Supplementary Material

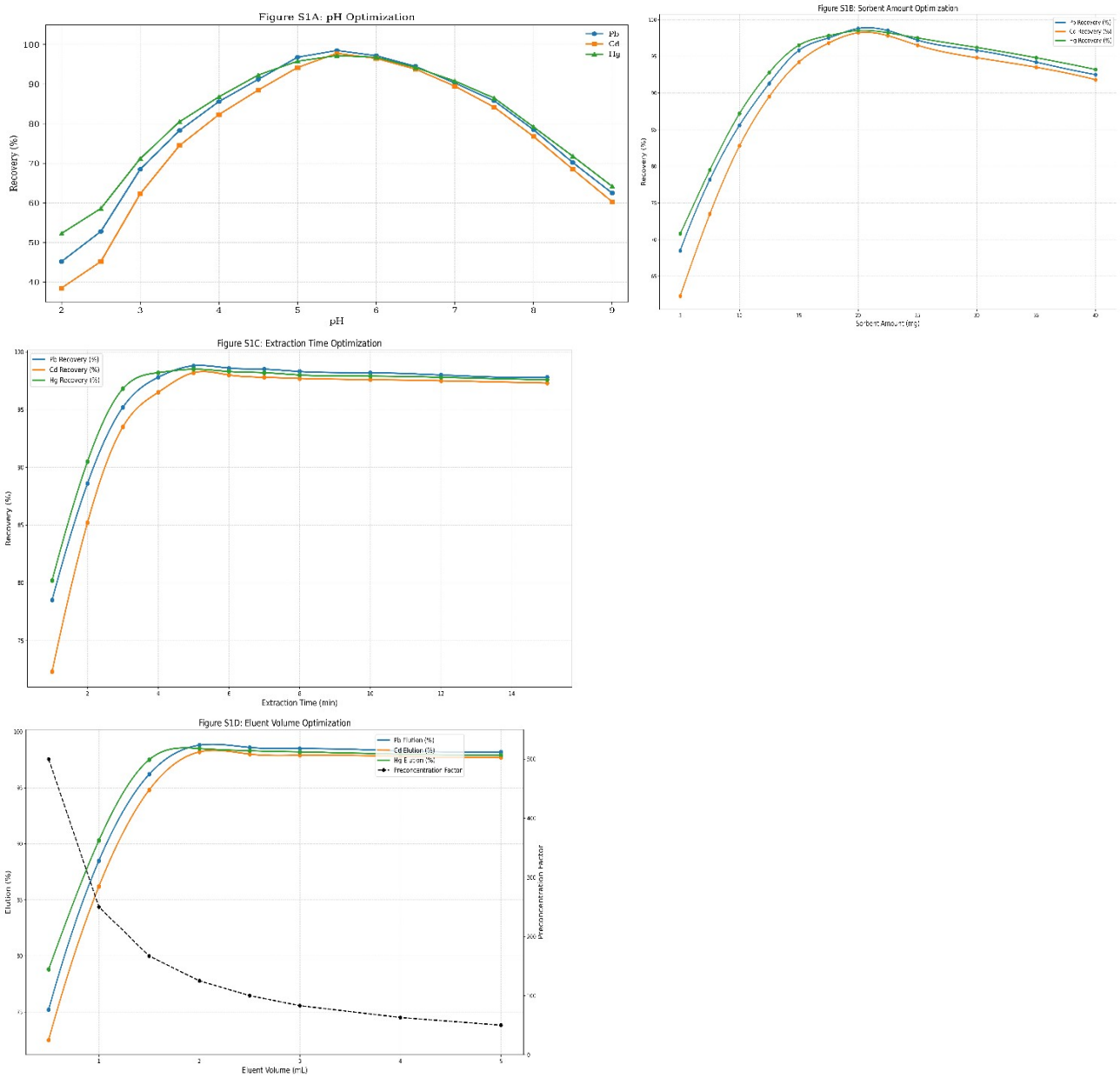

Figure S1. Optimization curves for (A) pH effect, (B) sorbent amount, (C) extraction time, and (D) eluent volume.

