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One-pot synthesis of graphene oxide-supported $Ti_xAl_{1-x}O_y$-based material modified with amidoxime for highly efficient uranium adsorption

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The adsorption efficiency (E%) and adsorption capacity (q_e, mg g^{-1}) of U(VI) on adsorbents are determined according to the initial concentration (C_0, mg L^{-1}) and the equilibrium concentration (C_e, mg L^{-1}):

$$E\% = \frac{C_0 - C_e}{C_0} \times 100 \tag{S1}$$

$$q_e = \frac{V(C_0 - C_e)}{m} \tag{S2}$$

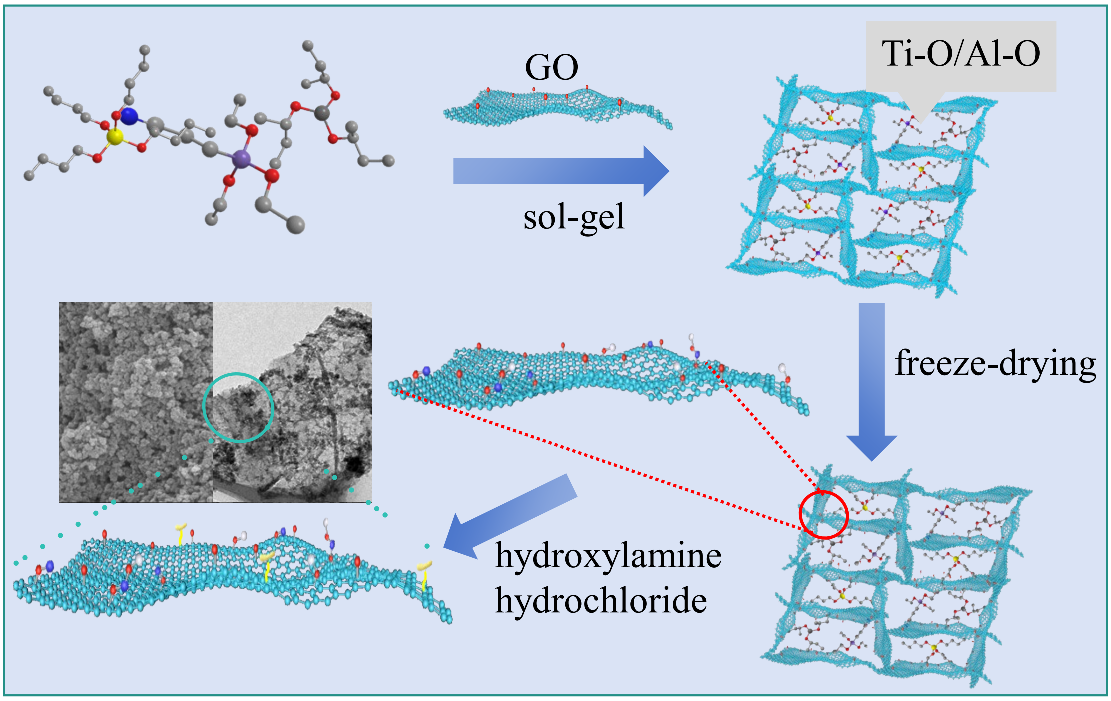
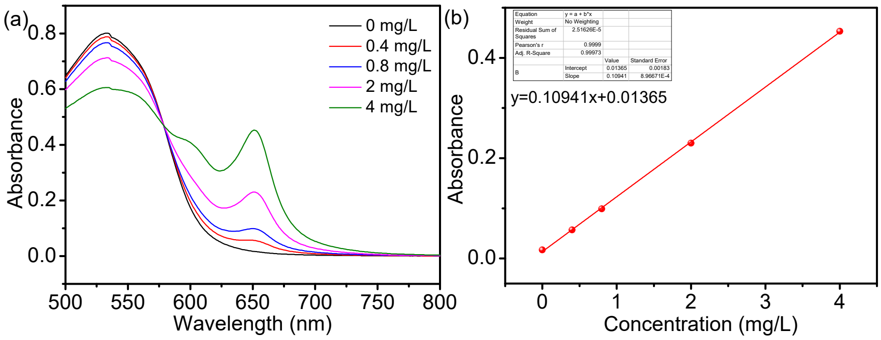


Figure S1. The preparation process of AO-GTA.

