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Simple construction of core-shell MnO_2@TiO_2 with highly enhanced U(VI) adsorption performance and evaluated adsorption mechanism

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Synthesis of MnO_2

Synthesis of MnO_2: Typically, 1 mmol of $KMnO_4$ and 1 mmol of NH_4Cl were separately dispersed into Milli-Q water (30ml) under magnetic stirring for 10 min to form two clear solutions. Then, the NH_4Cl solution was transferred to the $KMnO_4$ solution. After stirring for another 10 min, the obtained homogeneous solution was poured into a Teflon-lined autoclave (100 mL in capacity) and kept in an oven at 200 °C for 24 h. After cooling down to room temperature naturally, the resultant product was collected by centrifugation, and then washed with Milli-Q water and ethanol several times.

Characterization

The SEM images were performed via a Hitachi S4800 microscope, while the TEM images were conducted by applying the Jeol Jem-2100F transmission electron microscope. Elemental mapping analyses were recorded to explored the composition of the achieved samples by energy-dispersive X-ray spectroscope attached to the TEM apparatus. The crystalloid phases of MnO_2 and MnO_2@TiO_2 were analyzed through XRD on a Bruker D8advance X-Ray Diffractometer allocated with Ni filtered Cu Kα radiation (λ = 1.5406 Å) from the range of 10° to 80° at a scanning speed of 0.05° per second. A Nicolet Magana-IR 750 spectrometer (USA) whose meterage wavenumber is in the range of 275 - 4000 cm^{-1} was utilized to gauge FT-IR spectroscopy measurements at ambient temperature. The BET specific surface area tests were measured using the Tristar 3020 instrument at 77 K. The Thermo Fischer ESCALAB 250Xi electron spectrometer equipped with an Al Kα radiation source was employed to obtain XPS spectra. Zeta-potential values of MnO_2@TiO_2 were gauged through a Zetasizer Nano ZS from Malvern.

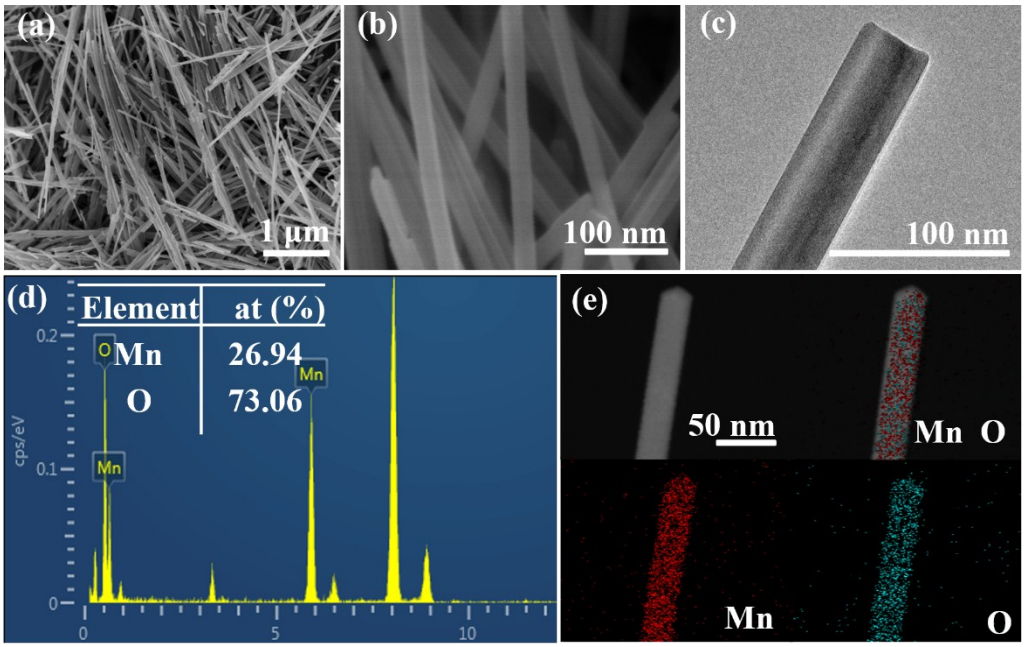

Fig. S1 (a, b) SEM, (c) TEM photographs, (d) EDX spectrum and (e) Elemental mapping of MnO_2.

