

Selective removal of lead ions from aqueous solutions using 1, 8-dihydroxyanthraquinon (DHAQ) functionalized graphene oxide; isotherm, kinetic and thermodynamic studies

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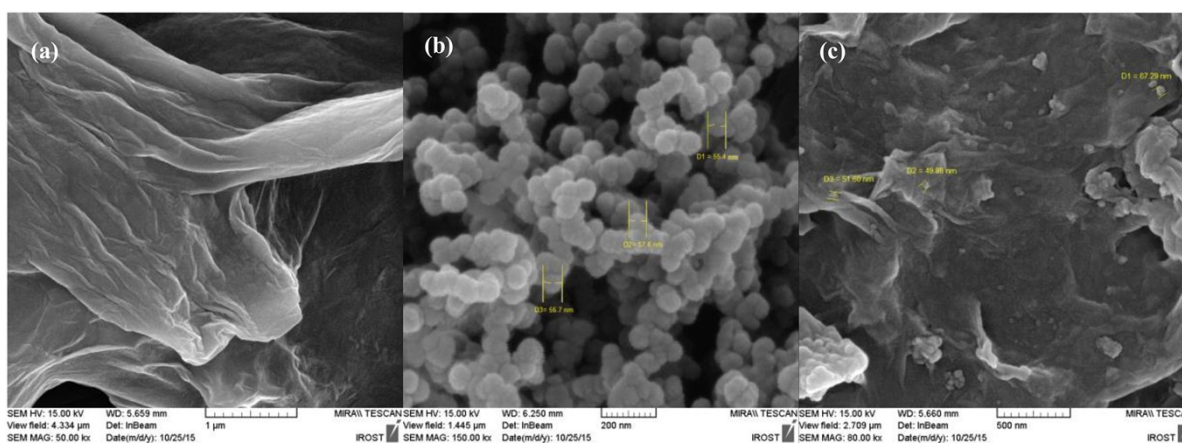


Figure S1. SEM images of GO (a), Fe₃O₄ nanoparticles (b), and Fe₃O₄@DHAQ_GO

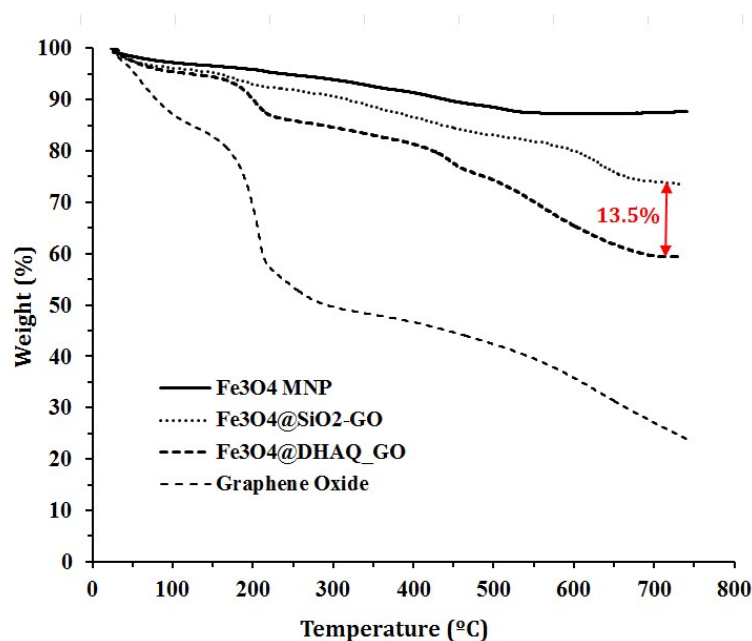


Figure S2. The TGA curves of Fe₃O₄ magnetic nanoparticles, Fe₃O₄@SiO₂-GO, Fe₃O₄@DHAQ_GO, and graphene oxide.

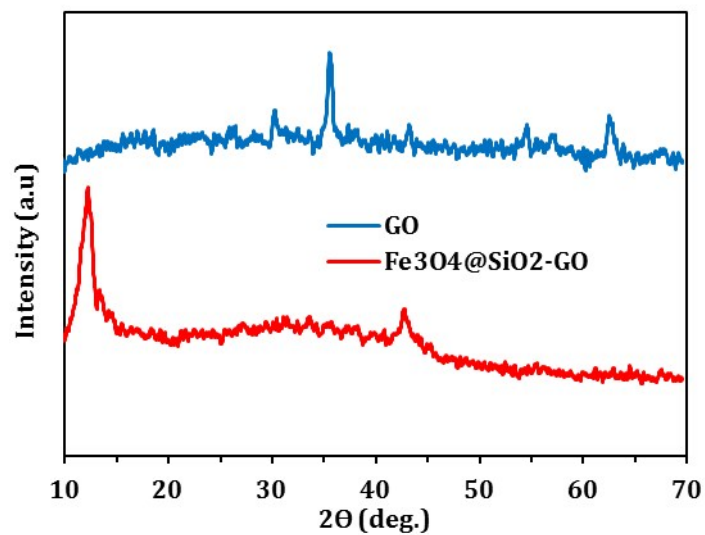


Figure S3. XRD patterns of GO (a) and $\text{Fe}_3\text{O}_4@SiO_2\text{-GO}$ (b).

