Supporting Information

Ni-Mn LDH decorated 3D Fe-inserted and N-doped carbon frameworks composites for efficient uranium (VI) removal

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Characterization

Materials Characterization

The morphology of the samples was characterized with scanning electron microscope (SEM, JEOLJSM-6480A microscope) and transmission electron microscopy (TEM) on a FEI Tecnai G2 S-Twin with an accelerating voltage of 200 kV. The texture and surface properties of the samples were measured by nitrogen adsorption isotherms using an AUTOSORB-IQ2-MP analyzer and ESCALAB 250Xi X-ray photoelectron spectrometer. The samples were analyzed by X-ray diffraction (XRD) which was performed on a Rigaku D/max-IIIB diffractometer with Cu Kα irradiation (λ = 1.54178 Å). The X-ray source was operated at 40 kV and the current used in XRD measurements was 150 mA. Fourier-transform infrared (FT-IR) spectra were recorded with an AVATAR 360 FT-IR spectrophotometer (resolution 4 cmÀ1) using standard KBr pellets. The magnetic measurement was carried out with a vibrating sample magnetometer (VSM, Lanzhou University LakeShore 7304).

Adsorption Measurement

The uranium (VI) concentration was analyzed using the inductively coupled plasma atomic emission spectrometer (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS), which were analyzed by IRIS Intrepid Ⅱ XSP and X SeriesⅡ instrument , respectively.

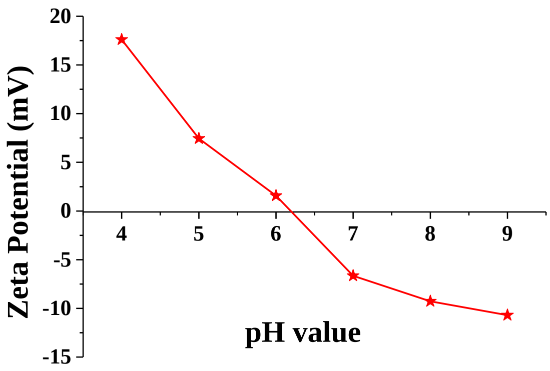

Fig. S1. ζ-Potential of Fe-NCNF-LDH sample at different pH values.

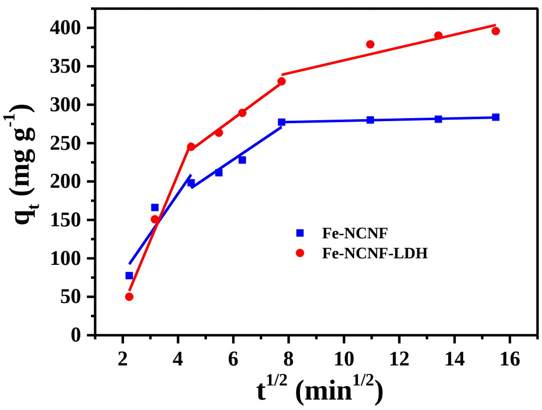

Fig. S2 Intra-particle diffusion kinetics for the adsorption of uranyl ions on Fe-NCNF and Fe-NCNF-LDH.

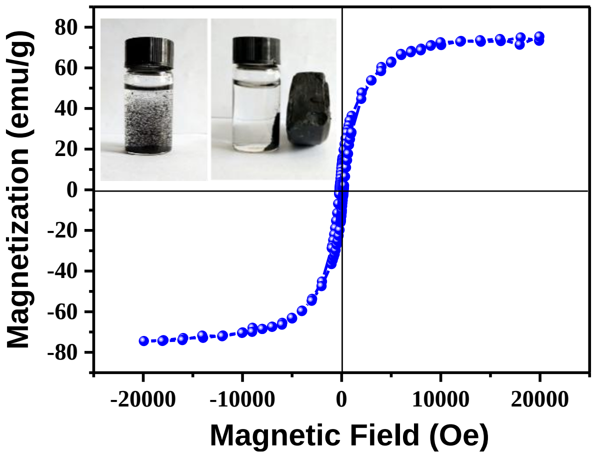

Fig. S3 Magnetic hysteresis curves and magnetic separation picture (inset) of Fe-NCNF-LDH.

