Highly Efficient Removal of Uranium from an Aqueous Solution by a Novel Phosphonic Acid-Functionalized Magnetic Microsphere Adsorbent

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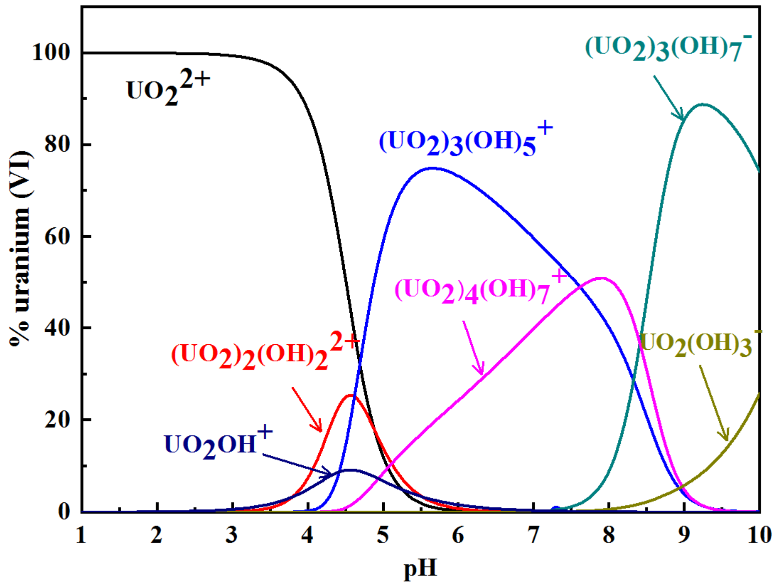

Figure S1. Distribution of uranium (VI) species in aqueous solution with a total concentration of 100 mg L^{-1} and pH values ranging from 1 to 10. Calculated by using a Medusa program.

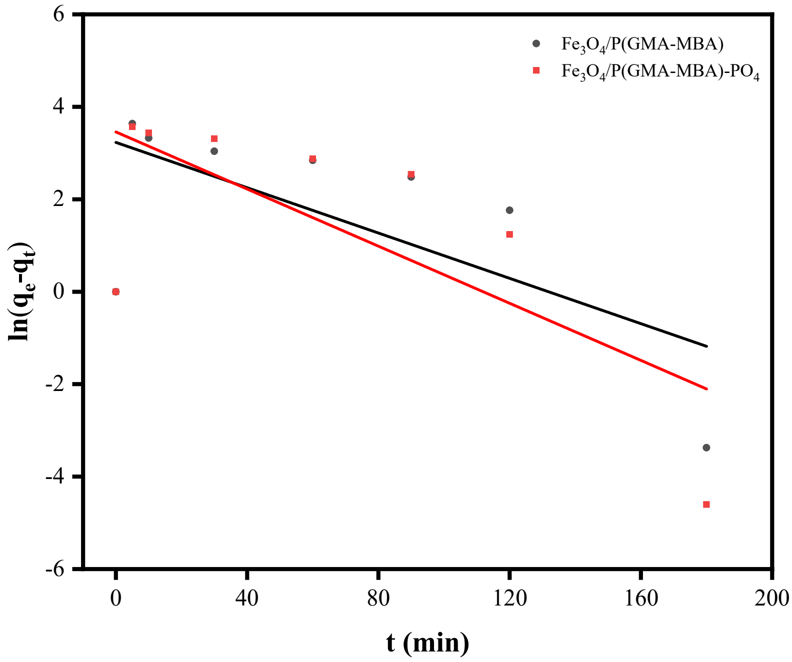

Figure S2. Pseudo-first-order model.

