Supporting information

Efficient Phosphate sequestration for water purification by Unique Sandwich-like MXene/Magnetic Iron Oxide Nanocomposites

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Figure S1

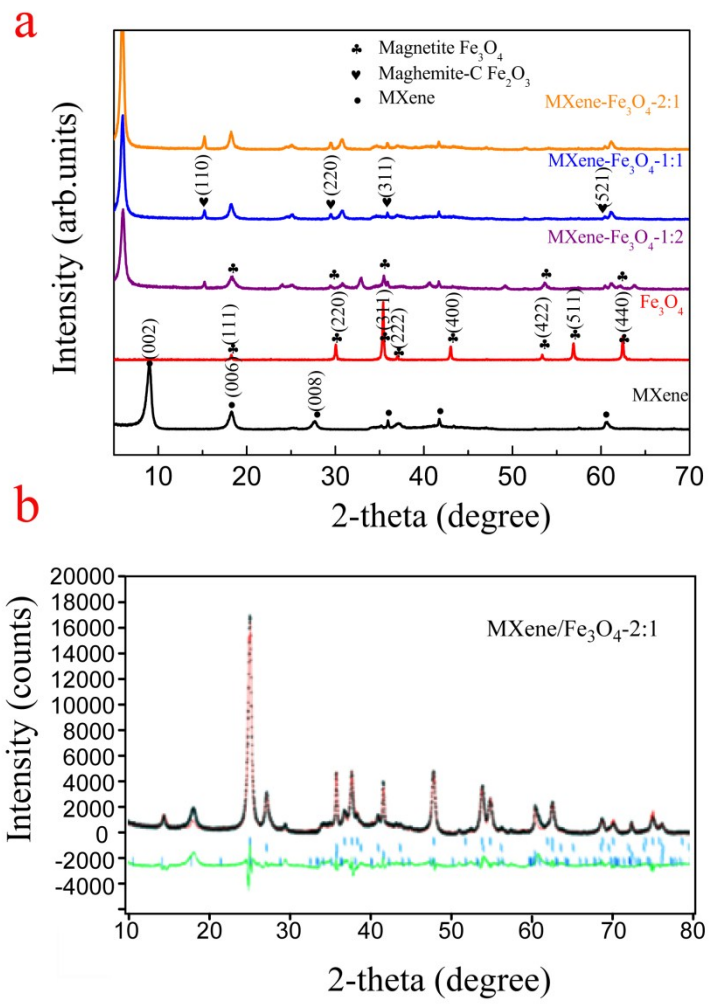

Figure. S1. (a) XRD patterns of MXene, Fe_3O_4 and MXI samples under different conditions. (b) The typical Rietveld refinement graph (Fullprof software) of the sample.

