Supporting Information on

Two-Dimensional MAX-Derived Titanate Nanostructures for Efficient Removal of Pb(II)

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1. Material Characterization Section

The scanning electron microscope (SEM, Hitachi S-4800) was operated at the beam energy of 5 kV. The TEM images was performed on FEI Tecnai G2 F30 microscope with an accelerating voltage of 200 kV. The phase transformation was examined by X-ray diffraction (XRD), which was measured on a Rigaku/Max-3A X-ray diffractometer with Cu-Kα radiation (the operation voltage and current were maintained at 40 kV and 200 mA), measured in the range of $5^o \leq 2\theta \leq 80^o$ and with a wavelength of 0.1542 nm and a scanning speed of 10o min-1). X-ray photoelectron spectroscopy (XPS) spectra were recorded on a VG Scientific ESCALAB Mark II spectrometer. The products of pore size distribution and Brunauer-Emmett-Teller (BET) surface area were obtained by using a Micromeritics ASAP 2010 system at 77 K. A ZETASIZER 3000 HSA system was used to measure the Zeta potential values. Fourier transform infrared (FTIR) spectra were performed on a Bruker Equinox 55 spectrometer with KBr pellets. Raman spectroscopy analysis was carried out by an In Via microscopic confocal at a 532 nm laser beam. The amount of metal element was detected by inductively coupled plasma (ICP-Optima 5300DV, PerkinElmer Inc., USA).

2. The kinetic equations used in this study were given as follows:

Pseudo-first-order model: $\ln(q_e - q_t) = \ln q_e - k_1 t$ (1)

Pseudo-second-order model: $\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e}$ (2)

where k_1 (min^{-1}) and k_2 ($g \cdot mg^{-1} \cdot min^{-1}$) are the rate constant of two models, and q_t ($mg \cdot g^{-1}$) and q_e ($mg \cdot g^{-1}$) represent the amount of adsorbed U(VI) at t (min) and equilibrium, respectively.

3. The thermodynamic formulas were given as follows:

The thermodynamic data of Gibbs free energy change (ΔG^0) was determined by the following formula:

$$\Delta G^0 = -RT \ln K^0$$

The standard enthalpy change (ΔH^0) and entropy change (ΔS^0) were calculated by plotting ΔG^0 as a function of T, which was described as:

$$\Delta G^0 = \Delta H^0 - \Delta S^0 T$$

where R (8.3145 J $mol^{-1} \cdot K^{-1}$) and T (K) are the ideal gas constant and Kelvin temperature.

Table S1 Chemical compositions of three samples based on ICP Analysis.

Samples	Elemental composition (mg/L)			NTO/KTO
	Ti	Al	Na/K	concentration (wt.%)
TAC	73.82	13.91	-	-
T-NTO	68.41	7.94	7.88	49.15
T-KTO	63.88	8.02	7.29	44.38

Table S2 Parameters for the kinetic adsorption data simulated by pseudo-first-order and pseudo-second-order model.

Adsorbent	Pseudo-first-order		Pseudo-second-order	
	k_1 (h^{-1})	R^2	k_2 ($g^{-1} \cdot mg^{-1} \cdot h^{-1}$)	R^2
T-NTO	0.382	0.991	0.059	0.999
T-KTO	0.314	0.965	0.039	0.999

Table S3 Thermodynamic parameters for Pb (II) adsorption on T-NTO and T-KTO.

Parameters	ΔH^0 ($kJ \cdot mol^{-1}$)	ΔS^0 ($J/mol \cdot K$)	ΔG^0 ($kJ \cdot mol^{-1}$)		
Adsorbents			298 K	313 K	328 K
T-NTO	32.5	82.7	-8.04	-9.85	-10.51
T-KTO	30.8	75.4	-6.28	-7.38	-8.08

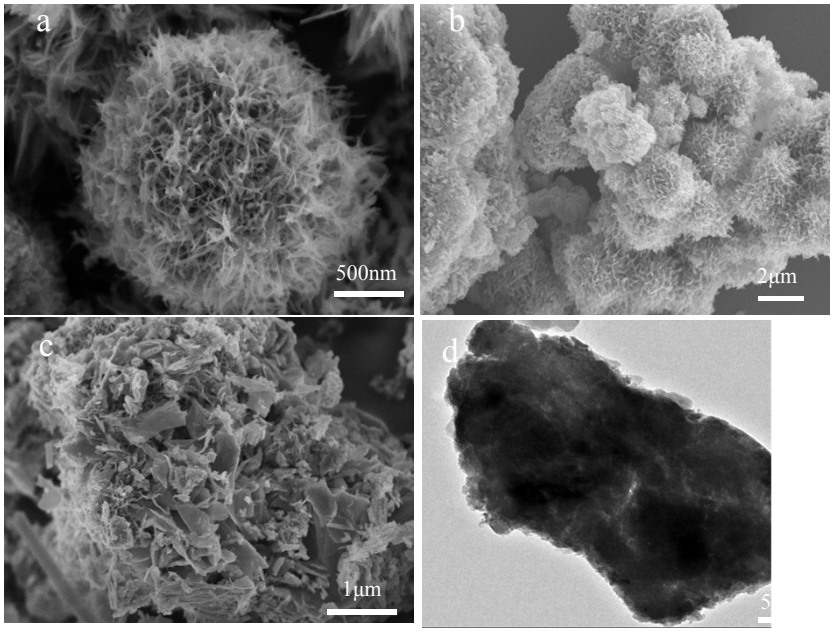

Fig. S1 The SEM images of T-NTO (a b) and T-KTO (c), respectively. (d) The TEM of pristine TAC.