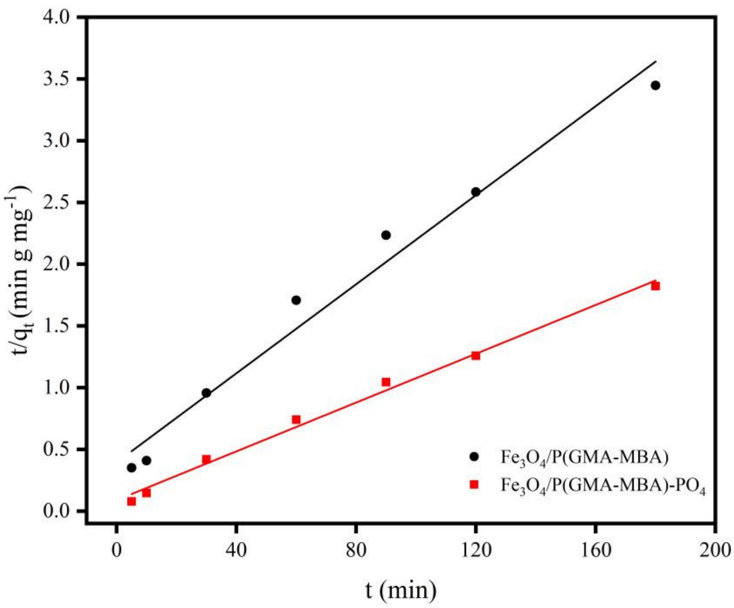

Figure S3. Pseudo-second-order model.

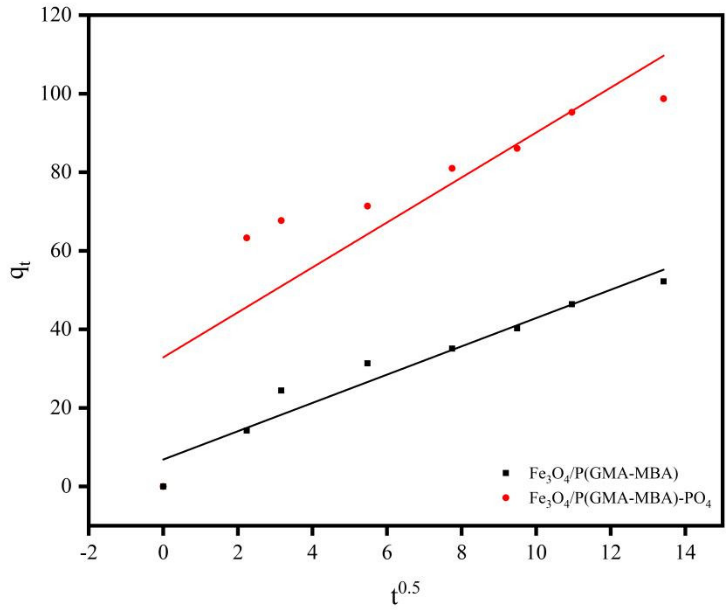

Figure S4. Intra-particle diffusion model.

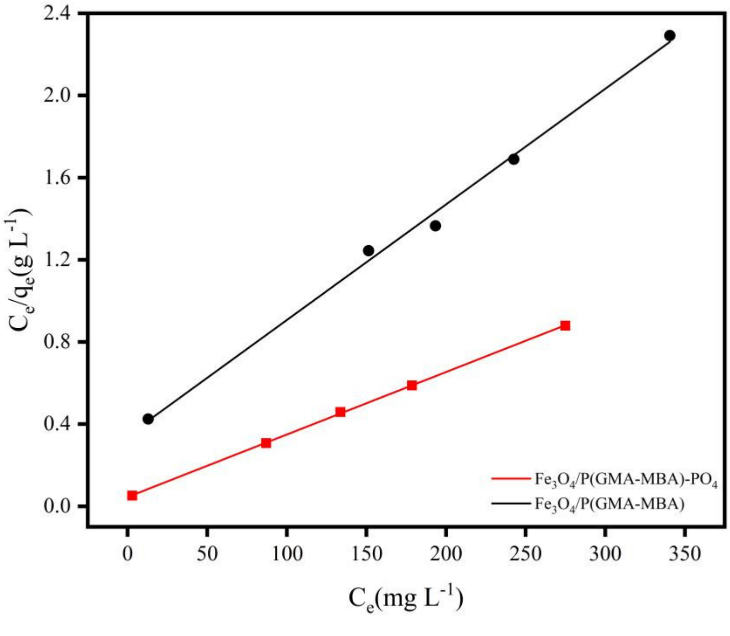

Figure S5. Langmuir modal.