Figure S2

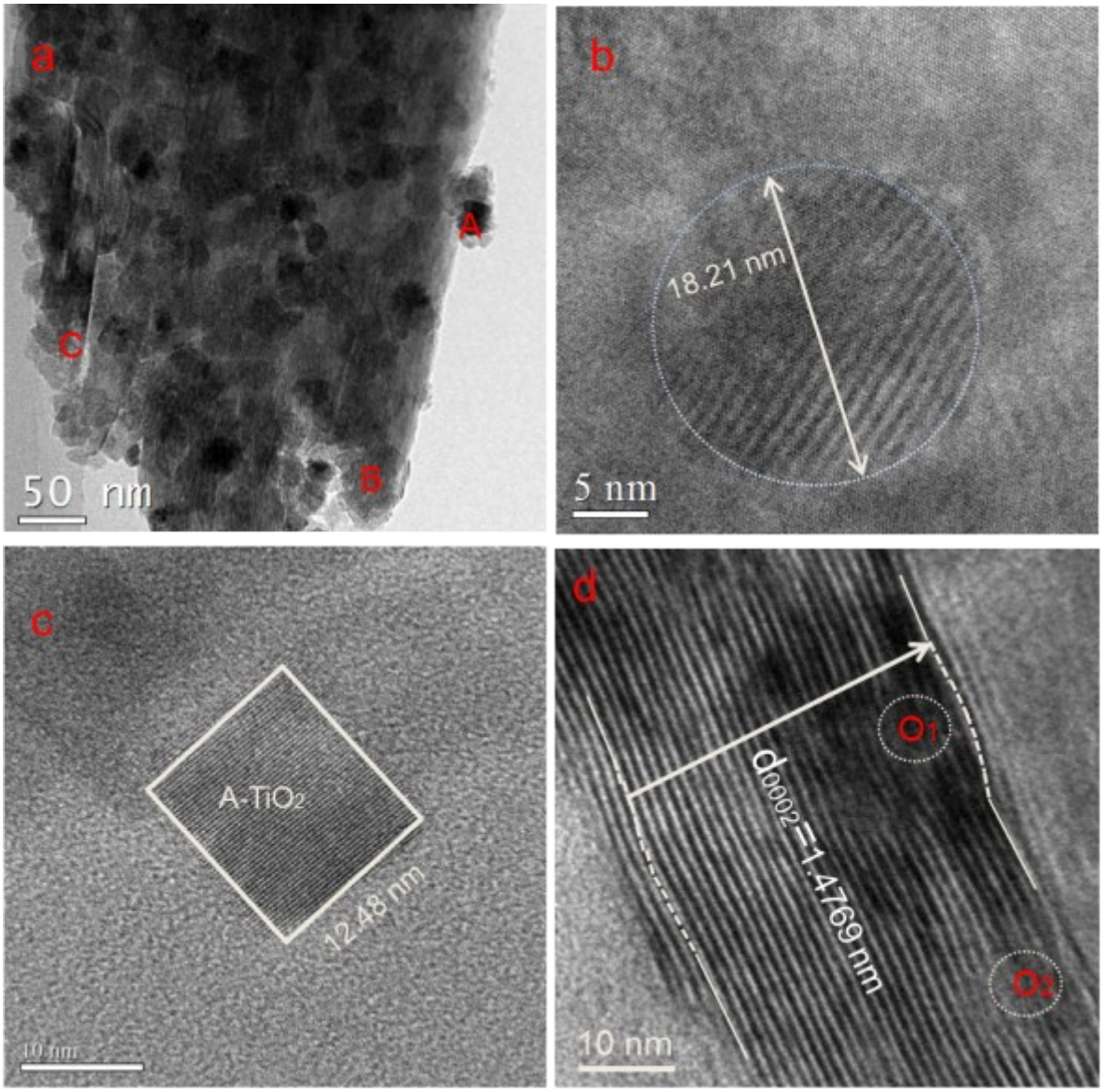

Figure S2. a) The high magnification image of local area in Figure 2c. b) the HRTEM image of area A, the average diameter is ～18.21nm. c) The HRTEM image of area B, a cuboid precipitate of anatase TiO_2 with the average length of 12.48 nm. d) The HRTEM image of area C, the layers are distorted owing the intercalation of oxide particles and the layer distance is ～1.4769 nm.

