applied sciences

MDPI

Supporting Information

Facile Preparation of Graphene Oxide-MIL-101(Fe) Composite for Efficient Capture of Uranium

Bing Han *, Enyao Zhang and Gong Cheng

MOE Key Laboratory of Resources and Environmental Systems Optimization, College of Environmental Science and Engineering, North China Electric Power University, Beijing 102206, China; zhangenyao0516@163.com (E.Z.); cg1182229006@ncepu.edu.cn (G.C.)

* Correspondence: hanbing01@ncepu.edu.cn; Tel.: +86-10-6177-1470

Table S1. Composition of groundwater and surface water used to evaluate the adsorption of U(VI) on GO15- MIL-101(Fe).

Parameter *	pH	Ca^{2+}	Mg^{2+}	Cl^{-}	NO_2^{-}	NO_3^{-}	PO_4^{3-}	SO_4^{2-}
Groundwater	8.0	1.95	0.411	1.78	0.011	0.356	<0.021	0.802
Surface water	7.9	0.0275	0.0041	0.0394	0.024	0.0854	0.010	0.035

* The unit of all the involved ions were mmol L^{-1}. The concentration takes reference from the previous study by Van Der Voort et al. (*Eur. J. Inorg. Chem.*, 2016, 27, 4395-4401). The experimental condition was [U(VI)] =10 mg L^{-1}, I = 0.01 M $NaNO_3$, adsorbent dose = 0.2 g L^{-1} and T =298 K.

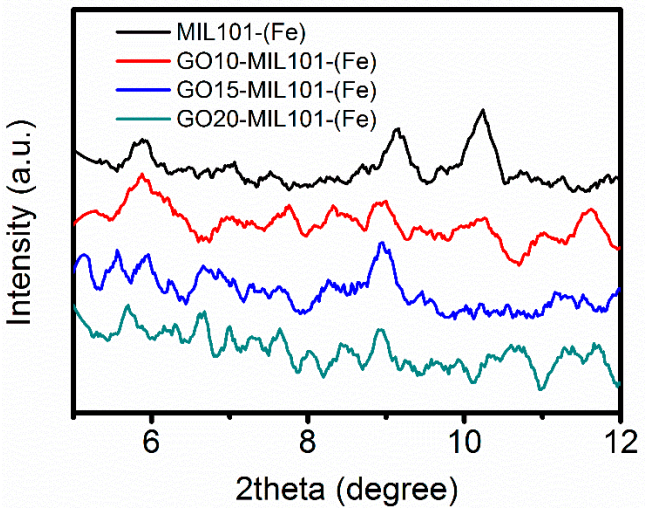

Figure S1. XRD pattern of as prepared MIL-101(Fe) and GO-MIL-101(Fe) composite.

