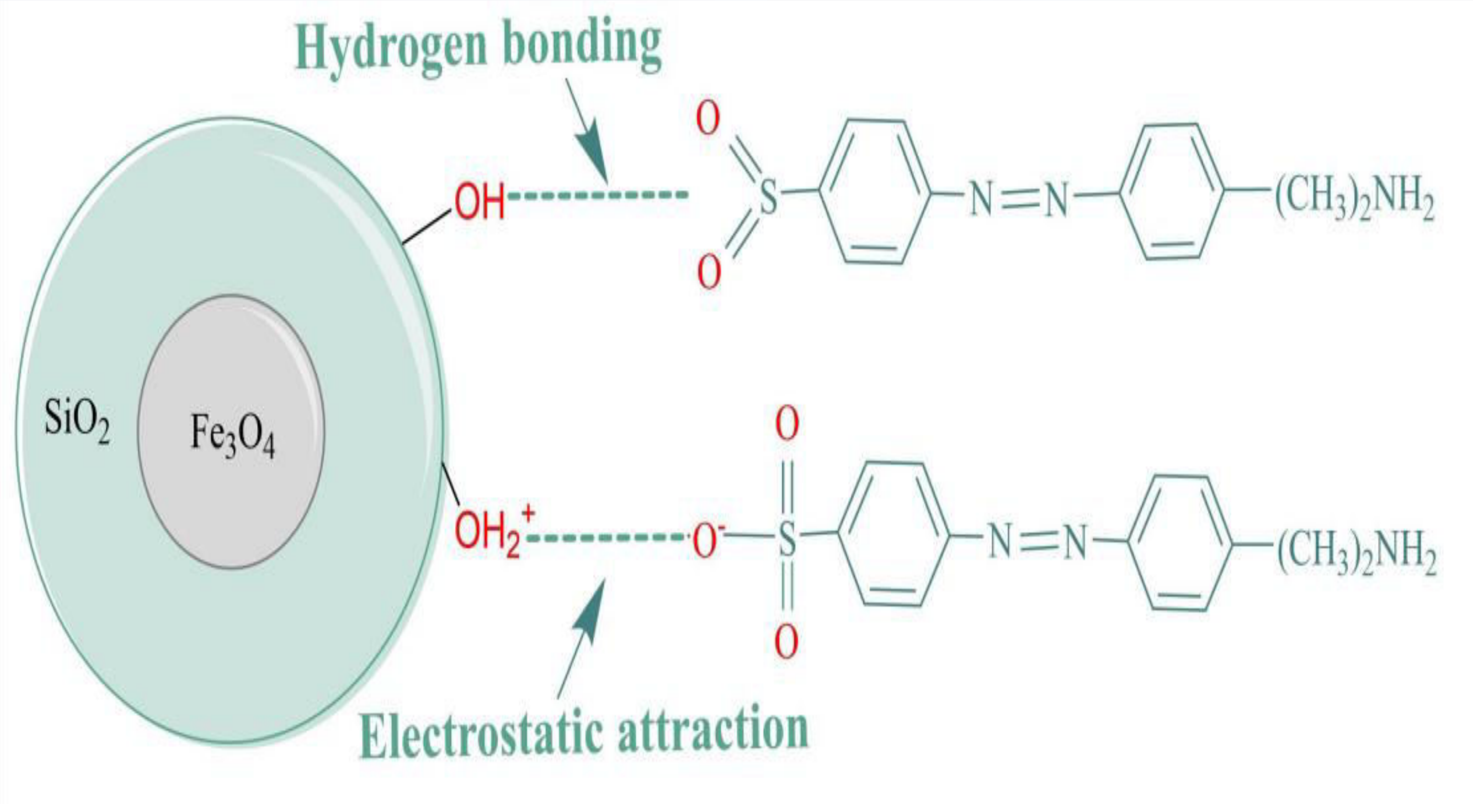
2 Adsorption experiment results



3 Exploration of adsorption mechanism



Findings

In this thesis, $Fe_3O_4@SiO_2$ core-shell nanomaterials with good adsorption properties were obtained by using Sol-Gel to encapsulate mesoporous SiO_2 on magnetic Fe_3O_4, and the increase in adsorption efficiency was attributed to the increased surface area of $Fe_3O_4@SiO_2$. Results show that the highest unit $Fe_3O_4@SiO_2$ to MO adsorption capacity can reach 182.503 mg/g, far more than unmodified Fe_3O_4 before 15.5 mg/g. The adsorption kinetics of the adsorbent is fitted with quasi-secondary kinetics, and the intraparticle diffusion kinetics indicates that the adsorption process is determined by multiple rate-controlling steps. thermodynamic studies show that the adsorption of $Fe_3O_4@SiO_2$ on MO is heat-absorbing and spontaneous, and MO can interact with the adsorbent through electrostatic interactions and hydrogen bonding. In addition, $Fe_3O_4@SiO_2$ has good regeneration ability, and the unit adsorption capacity can still reach 83% of the initial unit adsorption capacity after 5 times of reuse. Therefore, $Fe_3O_4@SiO_2$ nanomaterials have good adsorption performance, and are safe, efficient and reusable, which is an ideal adsorbent for treating MO dye wastewater.