Figure S3

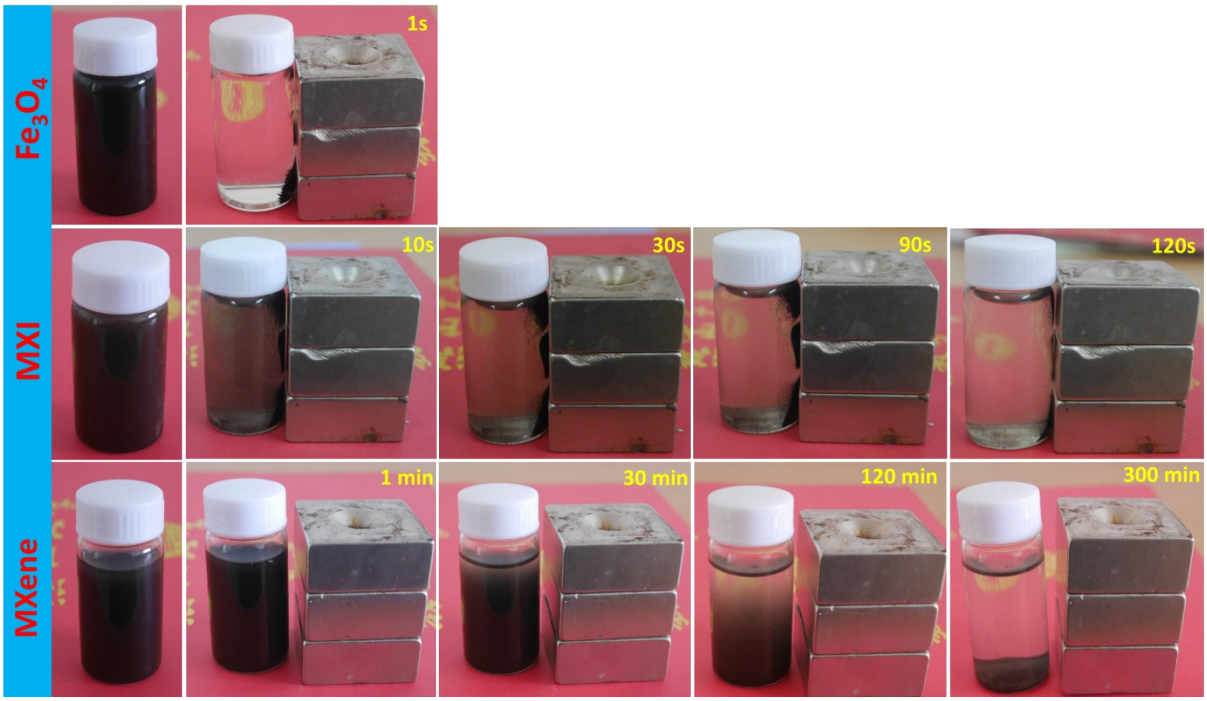

Figure S3. The typical magnetic separation maps under an industrial magnet with different separation time