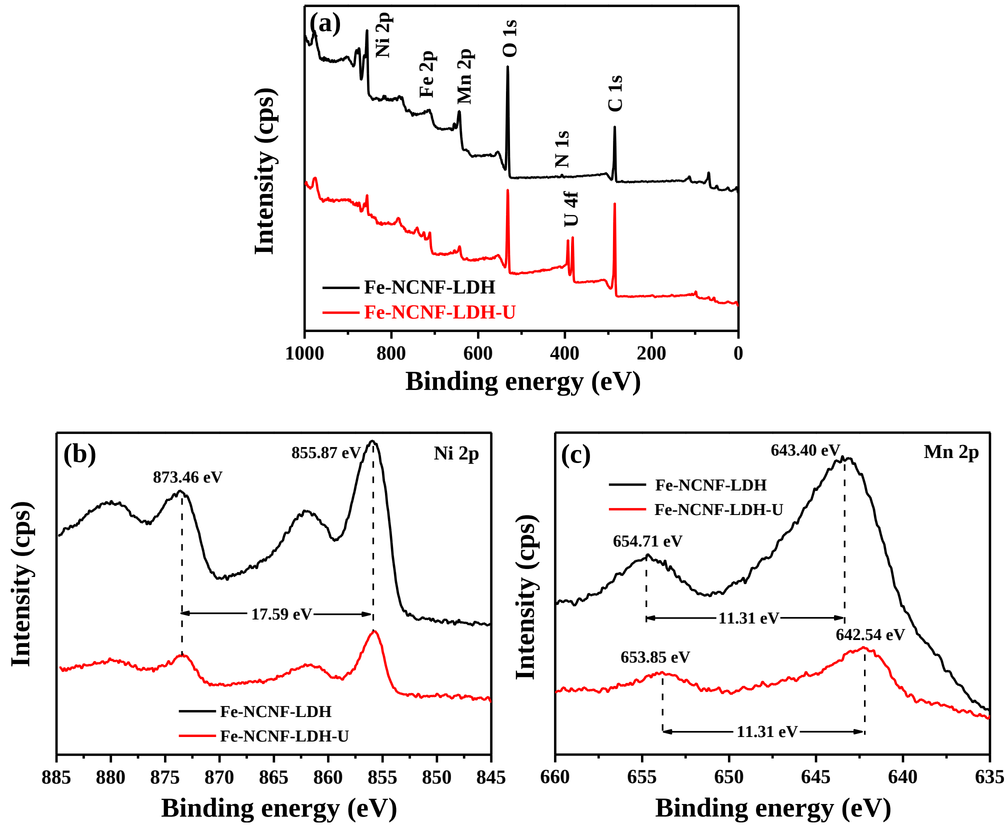

Fig. S4 XPS spectra (a), Ni 2p spectra (b), Mn 2p spectra (c) of Fe-NCNF-LDH and Fe-NCNF-LDH-U.

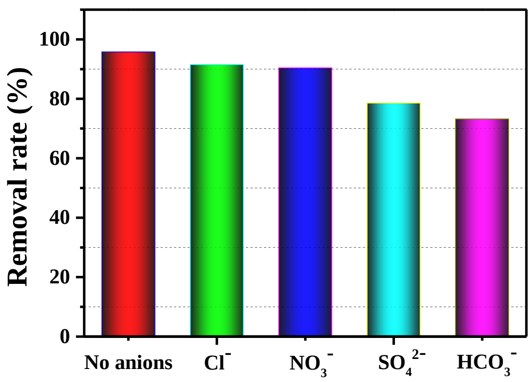

Fig. S5. Effect of coexisting anions on the adsorption of uranium (VI) by the Fe-NCNF-LDH.

