Sorbster Inc.

Ecologically Effective Contaminants Adsorption

Heavy Metals & Contaminants Removal — Product Line Card

EXPANDED CONTAMINANT MATRIX | REV. MARCH 2026

As · Ba · Cd · Cr · Pb · Hg · Se · Ag · U · V · F · B · Ni · SiO_2 · Sn · Zn · Cu · Sb · Tl · Mo

CORE TECHNOLOGY	PH OPERATING RANGE	RCRA 8 METALS	DISPOSAL
Chemisorption / Metal-Sulfide Precipitation	**3 – 10 · No sludge · Single-pass**	**As · Ba · Cd · Cr · Pb · Hg · Se · Ag**	**Passes EPA TCLP & CA WET (non-hazardous)**

Chemically Functionalized Medias

FeS and $(NH_4)Fe(SO_4)_2$ reactive surface layer on Fe_2O_3/Al_2O_3 bead

Sorbster® Hg-1
Sorbster® Se-1
Sorbster® MM-1

Macroporosity at >750Å = 0.12cc/g
Bulk density 52-54 lbs / Ft^3

METAL / ION	BONDING MECHANISM	BOND STRENGTH
RCRA 8 REGULATED METALS		
Hg (II)	HSAB soft acid/soft base: Hg^{2+} displaces Fe^{2+} in FeS lattice→ HgS ($K_{sp} = 10^{-53}$); surface precipitation + solid-solution substitution; irreversible	Permanent / Extremely Strong
Ag (I)	Ag_2S precipitation on FeS surface ($K_{sp} = 10^{-50}$); HSAB-matched soft-acid capture; most favorable thermodynamically	Permanent / Extremely Strong
Pb (II)	PbS surface precipitation ($K_{sp} = 10^{-28}$); reinforced by underlying ≡Fe–O–Pb inner-sphere complex	Permanent / Extremely Strong
Cd (II)	CdS precipitation ($K_{sp} = 10^{-27}$) on FeS layer; supplemented by ≡Fe–O–Cd coordination in sub-layer	Very Strong–Permanent
As (III/V)	Fe(III) in ammonium ferric sulfate layer oxidizes As(III)→As(V); strong ≡Fe– O–As inner-sphere complexation in sub-layers	Very Strong / Chemisorption
Se (IV/VI)	FeS reduces Se(VI)→Se(IV)→Se(0) / FeSe; coupled ≡Fe–O–Se inner-sphere in underlying Fe-oxide layer	Very Strong / Reductive+Sorptive
Cr (VI)	FeS reduces Cr(VI)→Cr(III); Cr(III) precipitates as $Cr(OH)_3$/ Cr–Fe co- precipitate; backed by ≡Fe–OH surface complex	Very Strong / Reductive Precip.

Dominant mechanism: Metal-sulfide precipitation (M–S covalent bond) via HSAB-matched soft acid/soft base. K_{sp} values for HgS, Ag_2S, CuS, PbS, CdS ZnS are among the lowest known — bonds thermodynamically near-permanent under normal groundwater pH/Eh. FeS also provides Fe(II/III) reductive pathways for Cr(VI), Se(VI), U(VI), Mo(VI), and V(V).

Iron-Oxide Promoted Activated Alumina

Fe_2O_3 / FeOOH (goethite/ferrihydrite) promoted inside Al_2O_3 bead

Macroporosity at >750Å = 0.12cc/g
Bulk density 48-50 lbs / Ft^3

METAL / ION	BONDING MECHANISM	BOND STRENGTH
RCRA 8 REGULATED METALS		
As (III/V)	Bidentate/monodentate inner-sphere ≡Fe–O–As complex; Fe–OH sites vastly higher K_{ads} than Al–OH; partial co-precipitation as Fe–As phase	Very Strong / Near-Irreversible
Se (IV/VI)	Bidentate inner-sphere ≡Fe–O–Se complex; Fe-OH dramatically expands capacity vs. plain AA	Very Strong / Chemisorption
Cr (VI)	Inner-sphere chromate at ≡Fe–OH_2^+; partial Fe(II)-mediated Cr(VI)→Cr(III) reductive precipitation	Strong–Very Strong
Pb (II)	Bidentate inner-sphere ≡Fe–O–Pb; high specificity & capacity; surface precipitation above loading threshold	Strong / Chemisorption
Cd (II)	Inner-sphere monodentate ≡Fe–O–Cd; iron oxide sites stronger than alumina alone	Strong / Chemisorption

Dominant mechanism: Inner-sphere bidentate/monodentate surface complexation at ≡Fe–OH iron oxyhydroxide groups. Fe sites carry 10–100× higher affinity constants (K_{ads}) than Al sites for oxyanions (As, Se, V, U, Mo, Sb, P) and divalent cations (Pb, Cd, Ni, Zn, Cu). Surface precipitation occurs at higher loadings.