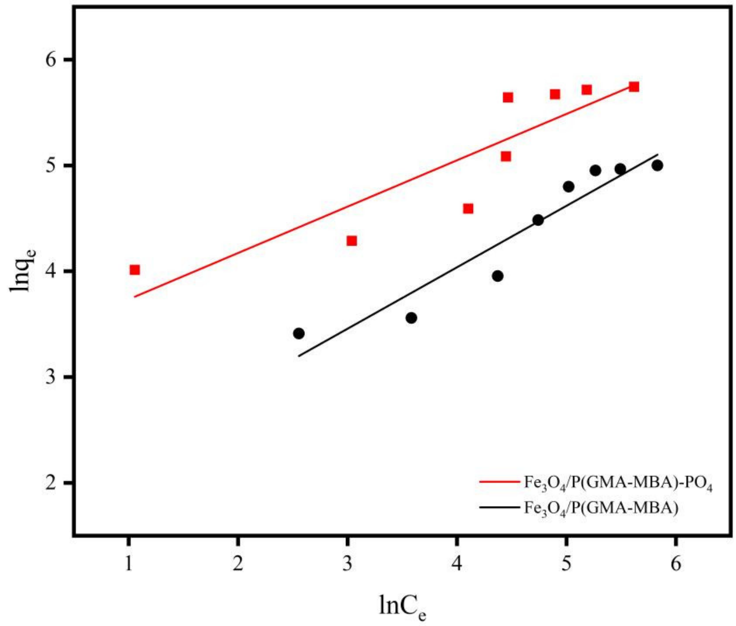

Figure S6. Freundlich modal.

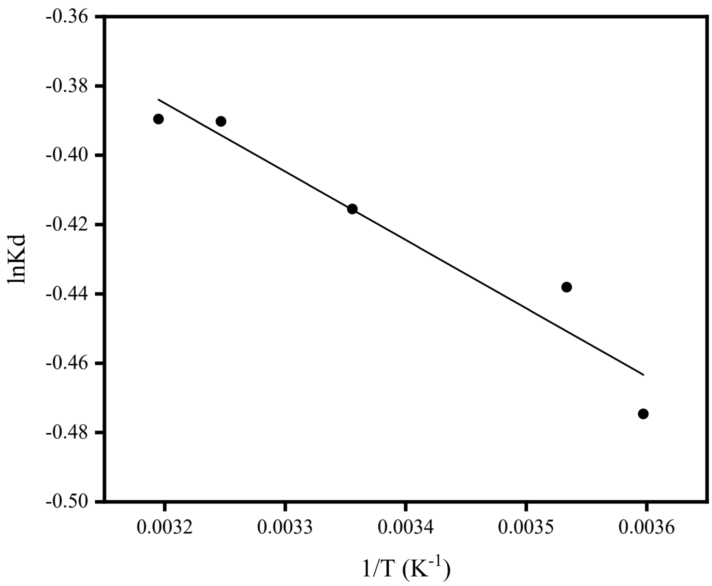

Figure S7. Thermodynamic image of U (VI) adsorbed by Fe_3O_4/P (GMA-MBA).