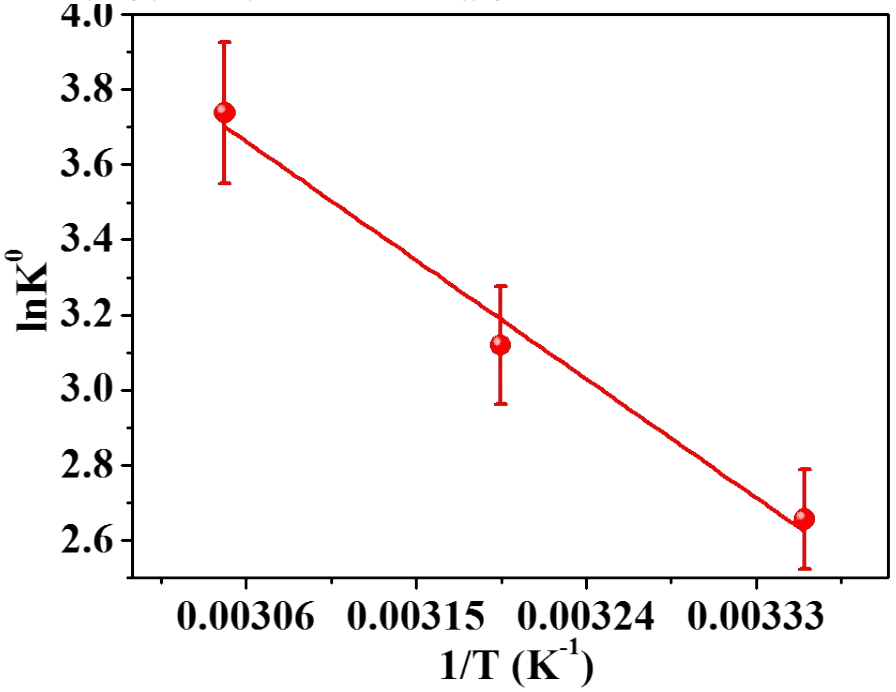

Fig. S2 linear plots of lnK^0 to 1/T for the adsorption of U(VI) onto MnO_2@TiO_2.

Table S1 Comparison of thermodynamic parameters, equilibrium time and maximum adsorption capacities of U(VI) on other adsorbents

Adsorbents	q_m (mg/g)	Equilibrium time (min)	Conditions	Thermodynamic parameters			Refs
				ΔH^0 (KJ/mol)	ΔS^0 (J/ (mol K))	ΔG^0 (KJ/mol)	
Fe_3O_4@SiO_2-AO	105.0	1440	pH 5.5, 298 K	14.85	114.40	-18.43	[1]
TiO_{2-X}	65.4	120	pH 5.0, 298 K	7.79	0.03	-1.32	[2]
Fe_3O_4@MnO_2	14.0	180	pH 5.5, 293 K	10.48	85.56	-14.59	[3]
MnO_2@PPy	63.0	300	pH 5.0, 298 K	26.98	115.15	-7.43	[4]
HMO	68.4	50	pH 5.0, 298 K	10.51	53.62	-5.54	[5]
FA@PEI	70.3	90	pH 5.0, 298 K	11.44	52.91	-4.41	[6]
PANI/H-TNB	216.8	300	pH 5.0, 293 K	30.77	134.75	-11.41	[7]
Fe_3O_4@TiO_2	91.1	175	pH 6.0, 298 K	23.82	87.41	-1.8	[8]
PVA/TiO_2/APTES	29.7	300	pH 4.5, 298 K	3.88	20.6	-2.24	[9]
MnO_2@TiO_2	105.3	20	pH 5.0, 298 K	29.21	119.84	-6.58	This work

Table S2 The XPS data of MnO_2@TiO_2 and MnO_2@TiO_2-U.

Binding Energy (eV)								
Samples	O 1s			Ti 2p			U 4f	
	Ti-O-Ti	Ti-O-H	the surface-adsorbed water molecules	Ti $2p_{3/2}$, Ti^{3+}	Ti $2p_{3/2}$, Ti^{4+}	Ti $2p1_{/2}$	U $4f_{7/2}$	U $4f_{5/2}$
MnO_2@TiO_2	529.7	531.3	533.2	458.05	459.1	463.9	-	-
MnO_2@TiO_2-U	529.92	531.41	533.5	458.2	459.1	463.9	381.74	392.67

Notes and references

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