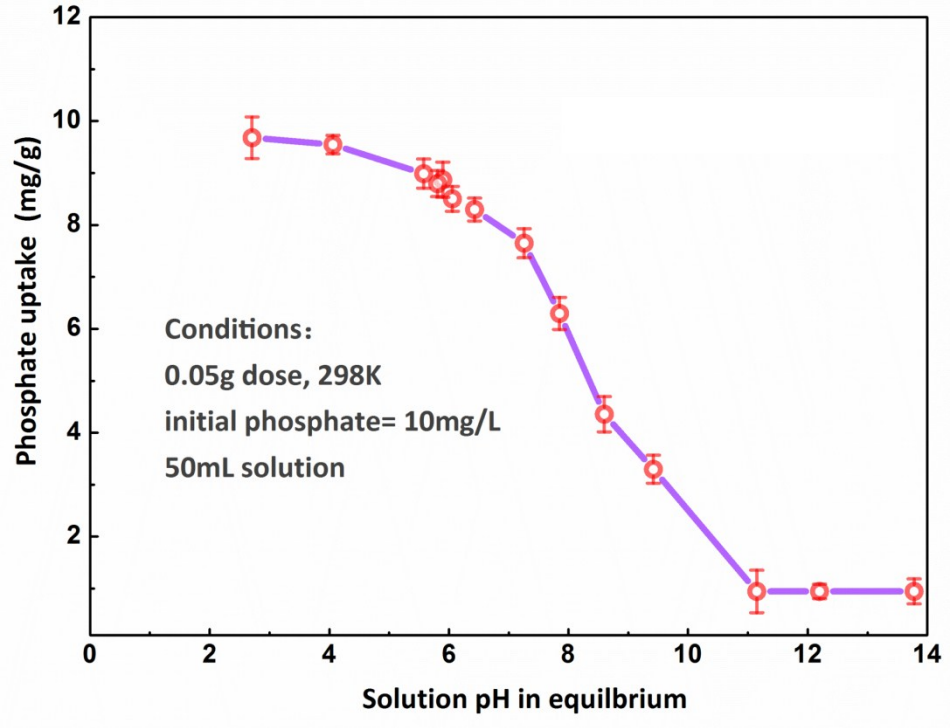

Figure S4 The effects of solution pH on phosphate sequestration

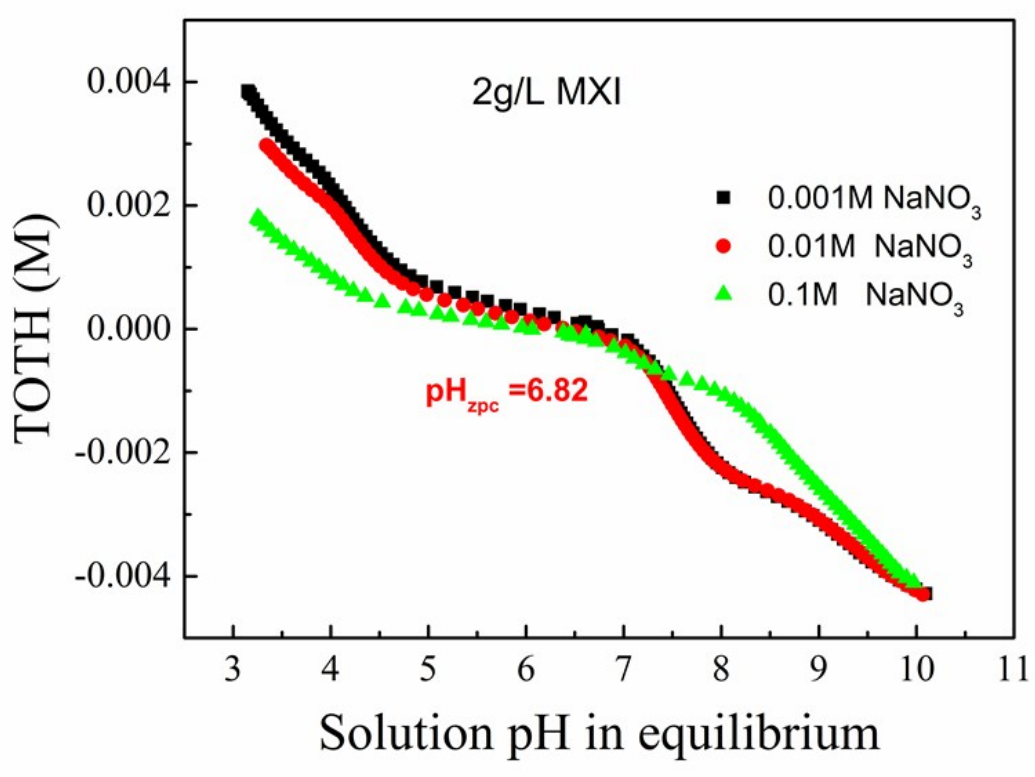

Figure S5 The acid-based titration curves for MXI at different ionic strengths.