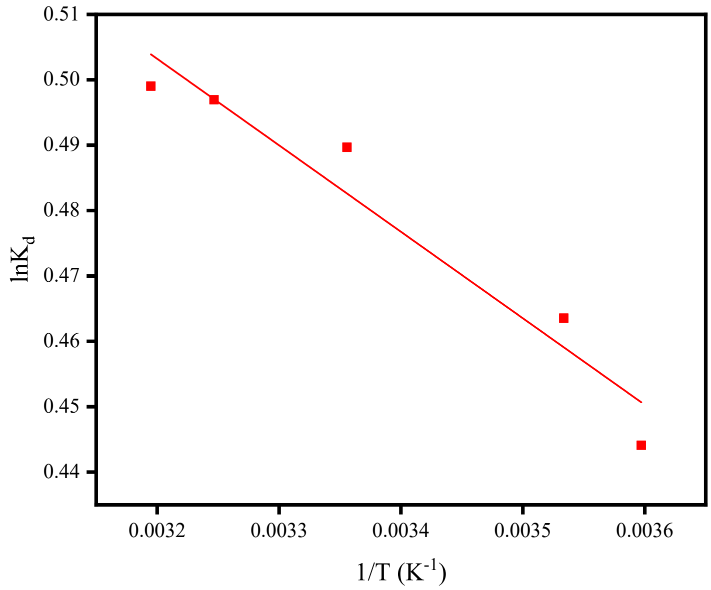

Figure S8. Thermodynamic image of U (VI) adsorbed by

Fe_3O_4/P(GMA-MBA)-PO_4

Table S1. Related kinetic parameters of uranium (VI) adsorption by Fe_3O_4/P(GMA-MBA) and Fe_3O_4/P(GMA-MBA)-PO_4.

Kinetic model	Parameter	Fe_3O_4/P(GMA-MBA)	Fe_3O_4/P (GMA-MBA)-PO_4
Pseudo-first-order	k_1 (1 sec^{-1})	0.0245	0.0309
	$q_{e.\ cal}$ (mg g^{-1})	20.28	31.70
	R^2	0.4478	0.5121
Pseudo-second-order	k_2 [g (mg^{-1} sec^{-1})]	0.0012	0.0011
	$q_{e.\ cal}$ (mg g^{-1})	52.91	101.21
	R^2	0.9729	0.9931
Intraparticle diffusion	K_{int} [mg (g^{-1} sec$^{-1/2}$)]	3.6017	5.7234
	c (mg g^{-1})	6.8808	32.894
	R^2	0.9430	0.7266

Table S2. Fe_3O_4/P(GMA-MBA) and Fe_3O_4/P(GMA-MBA)-PO_4 adsorption isotherm parameters for uranium.

Model	**Parameter**	**Fe_3O_4/P(GMA-MBA)**	**Fe_3O_4/P (GMA-MBA)-PO_4**
Langmuir	b (L mg $^{-1}$)	0.016	0.066
	q_{max} (mg g^{-1})	178.57	333.33
	R^2	0.995	0.9982
Freundlich	K_F (mg g^{-1})	5.77	27.042
	n_F	1.72	2.28
	R^2	0.9125	0.8051

Table S3. Thermodynamic parameters of Uranium adsorption by Fe_3O_4/P(GMA-MBA) and Fe_3O_4/P(GMA-MBA)-PO_4

Absorbent	**△H° (KJ mol⁻¹)**	**△S° (J mol⁻¹ K⁻¹)**	**△G° (KJ mol⁻¹)**				
			278K	283 K	298 K	308 K	313 K
Fe_3O_4/P(GMA-MBA)	1.640	2.048	-0.57	-0.58	-0.61	-0.63	-0.64
Fe_3O_4/P(GMA-MBA)-PO_4	4.514	7.702	-1.04	-1.12	-1.20	-1.28	-1.35

$$\ln K^\circ = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{RT} \qquad \text{Equation (S1)}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^0 \qquad \text{Equation (S2)}$$

where ΔH°, ΔS°, and ΔG° stands for the enthalpy (KJ mol^{-1}), entropy (J mol^{-1} K^{-1}) and Gibbs free energy (KJ mol^{-1}). K° is the sorption equilibrium constant (mL g^{-1}).