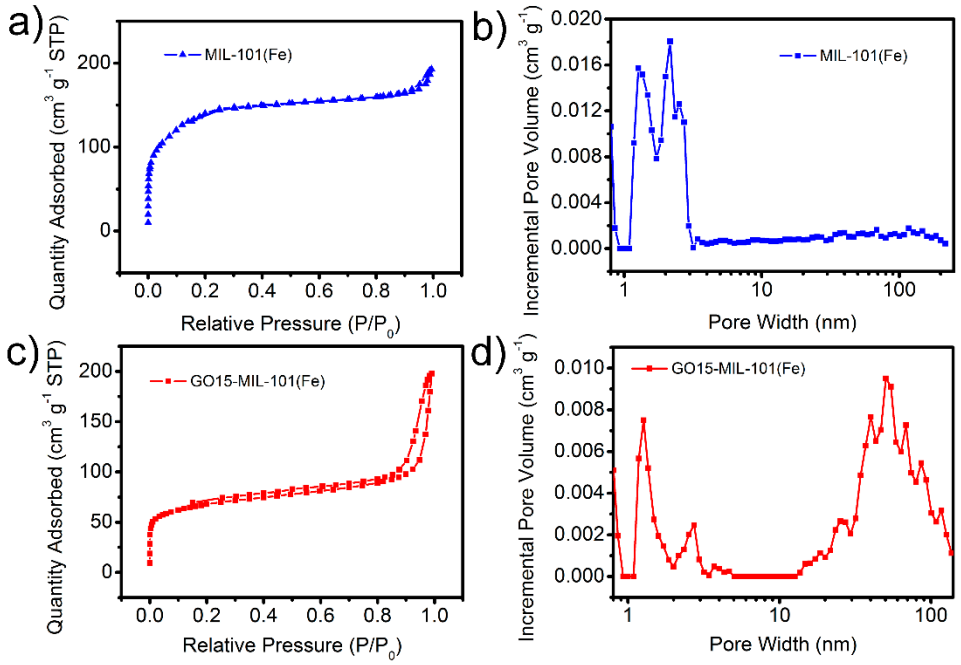

Figure S2. Nitrogen adsorption-desorption isotherm and pore size distribution of (a) and (b). MIL-101(Fe), (c) and (d) GO15-MIL-101(Fe).

Table S2. Summary of surface area and pore volume obtained from N_2 adsorption isotherms.

Sample	S_{BET}[a] ($m^2 \cdot g^{-1}$)	V[b] ($cm^3 \cdot g^{-1}$)	Pore Size (nm)
MIL-101(Fe)	537.98	0.29	2.21
GO15-MIL-101(Fe)	246.56	0.31	4.96

[a] The specific surface area (SBET) was calculated by the Brunauer-Emmett-Teller (BET) method.
[b] Total pore volume.

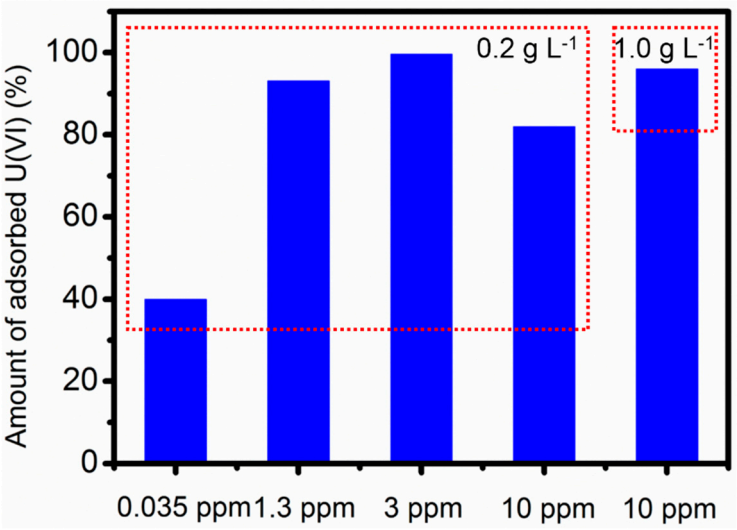

Figure S3. The adsorption efficiency of GO15-MIL-101(Fe) towards U(VI) at different initial U(VI) concentrations (0.035 ppm, 1.3 ppm, 3 ppm and10 ppm). The inset numbers represent the adsorbent dosage.