Figure S6 Phosphate uptake efficiency for Cr(VI) influences on adsorption

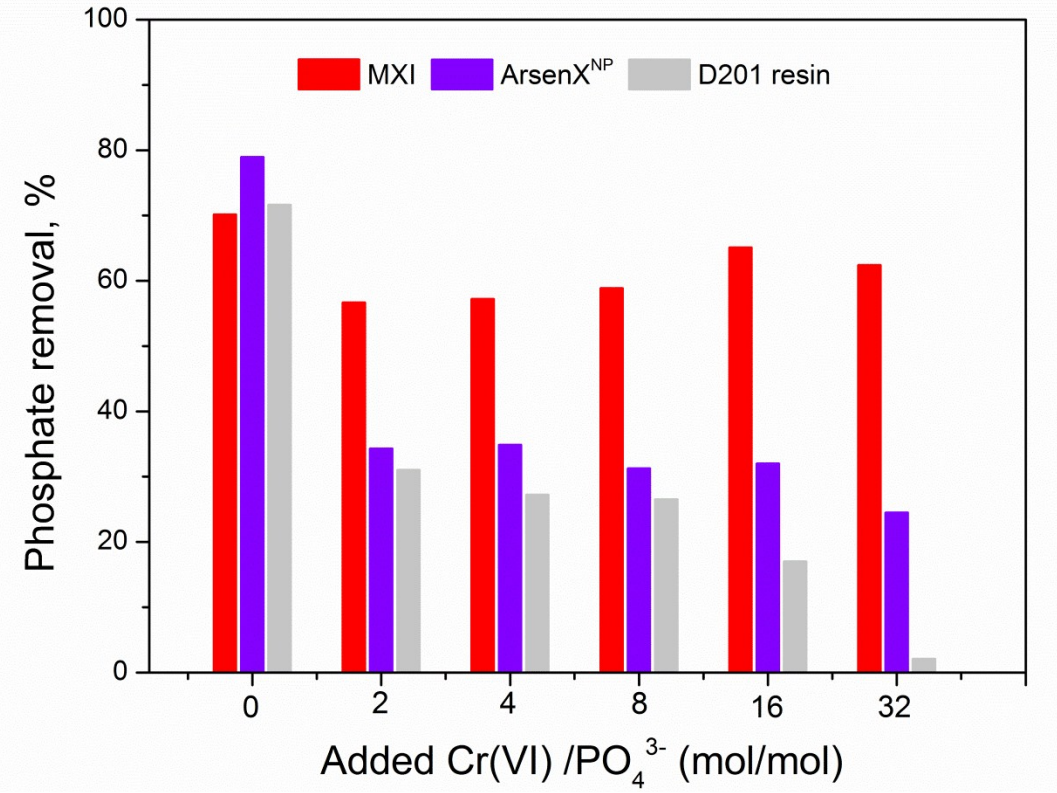

Figure S7

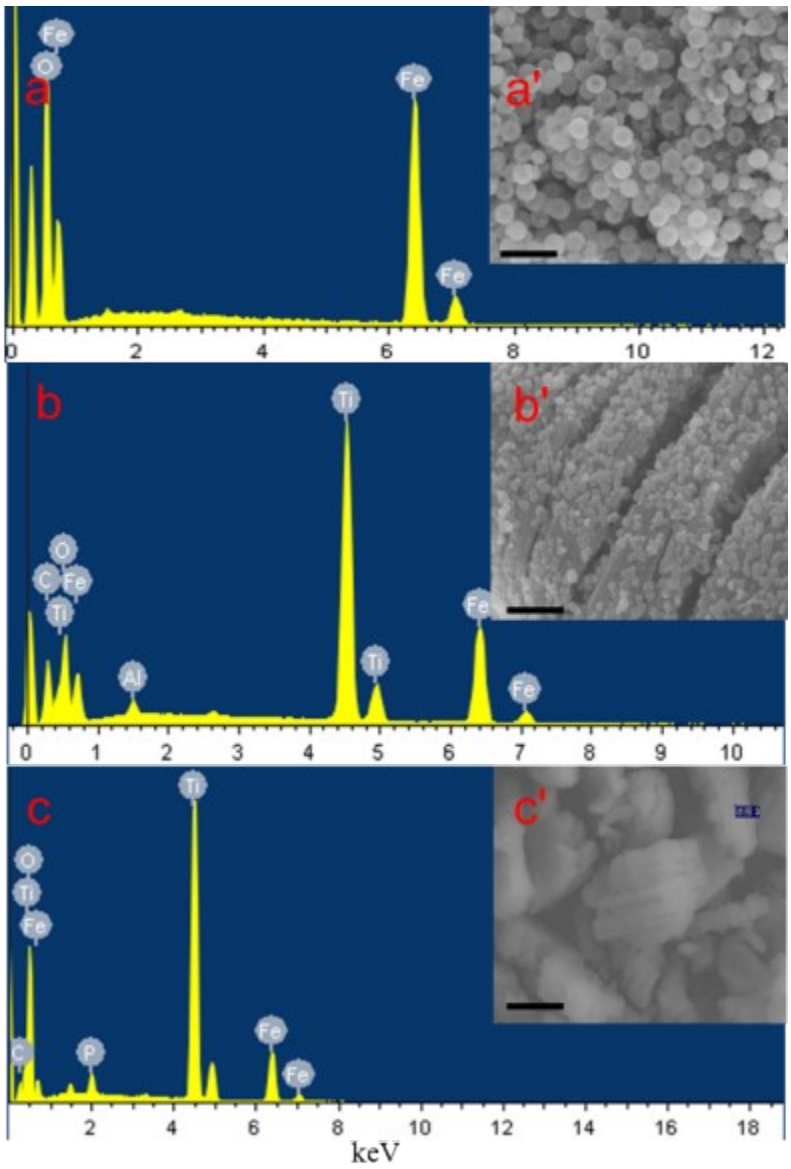

Figure S7 a) Fe_3O_4 morphology and element analyzed by SEM- EDS. b) MXI morphology and element analyzed by SEM- EDS; c) phosphate uptake MXI sample examined by SEM- EDS. The scale bar is 1 um.