Table S1. *Pseudo-first-order and pseudo-second-order constants and values of R^2 for Fe-NCNF-LDH.*

T(K)	*Pseudo-first-order*			*Pseudo-second-order*		
	$k_1 (min^{-1})$	q_e *(mg g^{-1})*	R^2	k_2 *(mg min)*	q_e *(mg g^{-1})*	R^2
Fe-NCNF	*0.066*	*274.1824*	*0.919*	*0.0003*	*301.9573*	*0.956*
Fe-NCNF-LDH	*0.0412*	*382.5334*	*0.969*	*0.0001*	*434.9932*	*0.977*

Table S2 *Parameters of the intra-particle diffusion model of uranium (VI) adsorption on Fe-NCNF and Fe-NCNF-LDH.*

	k_{p1}	R_1^2	k_{p2}	R_2^2	k_{p3}	R_3^2
Fe-NCNF	*52.07*	*0.93*	*24.28*	*0.97*	*0.78*	*0.98*
Fe-NCNF-LDH	*86.21*	*0.99*	*26.54*	*0.99*	*8.36*	*0.94*

Table S3. *Isotherm constants and values of R^2 for Fe-NCNF-LDH.*

T(K)	*Langmuir isotherm*			*Freundich isotherm*		
	q_m（$mg \cdot g^{-1}$）	*b*（$L \cdot mg^{-1}$）	R^2	*K*（$L \cdot g^{-1}$）	n	R^2
298	*598.497*	*0.002*	*0.977*	*77.601*	*0.013*	*0.915*
308	*769.532*	*0.001*	*0.971*	*139.402*	*0.007*	*0.837*
318	*851.607*	*0.001*	*0.931*	*229.083*	*0.004*	*0.652*

Table. S4 *The maximum adsorption capacity of different adsorbents for uranium (VI).*

Adsorbents	*Adsorption Capacity mg-U/g-adsorbent*	*Conditions*	*Ref.*
Fe_3O_4@SiO_2 magnetic composites	*52.36*	*T = 298 K, pH=6.0*	*[1]*
Graphene oxide-manganese dioxide	*185.2*	*T = 298 K, pH = 3.8*	*[2]*
Fe(II)-Al(III) layered double hydroxides	*99.01*	*T = 298 K, pH=6.0*	*[3]*
PAF magnetic sorbent	*115.3*	*T = 298 K, pH =5*	*[4]*
LDH@MMT	*33*	*T = 298.15K, pH=9*	*[5]*
AO-g-MWCNTs	*145*	*T = 298 K, pH = 4.5*	*[6]*
GO	*299*	*RT, pH = 4*	*[7]*
Layered double hydroxide/graphene	*277.80*	*T = 298 K, pH =4*	*[8]*
Fe-NCNF-LDH	*598.50*	*T = 298 K, pH = 7*	*this work*

Table S5. Thermodynamics parameters for uranium (VI) adsorption on Fe-NCNF-LDH**.**

T（K）	ΔG (kJ/mol)	ΔH (kJ/mol)	ΔS (J/(mol·K))
298	-79.66		
308	-82.34	77.76	267.57
318	-85.01		

Table S6 Selected results for the extraction of uranyl ions from simulated seawater

Elements	**Ion concentration (ppb)**		**Removal**
	initial	**final**	**(%)**
U	3.227	0.102	96.84
Fe	118.3	63.9	45.98
Al	14.42	8.333	42.21
Na	$1.667*10^4$	$1.202*10^4$	38.68
V	0.537	0.389	27.56
Ca	$9.903*10^3$	$7.072*10^3$	28.59
Mg	$6.521*10^3$	$5.504*10^3$	15.6
Cu	52.33	50.18	4.11
Ba	90.46	88.3	2.39
Zn	38.95	38.88	0.18

References

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