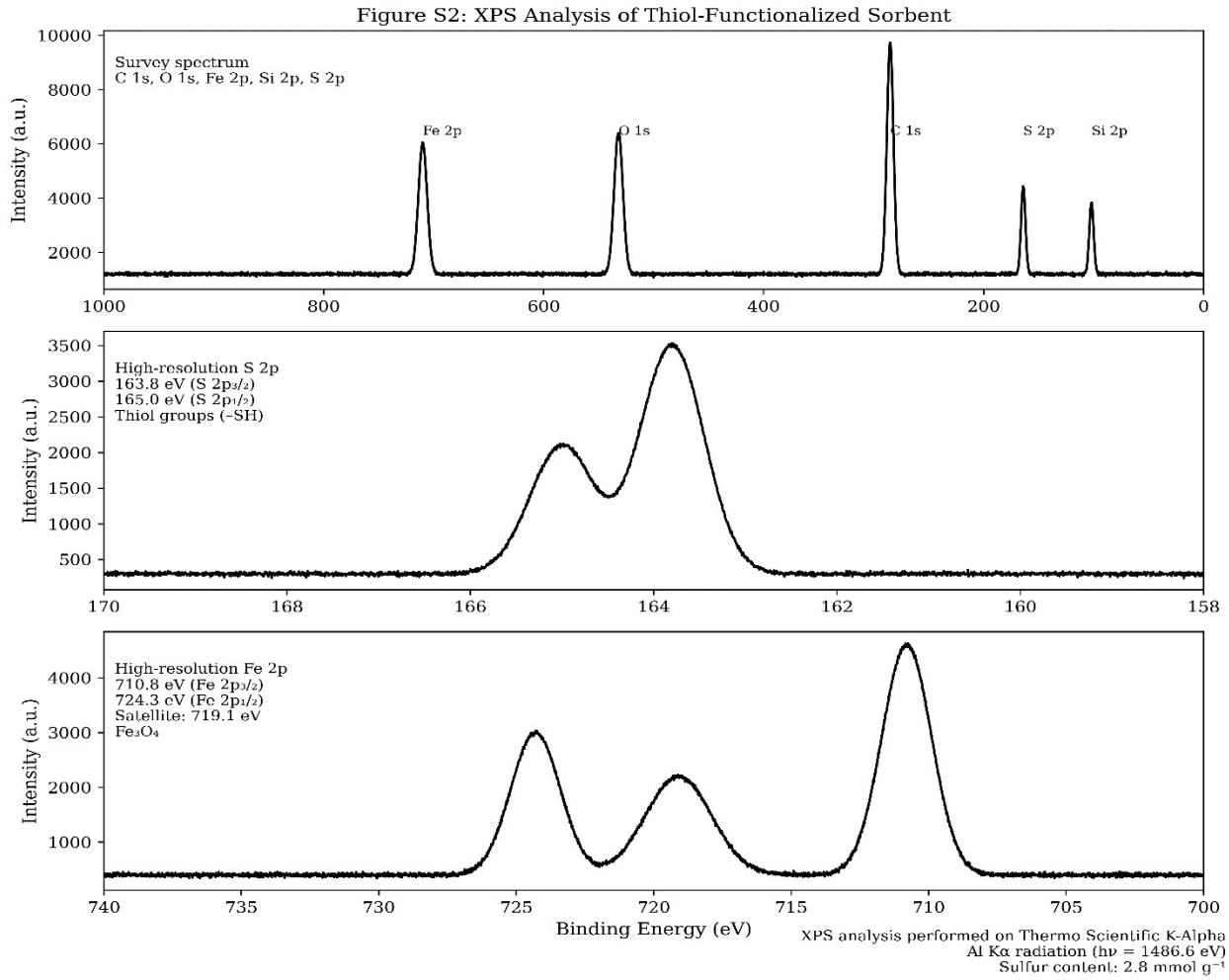

Figure S2. XPS survey spectrum and high-resolution spectra of S 2p, Fe 2p regions for MB–SH before and after metal adsorption.