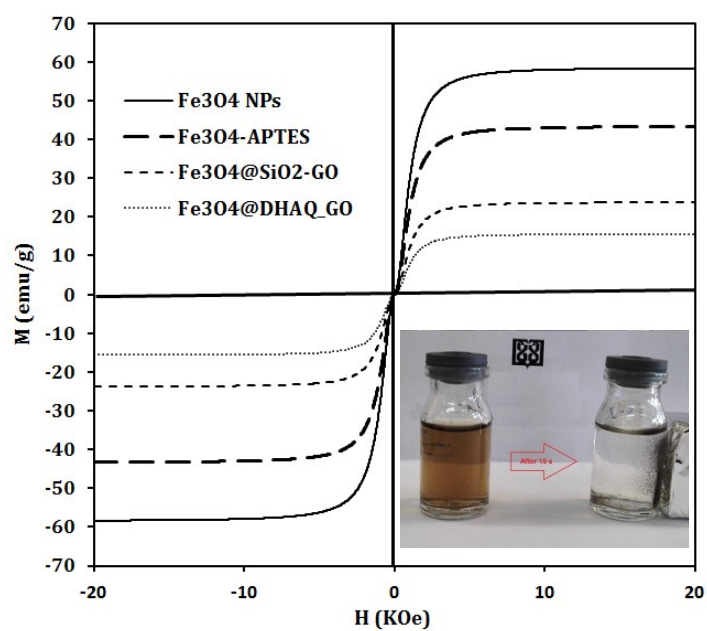


Figure S4. Hysteresis curves assigned to the Fe_3O_4 NPs (a), $\text{Fe}_3\text{O}_4\text{-APTES}$ (b), $\text{GO}@SiO_2\text{-Fe}_3\text{O}_4$ (c), and $\text{Fe}_3\text{O}_4@DHAQ_GO$ nanocomposite (d).

Table S1. The kinetic models for the adsorption of Pb²⁺ onto the Fe₃O₄@DHAQ_GO nanocomposite (adsorbent dosage 55 mg L⁻¹, pH 7).

T (K)	C ₀ (mg/L)	Pseudo-First Order			Pseudo-Second Order		
		q _e	K ₁	R ²	q _e	K ₂	R ²
278	2.5	35.9	0.153	0.972	39.9	5.50	0.988
	5	72.8	0.052	0.968	87.6	0.63	0.969
	10	127.5	0.077	0.956	142.7	0.69	0.981
293	2.5	38.9	0.114	0.829	42.4	4.43	0.891
	5	82.3	0.077	0.951	92.9	1.08	0.967
	10	134.5	0.085	0.829	149.7	0.76	0.903
308	2.5	39.7	0.323	0.928	43.2	11.45	0.961
	5	85.1	0.092	0.961	94.4	1.34	0.978
	10	155.0	0.103	0.944	169.5	0.86	0.974
323	2.5	41.2	0.695	0.948	44.1	22.04	0.965
	5	88.3	0.116	0.970	95.3	1.91	0.972
	10	161.3	0.157	0.973	174.3	1.30	0.987

Table S2. Ranking list of linear multiple regression models applied to describe the effect of main natural water ions on Pb²⁺ removal by Akaike's Information Criterion (AIC).

Model	DF ¹	SS ²	RSS ³	AIC	Rank
Y [*] =f(x ^{**})	-	-	290.69	86.131	1
y=f(x)+f(F ⁻)	1	9.741	280.95	87.109	2
y=f(x)-f(NO ₃ ⁻)	1	36.322	327.01	87.664	3
y=f(x)-f(K ⁺)	1	42.758	333.44	88.248	4
y=f(x)-f(Na ⁺)	1	52.605	343.29	89.121	5
y=f(x)-f(SO ₄ ²⁻)	1	113.585	404.27	94.027	6
y=f(x)-f(HCO ₃ ⁻)	1	171.305	461.99	98.03	7
y=f(x)-f(Cl ⁻)	1	185.74	476.43	98.953	8
y=f(x)-f(Mg ²⁺)	1	210.069	500.76	100.448	9
y=f(x)-f(Ca ²⁺)	1	304.764	595.45	105.644	10

P-value (Shapiro-Wilk normality test for Pb(II) Removal (-log(C_t/C₀)) = **0.094**

1. Degree of Freedom

2. Sum of Squares

3. Residual Sum of Squares

*y: Pb²⁺ Removal (-log(C_t/C₀))

**x: a×NO₃⁻+ b×K⁺+ c×Na⁺+ d×SO₄²⁻+ e×HCO₃⁻+ f×Cl⁻+ g×Mg²⁺+ h×Ca²⁺

Model coefficients: a, b, c..., h.

Ions concentration unit: mg/L