After adsorption, the solid (adsorbent + U(VI) species) was filtered out by a polyether sulfone filter and the residual U(VI) concentration in the supernatants was determined by using UV-vis spectrophotometer at 651 nm with arsenazo(III) (0.1 %) as the chromogenic agent. The standard curves of uranium adsorption were shown in Figure S2. All of the adsorption experiments were carried out in triplicate and the results were obtained by the average of triplicate determination with the relative standard deviation (RSD) of 4.5%.



Equation	y = a + b*x		
Weight	No Weighting		
Residual Sum of Squares	2.51626E-5		
Pearson's r	0.9999		
Adj. R-Square	0.99973		
		Value	Standard Error
B	Intercept	0.01365	0.00183
	Slope	0.10941	8.96671E-4

Figure S2. (a) UV patterns of different U(VI) concentration and (b) standard curve of U(VI) adsorption.

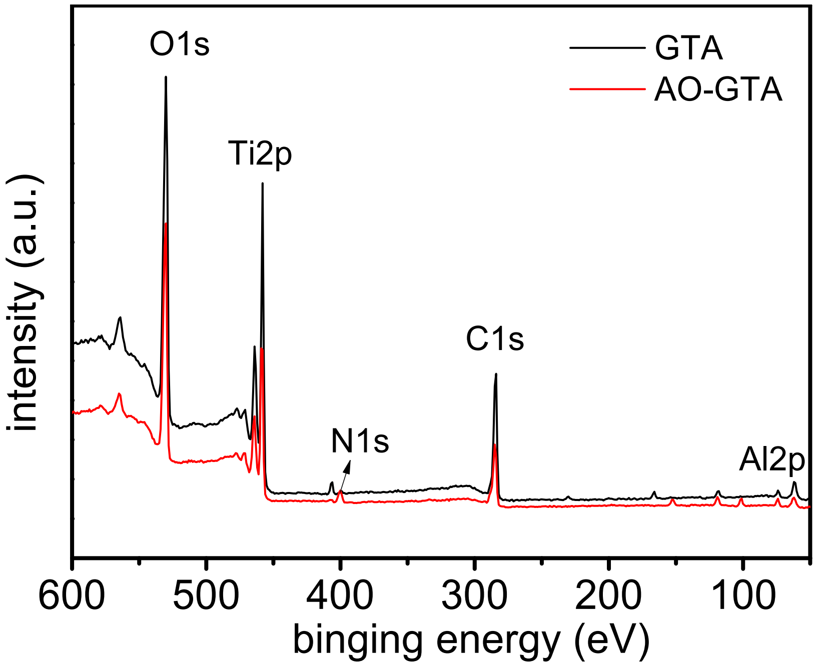


Figure S3. The XPS spectra of GTA and AO-GTA.

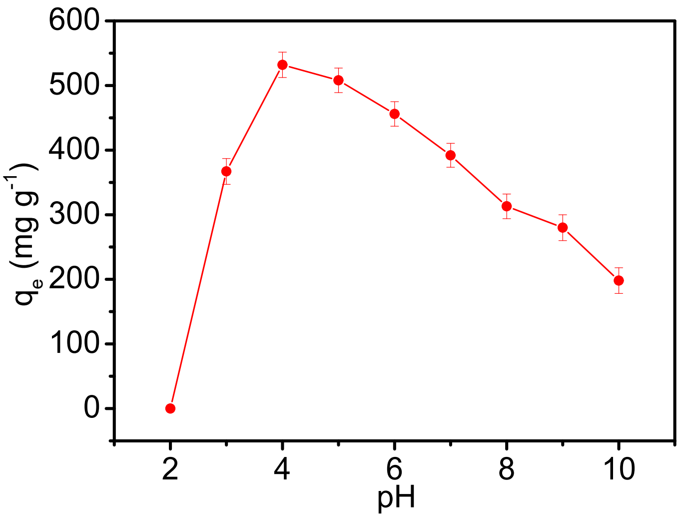


Figure S4. (a) effect of pH on the adsorption for uranium by TiO_2-Al_2O_3 (C_0 = 200 mg L^{-1}, m/V = 0.1 g L^{-1}, t = 2 h and T = 298 K)