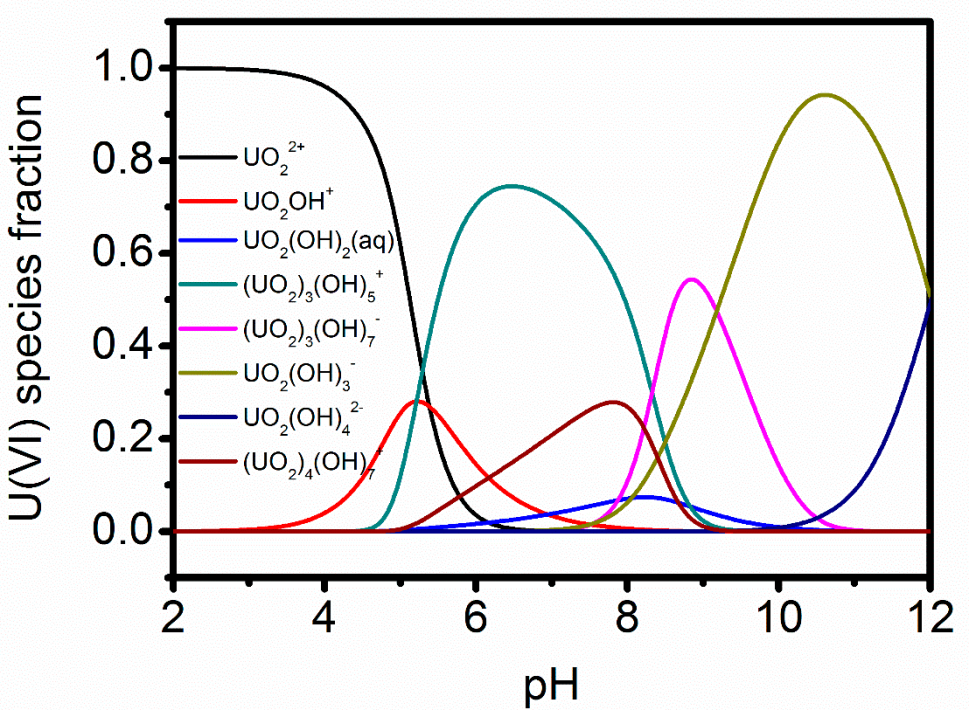

Figure S4. U(VI) speciation based on Visual MINTEQ program in the experimental adsorption solution ([U(VI)] =10 mg L^{-1}, I = 0.01 mol L^{-1} ($NaNO_3$), and T =25 °C.

Table S3. Comparison of the adsorption efficiency of GO15-MIL-101(Fe) and MIL-101(Fe) under different coexisted ions with that in the absence of these ions.

	Maintained Percentage (%)*				
Cation	MIL-101(Fe)	GO15-MIL-101(Fe)	Anion	MIL-101(Fe)	GO15-MIL-101(Fe)
Na^+	87.3	89.8	NO_3^-	84.7	86.9
K^+	80.7	81.3	Cl^-	33.3	84.0
Mg^{2+}	87.9	98.9	SO_4^{2-}	79.9	81.1
Ca^{2+}	24.3	64.0	CO_3^{2-}	24.9	99.5

* The ratio of adsorption percentage under different existed ions with that in the absence of these ions.

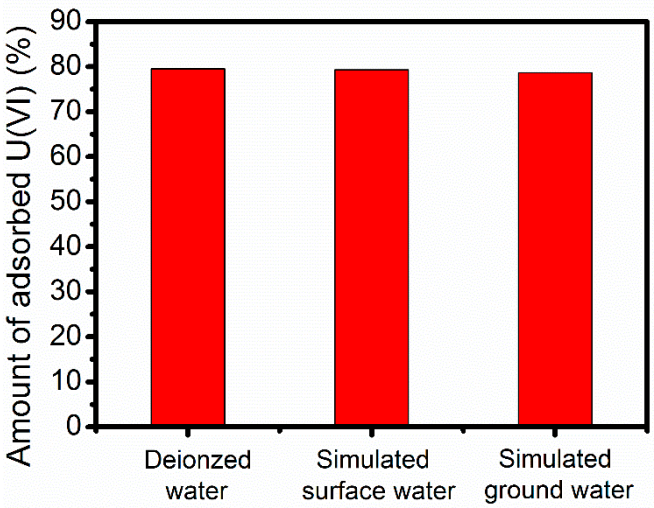

Figure S5. The adsorption efficiency of GO15- MIL-101(Fe) towards U(VI) in deionized water (pH = 5.5), simulated surface water (pH = 7.9) and simulated ground water (pH = 8.0) at T = 298 K, and C_0 = 10 mg L^{-1}, adsorbent concentration = 0.2 g L^{-1}.

Table S4. Comparison of the adsorption capacity of GO-MIL-101(Fe) composite towards U(VI) with other adsorbents.