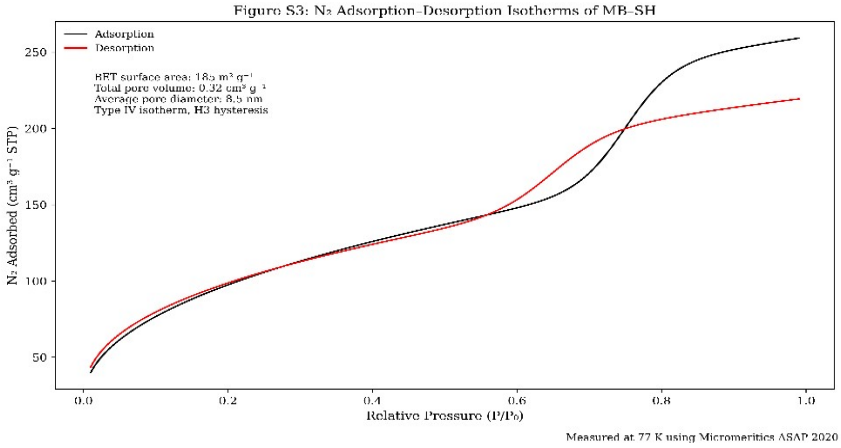

Figure S3. N_2 adsorption-desorption isotherms

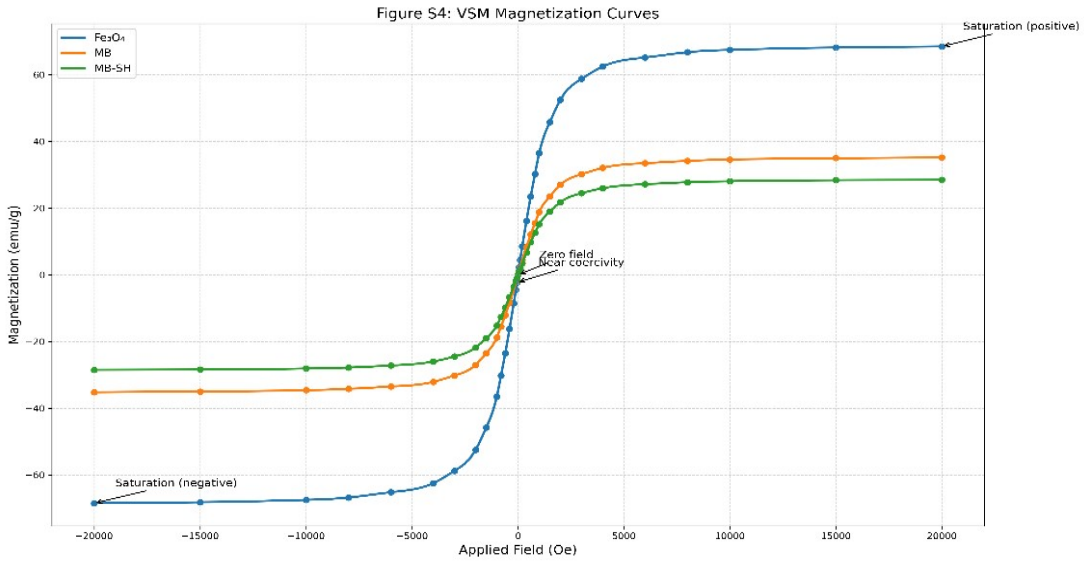

Figure S4. VSM magnetization curves of Fe_3O_4, MB, and MB–SH at room temperature.

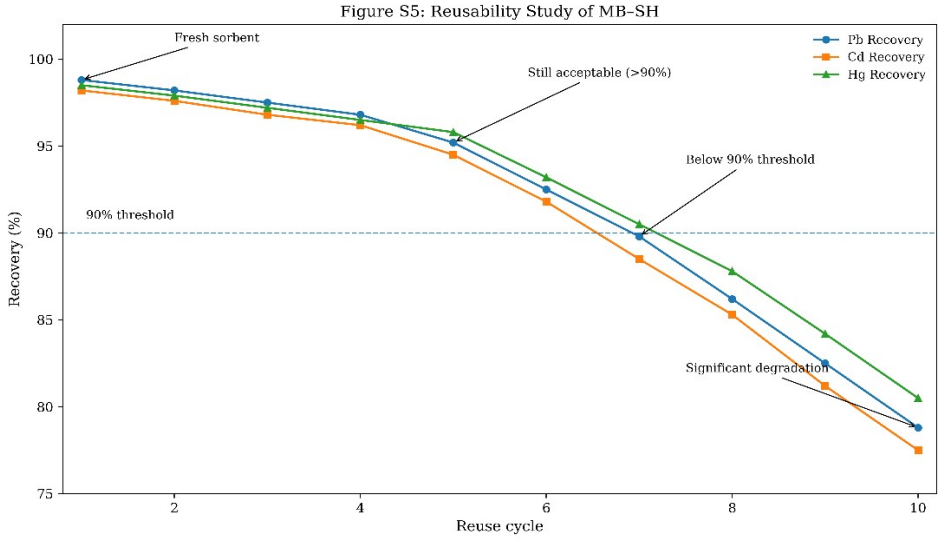

Figure S5. Reusability study showing recovery percentages over 10 consecutive adsorption-desorption cycles.