Figure S8

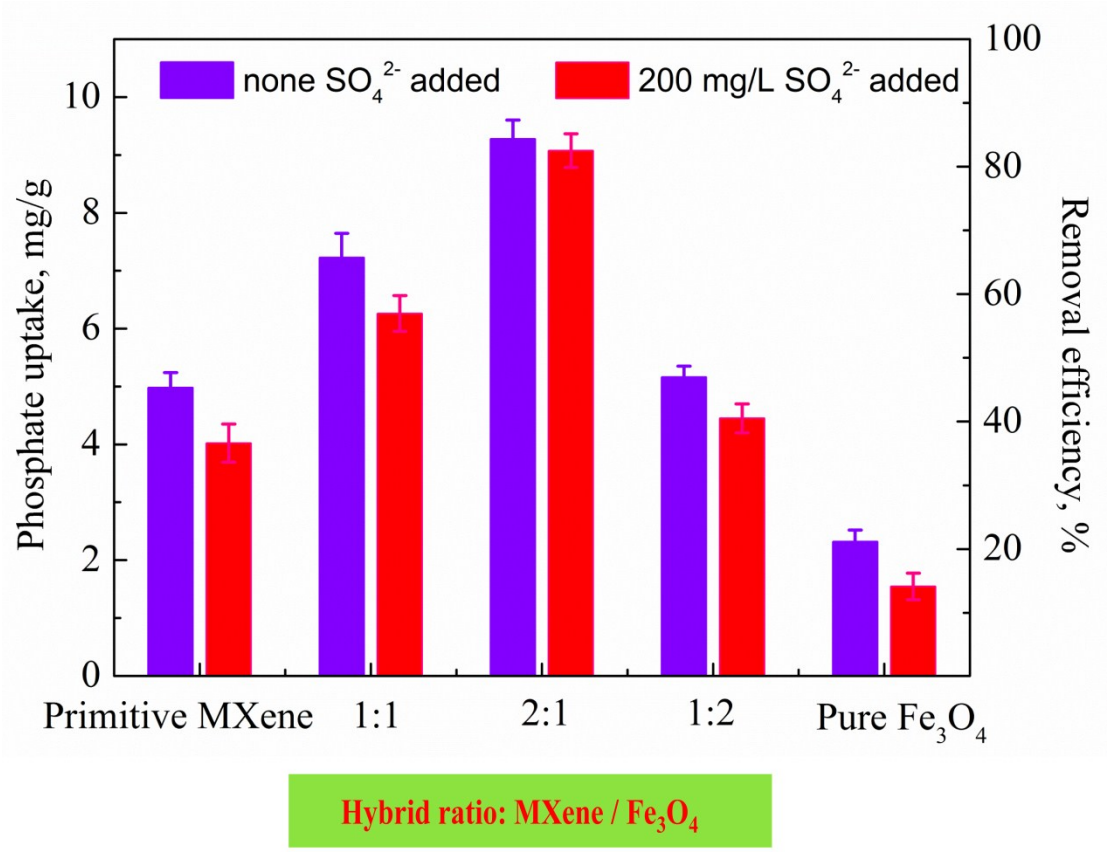

Figure S8. The phosphate uptake comparison with different hybrid ratios of MXene/Fe_3O_4