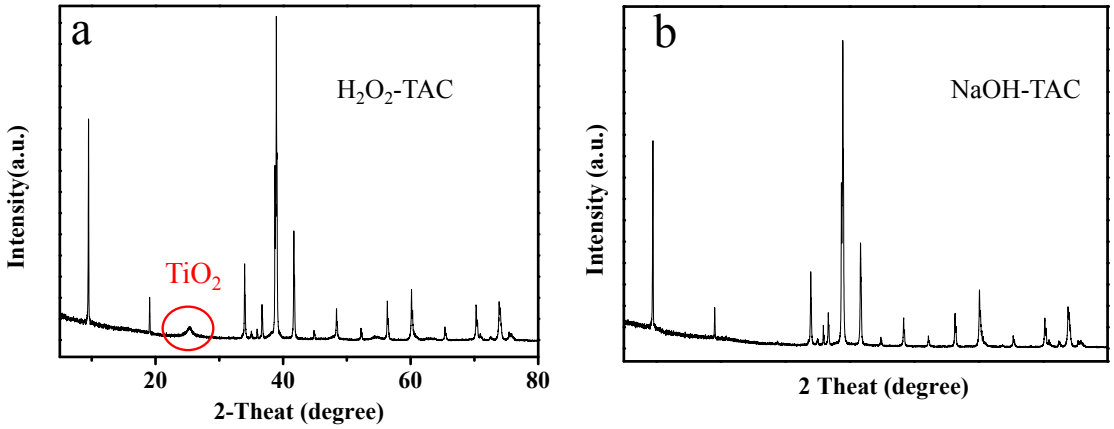

Fig. S2 XRD patterns of H_2O_2-TAC (a) and NaOH-TAC (b).

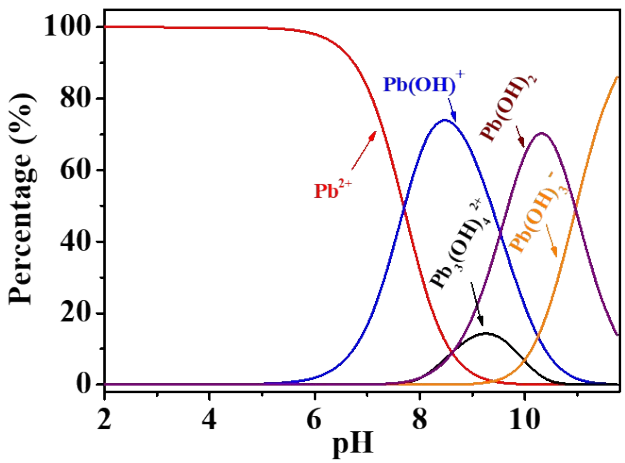

Fig. S3 The relative distribution of Pb(II) species under different pH values.

Conditions: $C_{(Pb)\ initial}$ = 20 mg/L, C($NaNO_3$) = 0.01 M.

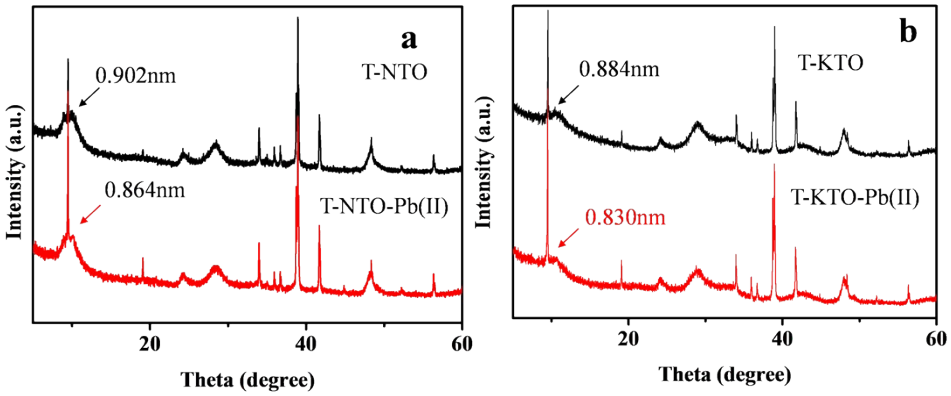

Fig. S4 XRD patterns of T-TNO (a) and T-KTO (b) before and after Pb(II) removal.

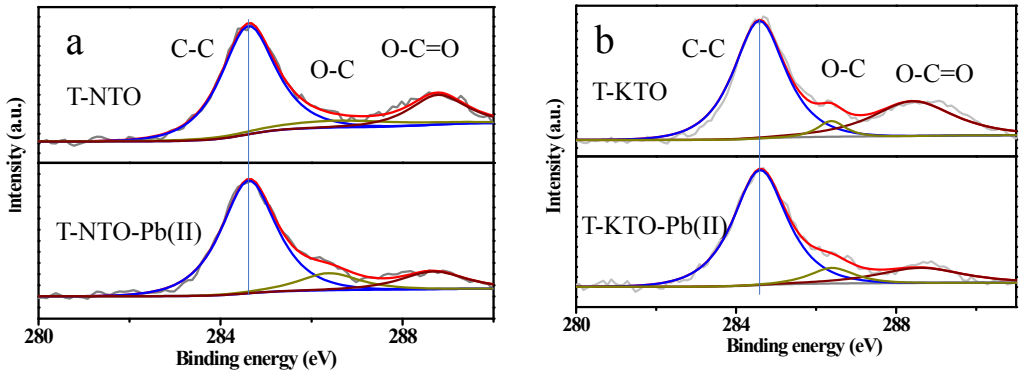

Fig. S5 XPS spectra of C 1s before (a) and after (b) Pb(II) removal.