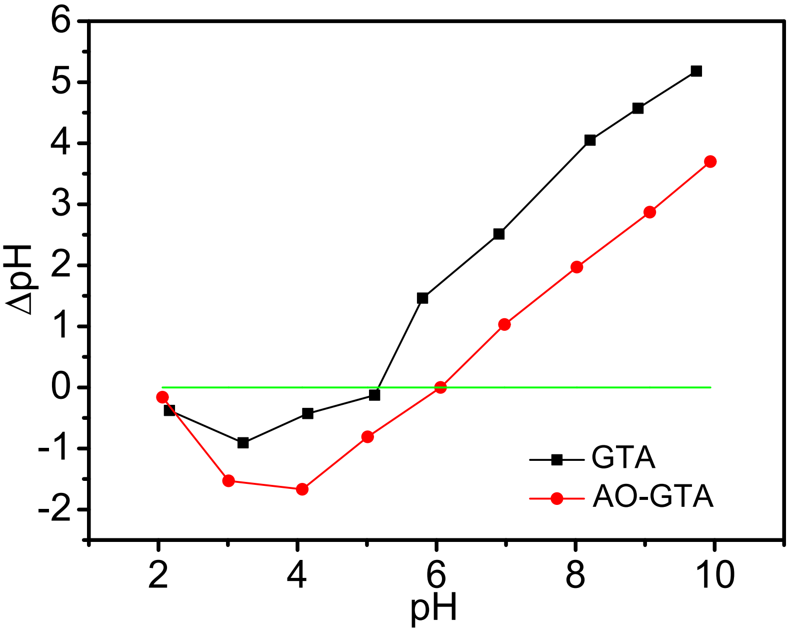


Figure S5. Zeta potential analysis of GTA and AO-GTA (T = 298 K, m/V = 1 g L^{-1}, C_{NaCl} = 0.01 mol L^{-1} and t = 24 h).

Pseudo-first-order kinetic model

non-linear: $q_t = q_e(1-e^{-k_1 t})$ (S3)

Where q_e (mg g^{-1}) and q_t (mg g^{-1}) are the amount of U(VI) adsorbed at equilibrium time and at time t (min), respectively. k_1 is the adsorption rate constant.

Pseudo-second-order kinetic model

non-linear: $q_t = (\frac{k_2 q_e^2 t}{1+k_2 q_e t})$ (S4)

Where q_e and q_t are the amount of U(VI) adsorbed (mg g^{-1}) at equilibrium and at time t (min), respectively. k_2 (g m^{-1} g min) is the rate constant of the pseudo-second order equation.

Elovich kinetic model

$$q_t = \frac{1}{\beta}\ln(1+\alpha\beta t) \tag{S5}$$

Where q_t is the amount of U(VI) adsorbed (mg g^{-1}) at equilibrium and at time t (min). α (mg/(g h)) and β (g/mg) are the initial adsorption and desorption rate constants of Elovich model, respectively.

Ritchie model

$$q_t = q_\infty - q_\infty (1+(n-1)\alpha t)^{1/(1-n)} \tag{S6}$$

where n is the number of active sites occupied by an adsorbate ion or molecule, α (min^{-1}) is the rate constant of Ritchie's equation, and q_∞ (mg/g) is the equilibrium adsorption capacity at infinite time, which could be obtained from the best fitted isotherm model ($q_\infty = f(C_e)$) when C_0(U) = 1000 mg/L.

Langmuir isotherm model

The Langmuir model assumes that monolayer adsorption takes place on the homogenous surfaces. It is one of the most widely used isotherm in adsorption.

non-linear: $$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \tag{S7}$$

Where q_m (mg/g) and q_e (mg/g) are the Langmuir maximum adsorption capacity. K_L (L/mg) is the Langmuir adsorption isotherm constant related to the interaction energies or net enthalpy of adsorption and represents the affinity of adsorbate and adsorbent.

Freundlich isotherm model

The Freundlich model has been regarded as an empirical equation without physical meaning. In many published papers, the Freundlich isotherm was applied to represent the multilayer adsorption on heterogamous surfaces.

non-linear: $$q_e = K_F C_e^{\frac{1}{n}} \tag{S8}$$

Where K_F (mg/g) and n are the Freundlich constants indicating the relative adsorption capacity of adsorbent and intensity of adsorption.

Redlich-Peterson isotherm model

$$q_e = \frac{K_{RP} C_e}{1 + \alpha C_e^{\beta}} \tag{S9}$$

K_{RP} is a Redlich-Peterson constant (L/mg), α and β are the R-P model constant (L/mg).