Figure S9

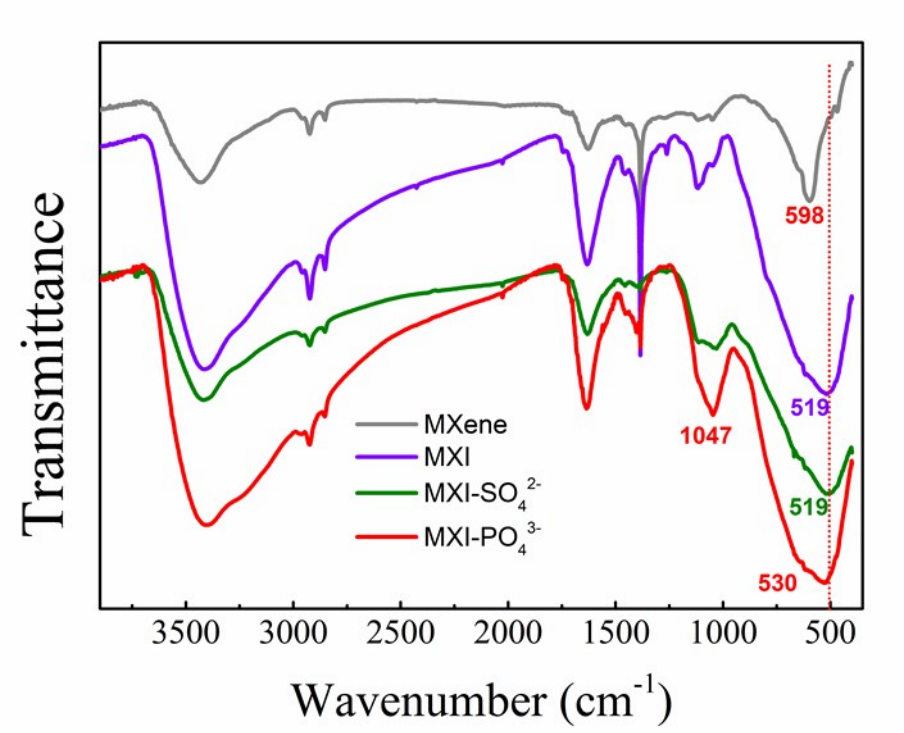

Figure S9 FT-IR spectra of MXene samples before and after loaded with different anions