Adsorbents	Experimental conditions	q_{max} (mg g^{-1})	Ref.
MIL-101(Cr)	pH = 5.5, T = 298 K	20.00	[1]
Two-step amino functionalized MIL-101(Cr)	pH = 5.5, T = 298 K	90.00	[1]
N,N-Diisobutyl-2-(octylphenylphosphoryl)acetamide (CMPO) trapped MIL-101(Cr)	pH = 4.0, T = 298 K	27.99	[2]
Amino Functionalized Flake Graphite	pH = 6.0, T = 333.15 K	140.68	[3]
Carbon nanofiber	pH = 4.5, T = 298 K	125.00	[4]
GO nanosheets	pH=5.0, T= 293.15K	97.50	[5]
UiO-66–NH_2	pH =6.0, T = 298 K	114.90	[6]
GO15- MIL-101(Fe) composite	pH = 5.5, T = 298 K	106.89	This work

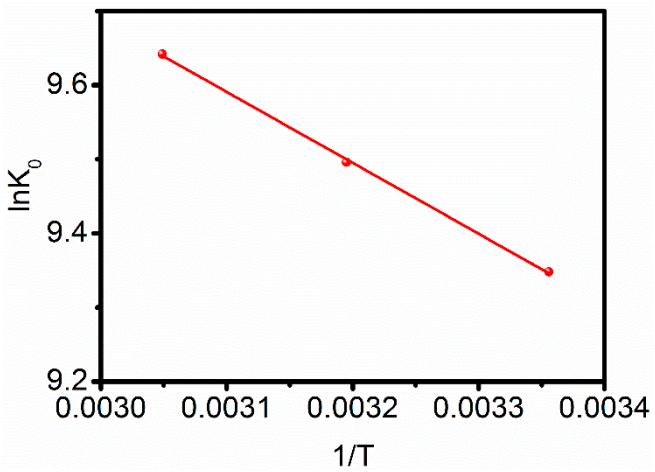

Figure S6. The plot of $\ln K^0$ to 1/T of U(VI) adsorption onto GO15-MIL-101(Fe).

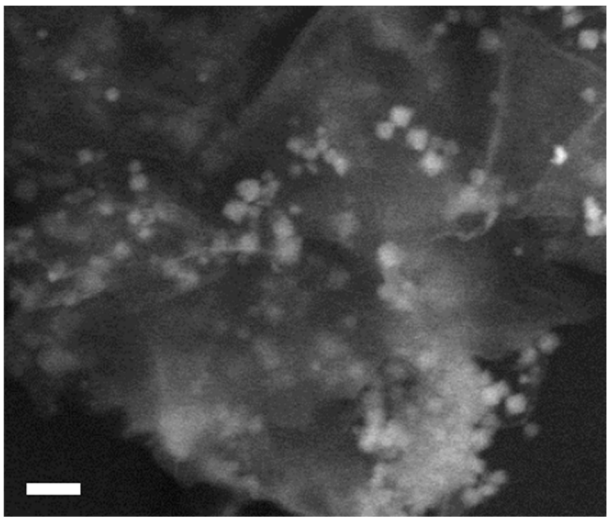

Figure S7. The morphology of regenerated composite sample after 4 cycles, scale bar = 1 μm.

References

1 Bai Z-Q, Yuan L-Y, Zhu L, *et al.* Introduction of amino groups into acid-resistant mofs for enhanced U(VI) sorption. J Mater Chem A, 2015, 3: 525-534.

2 De Decker J, Folens K, De Clercq J, *et al.* Ship-in-a-bottle cmpo in mil-101(cr) for selective uranium recovery from aqueous streams through adsorption. J Hazard Mater, 2017, 335: 1-9.

3 Duan S, Wang Y, Liu X, *et al.* Removal of U(VI) from aqueous solution by amino functionalized flake graphite prepared by plasma treatment. ACS Sustainable Chem Eng, 2017, 5: 4073-4085.

4 Sun Y, Wu Z-Y, Wang X, *et al.* Macroscopic and microscopic investigation of U(VI) and Eu(III) adsorption on carbonaceous nanofibers. Environ Sci Technol, 2016, 50: 4459-4467.

5 Zhao G, Wen T, Yang X, *et al.* Preconcentration of U(VI) ions on few-layered graphene oxide nanosheets from aqueous solutions. Dalton Transactions, 2012, 41: 6182-6188.

6 Luo B-C, Yuan L-Y, Chai Z-F, *et al.* U(VI) capture from aqueous solution by highly porous and stable mofs: UiO-66 and its amine derivative. J Radioanal Nucl Chem 2016, 307: 269-276.