Thermodynamic parameters

The thermodynamic parameters (e.g., standard enthalpy change (ΔH, kJ·mol^{-1}), standard entropy change (ΔS, J·K^{-1}·mol^{-1}), standard free energy change (ΔG, kJ·mol^{-1}) of the U(VI).

$$\ln K = \frac{\Delta S}{R} - \frac{\Delta H}{RT} \tag{S10}$$

$$\Delta G = -RT \ln K \tag{S11}$$

Where K were the thermodynamic equilibrium constant, T was the absolute temperature in Kelvin and R was the gas constant (8.314 J·mol^{-1}·K^{-1}). The ΔH and ΔS were calculated from the slope and intercept of linear plot of ln K versus T^{-1}.

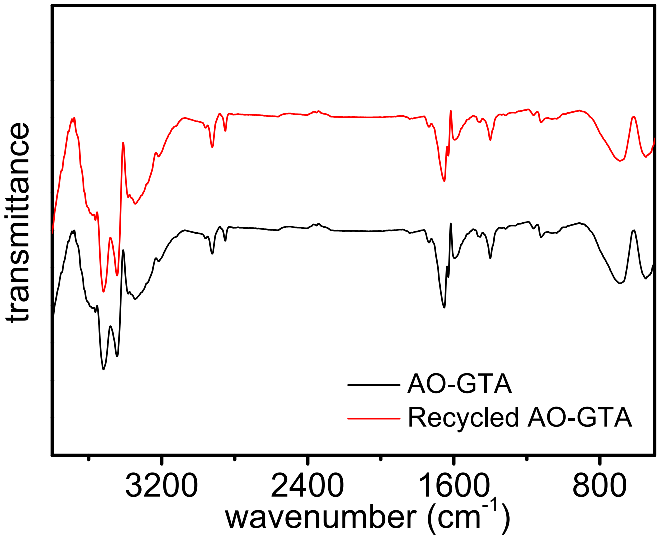


Figure S6. the FTIR spectra of AO-GTA before and after cycles.

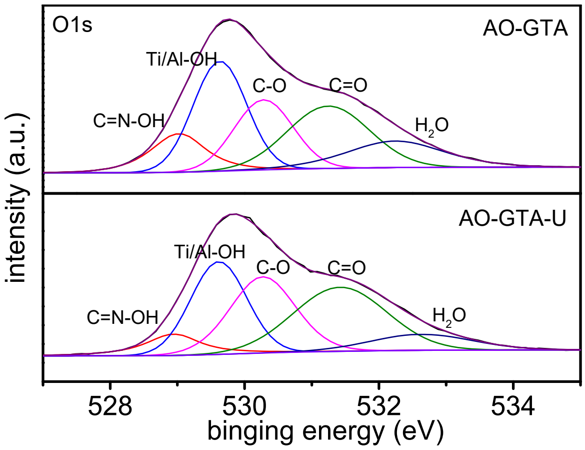


Figure S7. the high-resolution XPS spectra of O1s.

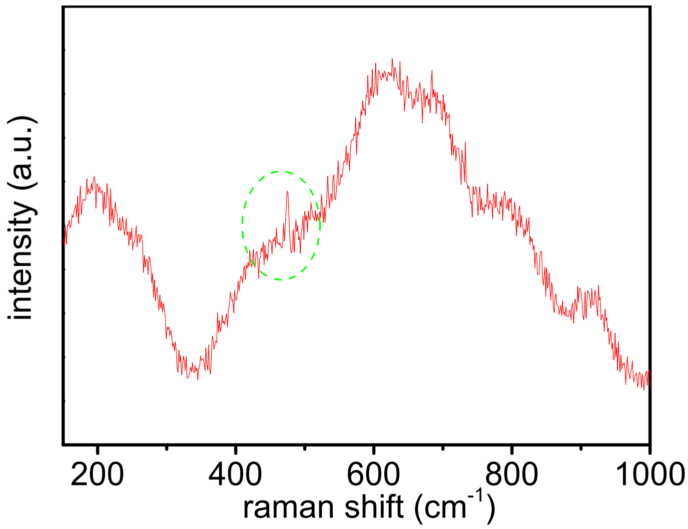


Figure S8. the Raman spectrum of AO-GTA-U.