Figure S10

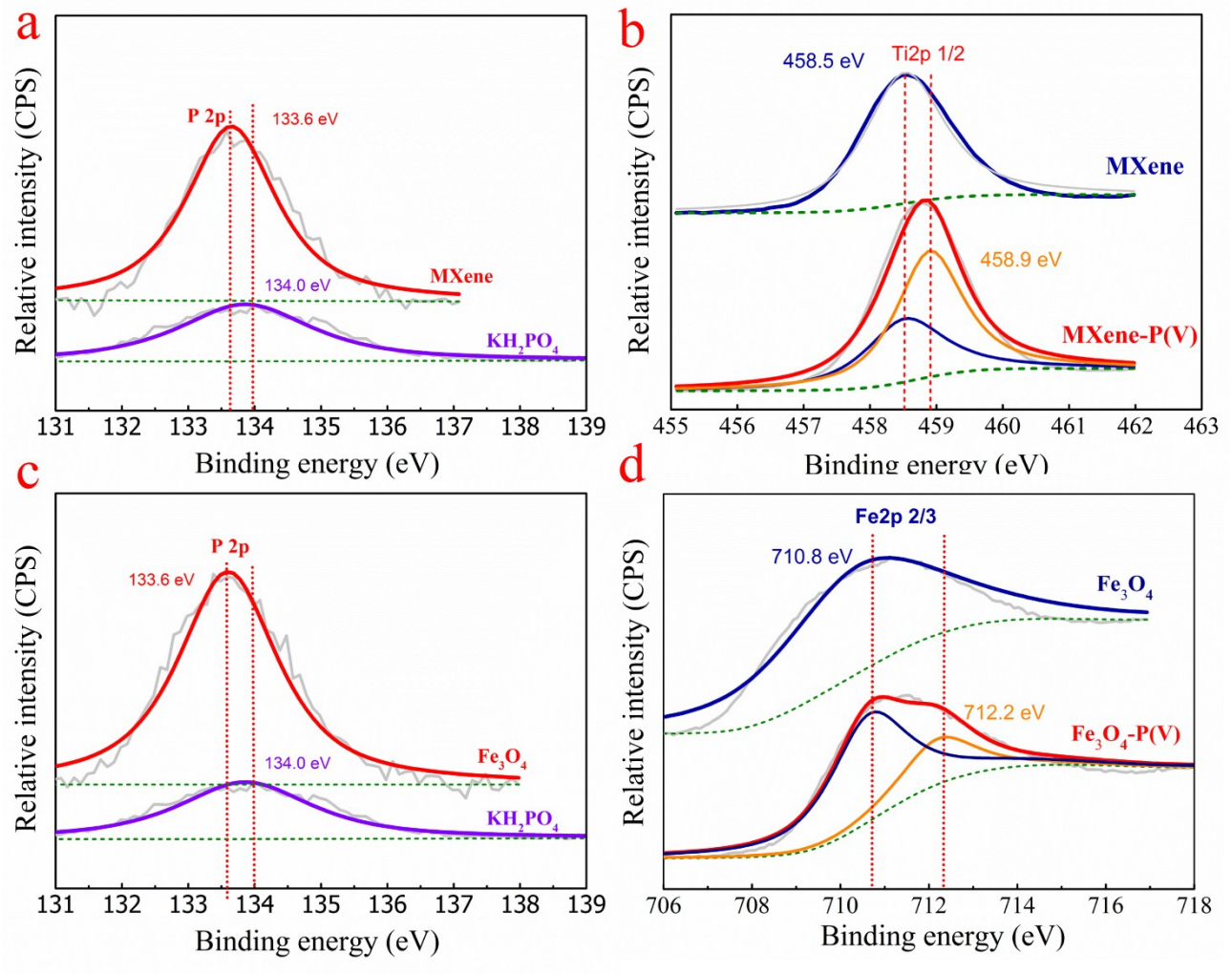

Figure S10. XPS spectra of primitive MXene and Fe_3O_4. a) P 2*p* spectra of P(V)-adsorbed MXene and the pure KH_2PO_4; b) Ti 2*p* spectra of samples from MXene and P(V) loaded samples; c) P 2*p* spectra of samples from Fe_3O_4 and the pure KH_2PO_4 samples; d) Fe 2p spectra of Fe_3O_4 before and after phosphate uptake.

Table S1. The mean grain sizes of Fe_3O_4 and Fe_2O_3 particles were determined by the XRD Scherrer formula: $D= k\lambda/\beta\cos\theta$, where $k=0.9$, $\lambda=0.154$ nm, $\beta=$ the corresponding width at the half peak height in radian, and $\theta=$Bragg angle).

Phases		**Fe_3O_4**			**Fe_2O_3**	
Crystal facets	(111)	(220)	(222)	(104)	(012)	(220)
β (degree)	0.496	0.481	0.530	0.725	0.715	0.763
Grain size (nm)	13.11	13.73	12.21	7.18	7.46	6.34
Average value (nm)		13.01			6.99	

Table S2. The summarized date of the mole ratio of Ti/ Fe analysed by inductively coupled plasma, the ratio of Fe_2O_3/Fe_3O_4 obtained by XRD refinement and the adsorption capacity in terms of adsorption curves.

Samples	Normal composition (wt.%)	Ti/Fe (mole ratio)	Fe_2O_3/Fe_3O_4 (mole ratio)	P-removing capacity (mg/g)
1	Pure Fe_3O_4	-	-	2.25
2	MXene:Fe_3O_4=2:1	10:1	2:8.9	9.42
3	MXene:Fe_3O_4=1:1	7:1	2:8.0	7.38
4	MXene:Fe_3O_4=1:2	6:1	2:7.9	5.21
5	MXene	-	-	4.92

Table S3 The effects of common anions on the distribution coefficient (K_d) of phosphate onto MXI, ArsenX^{np} and D201 at 298K

Competing Anions (M)	**Adsorbent**	***K*$_d$ (L/g) (at different initial competing anions contents in solution (M/PO_4^{3-} mol/mol)**				
		0	**8**	**16**	**32**	**64**
Sulfate	MXI	**2.36** (2.98)	**2.49** (2.86)	**2.90** (2.56)	**2.90** (2.56)	**2.86** (2.59)
	ArsenX^{np}	3.78 (2.09)	0.79 (5.59)	0.74 (5.75)	0.78 (5.62)	0.76 (5.68)
	D201	2.53 (2.83)	0.07 (9.35)	0.20 (8.33)	0.07 (9.35)	0.09 (9.17)
Nitrate	MXI	**2.36** (2.98)	**3.21** (2.38)	**2.86** (2.59)	**2.78** (2.65)	**3.90** (2.04)
	ArsenX^{np}	3.78 (2.09)	1.15 (4.65)	1.00 (5.00)	0.88 (5.32)	0.89 (5.29)
	D201	2.53 (2.83)	0.20 (8.33)	0.16 (8.62)	0.09 (9.17)	0.02 (9.80)
Chloride	MXI	**2.36** (2.98)	**2.52** (2.84)	**3.07** (2.46)	**3.59** (2.18)	**3.90** (2.04)
	ArsenX^{np}	3.78 (2.09)	1.49 (4.02)	1.01 (4.98)	0.93 (5.18)	0.88 (5.32)
	D201	2.53 (2.83)	0.29 (7.75)	0.15 (8.70)	0.03 (9.71)	0.04 (9.62)

Note the corresponding contents at different K_d values are presented in brackets with the unit mg/L