Table S1. Instrumental operating conditions for ICP-MS analysis.

Parameter	Value	Unit	Notes
RF Power	1550	W	Optimized daily
Plasma Gas Flow (Ar)	15.0	L/min	Outer gas
Auxiliary Gas Flow (Ar)	0.90	L/min	Intermediate gas
Nebulizer Gas Flow (Ar)	1.05	L/min	Carrier gas
Sampling Depth	8.0	mm	From the load coil
Spray Chamber	2	°C	Peltier cooled

Temperature			
Nebulizer Type	MicroMist		Glass concentric
Spray Chamber	Scott type		Double pass
Sample Uptake Rate	0.4	mL/min	Self-aspiration
Stabilization Time	30	s	Before measurement
Integration Time	0.1	s	Per mass
Replicates	3		Per sample
Acquisition Mode	Peak hopping		
Dwell Time	0.1	s	Per isotope
Sweeps per Replicate	100		
CRC Mode	He collision		For interference removal
He Gas Flow	4.5	mL/min	In the collision cell
Octopole Bias	-18	V	
Quadrupole Bias	-15	V	
Monitored Isotopes	208Pb, 111Cd, 202Hg		Main isotopes
Internal Standards	115In, 103Rh, 209Bi		At 10 µg/L
Internal Standard Mode	Online addition		Via T-piece
Rinse Time	60	s	Between samples
Rinse Solution	2% HNO3		Trace metal grade
Oxides (CeO/Ce)	<2	%	Daily check
Doubly Charged (Ce++/Ce+)	<3	%	Daily check

Table S2. Interference study results showing the effect of coexisting ions on the recovery of target analytes.

Interfering Ion	Concentration (mg/L)	Concentration Ratio (Ion: Metal)	Pb Recovery (%)	Cd Recovery (%)	Hg Recovery (%)	Notes
Na^+	100	10000	97.8	97.2	97.5	No interference
Na^+	200	20000	97.5	96.8	97.2	
K^+	100	10000	97.6	97.0	97.3	No interference
K^+	200	20000	97.3	96.7	97.0	
Ca^{2+}	250	25000	96.8	96.2	96.5	No interference
Ca^{2+}	500	50000	96.2	95.5	96.0	
Mg^{2+}	100	10000	97.2	96.8	97.0	No interference
Mg^{2+}	300	30000	96.5	96.0	96.3	
Al^{3+}	10	1000	96.8	96.2	96.5	Slight interference
Al^{3+}	50	5000	93.5	92.8	93.2	
Fe^{3+}	10	1000	96.2	95.5	96.0	Slight interference
Fe^{3+}	50	5000	92.8	91.5	92.5	

Cu^{2+}	5	500	96.5	95.8	96.2	Competing soft metal
Cu^{2+}	50	5000	88.5	87.2	89.2	Significant competition
Zn^{2+}	5	500	96.8	96.0	96.5	Competing soft metal
Zn^{2+}	50	5000	89.2	88.5	90.0	Significant competition
Cl^-	500	50000	97.5	97.0	97.2	No interference
Cl^-	1000	100000	97.2	96.5	96.8	
SO_4^{2-}	500	50000	97.3	96.8	97.0	No interference
SO_4^{2-}	1000	100000	96.8	96.2	96.5	
NO_3^-	500	50000	97.6	97.0	97.3	No interference
NO_3^-	1000	100000	97.2	96.6	96.9	
CO_3^{2-}	100	10000	96.5	95.8	96.2	Slight pH effect
CO_3^{2-}	500	50000	94.2	93.5	94.8	

Table S3. Comparison of the adsorption capacities of MB–SH with other thiol-functionalized sorbents reported in the literature.

Sorbent Material	Surface Area (m^2/g)	Pb Capacity (mg/g)	Cd Capacity (mg/g)	Hg Capacity (mg/g)	Synthesis Time (h)	Cost	Reference
Fe_3O_4–SiO_2–SH	245	85.2	62.5	105.8	48	High	[15]
MOF–SH	820	125.6	95.3	158.2	72	Very High	[22]
GO–Fe_3O_4–thiol	320	95.8	72.6	128.5	36	High	[28]
Mesoporous silica-MPTMS	580	105.3	82.5	145.6	60	Medium	[31]
Thiol-chitosan beads	125	68.5	52.3	88.6	24	Low	[37]
MB–SH (this work)	185	92.5	75.8	135.2	28	Low	This work