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One-step facile fabrication of the sea urchin-like zirconium oxide for efficient phosphate sequestration

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Figure S1 lower magnification images of the sea urchin-like zirconium oxide

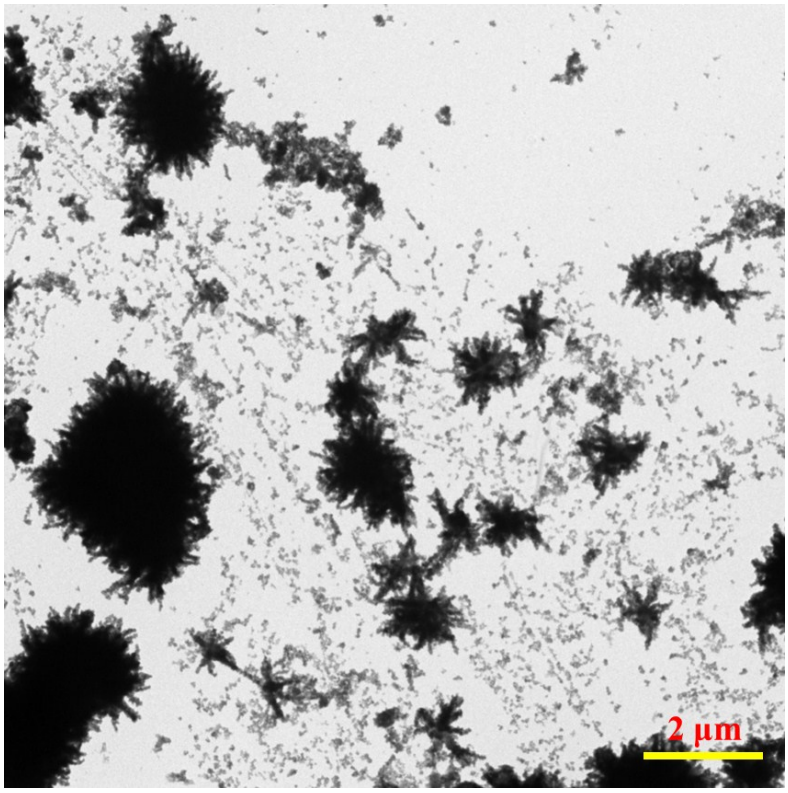

Fig. S2 XRD pattern of the resulting Ur-Zr and the Standard tetragonal ZrO_2

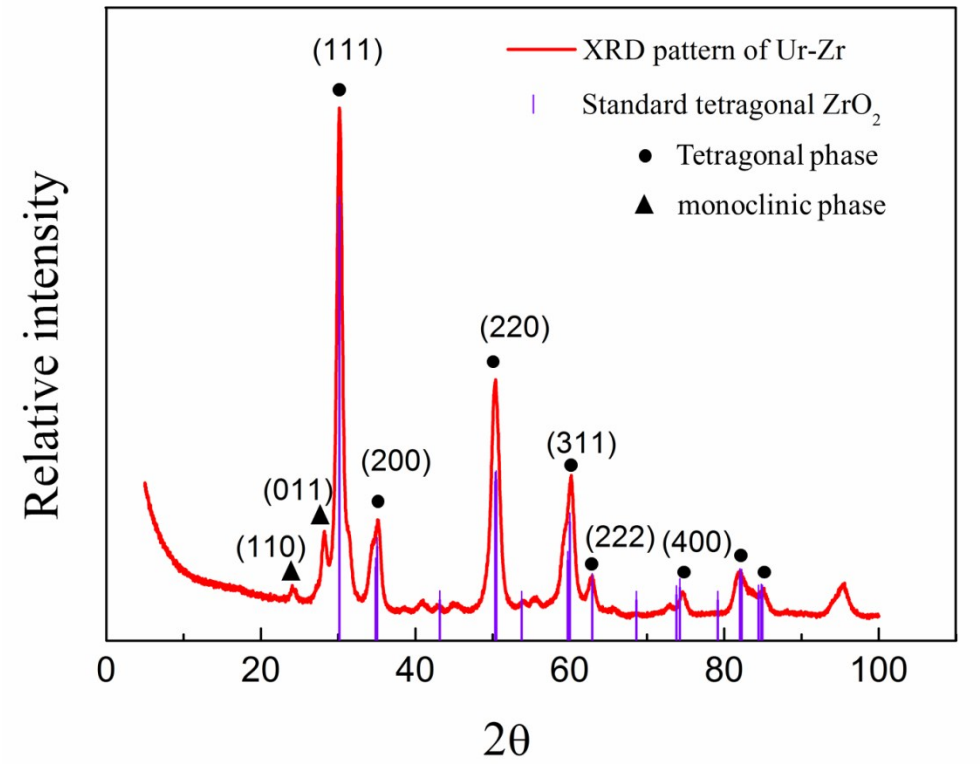

Table S1 Salient properties from N2 adsorption at 77 K of as-prepared sea urchin-like zirconium oxide

Designation	Nanostructured zirconium oxide
morphology	Sea urchin similar structure
BET surface area (m^2/g)	64.5
Average pore diameter (nm)	12.6
Pore volume (cm^3/g)	0.142

Table S2 The distribution ratio K_d (L/g) for three competing anions.

Competing Cations (M)	Adsorbent	K_d (L/g) at different competing ions in solution				
		0	200 mg/L	400mg/L	600mg/L	1000mg/L
SO_4^{2-}	Ur-Zr	29.2	22.5	23.4	18.8	20.1
	FerriX™	3.78	1.10	0.79	0.78	0.74
Cl^-	Ur-Zr	29.2	20.7	21.4	21.7	20.2
	FerriX™	3.78	1.01	0.92	0.88	0.95
NO_3^-	Ur-Zr	29.2	19.9	20.1	20.9	20.6
	FerriX™	3.78	1.00	0.87	0.88	0.78

Table S3 the parameters of kinetic model for the adsorption of phosphate onto Ur-Zr.

Materials	Pseudo-first-order model			Pseudo-second-order model			Intraparticle-diffusion model	
	q_e (mg/g)	k (/min)	R^2	q_e (mg/g)	k (/min)	R^2	k_p (mg/(g $min^{1/2}$))	R^2
Ur-Zr	17.01	0.0124	0.987	14.2	0.00134	0.958	1.078	0.990

Table S4 the parameters of sorption isotherm models for phosphate uptake onto Ur-Zr.

Temperature	Model	Parameter1	Parameter 2	Parameter 3	R^2
	Langmuir	k_L=0.1207L·mg^{-1}	Q_{max}=44.59203mg·g^{-1}		0.78607
25℃	Freundlich	k_F=12.42574mg$^{(1-n)}$·L^n·g^{-1}		n=0.29373	0.96281
	Temkin	b=515.02377J·g·mg^{-1}	A=30.36302L·mg^{-1}		0.80258
	Langmuir	k_L=0.09249L·mg^{-1}	Q_{max}=57.8409mg·g^{-1}		0.86459
45℃	Freundlich	k_F=12.4323mg$^{(1-n)}$·L^n·g^{-1}		n=0.35212	0.96562
	Temkin	b=442.35866J·g·mg^{-1}	A=30.36302L·mg^{-1}		0.76314
	Langmuir	k_L=0.0723L·mg^{-1}	Q_{max}=74.858mg·g^{-1}		0.89933
65℃	Freundlich	k_F=11.72062mg$^{(1-n)}$·L^n·g^{-1}		n=0.4277	0.96494
	Temkin	b=346.3922J·g·mg^{-1}	A=8.48491L·mg^{-1}		0.74212