Activated Alumina

Al_2O_3 · Amorphous aluminum oxide bead · Surface area >300 m^2/g

Macroporosity at >750Å = 0.12cc/g
Bulk density 36-40 lbs / Ft^3

METAL / ION	BONDING MECHANISM	BOND STRENGTH
RCRA 8 REGULATED METALS		
As (III/V)	Inner-sphere ligand exchange: arsenate displaces ≡Al–OH → ≡Al–O–As covalent surface complex	Strong / Chemisorption
Se (IV/VI)	Inner-sphere complexation of selenite/selenate at ≡Al–OH_2^+ via ligand exchange	Strong / Chemisorption
F^- / Fluoride	Ligand exchange: F^- replaces ≡Al–OH → ≡Al–F; strongest inner-sphere Al anion bond (highest selectivity)	Strong / Chemisorption

Dominant mechanism: Ligand exchange (inner-sphere) at amphoteric ≡Al–OH surface hydroxyls for oxyanions (F^-, As, Se, Cr, V, U, Mo, Sb, P). Outer-sphere electrostatic adsorption for divalent cations (Pb, Cd, Ni, Zn, Cu, Ba). Optimal pH: 5.5–7.5 for anions; 7–9 for cations.

Bond Strength

- Permanent/Extremely Strong — Metal-sulfide precipitation (HgS, Ag_2S, CuS, PbS, CdS); thermodynamically irreversible (K sp $<10^{-24}$)
- Very Strong/Chemisorption — Inner-sphere bidentate complex or reductive immobilization; K d $>10^4$;not regenerable under normal conditions
- Strong/Chemisorption — Inner-sphere monodentate; Kd10^3–10^4; reversible only at extreme pH

★ **HSAB** Hard-Soft Acid-Base theory (Pearson). Soft acids (Hg,Ag, Cu, Pb, Cd) bond preferentially with soft bases (S^{2-}); hard acids (As, Se, V, Cr) bond preferentially with hard bases (O^{2-}, OH^-). The chemically functionalized media's FeS layer exploits both.

★ **Boron / B** All three products provide moderate boron removal (≤~40–65%at optimal pH8–9).For demanding boron targets consider supplemental media or pH adjustment pre-treatment.

★ **Competing Ions** Phosphate, silicate, bicarbonate, and sulfate compete for anion sites on activated alumna media. Pilot testing recommended for complex matrices. Contact Sorbster for site-specific capacity estimates.

sorbster.com · 216-533-2343 · info@sorbster.com

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Chemically Functionalized Medias

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METAL / ION	BONDING MECHANISM	BOND STRENGTH
ADDITIONAL PRIORITY CONTAMINANTS		
Cu (II)	CuS precipitation (K_{sp} = 10^{-36}); Cu^{2+} displaces Fe^{2+} in FeS lattice via HSAB-matched soft-acid mechanism	Permanent / Extremely Strong
U (VI)	FeS reductively immobilizes UO_2^{2+}→U(IV)/UO_2(s); electrostatic attraction + surface complexation; FeS among most effective reductants for uranium	Very Strong / Reductive
Zn (II)	ZnS precipitation (K_{sp}= 10^{-24}); Zn^{2+} displaces Fe from FeS; chemisorption + metal-sulfide bond formation	Very Strong
Ni (II)	Sulfide-mediated FeS surface reaction; NiS precipitation + FeS-bcatalyzed Ni reduction to Ni^0 on sulfidated Fe surface	Strong–Very Strong
V (V)	FeS/Fe(III) redox pathways partially reduce V(V)→V(IV); underlying ≡Fe–OH inner-sphere complexation retained	Strong
Mo (VI)	FeS reduces Mo(VI)→Mo(IV); MoS_2/FeMoS surface phases; combined reductive + sorptive removal	Strong / Reductive
Sb (V)	Partial FeS reductive conversion Sb(V)→Sb(III); Sb_2S_3 surface precipitation(K_{sp} very low); inner-sphere ≡Fe–O–Sb	Strong
Tl (I/III)	Tl_2S precipitation (soft acid); Tl(I) displaces Fe in FeS surface — notable improvement over activated alumina media and Fe-Oxide promoted media	Strong (Tl_2S surface precip.)
Sn (IV)	SnS_2 surface precipitation possible (K_{sp} very low); combined sulfide + ≡Fe–OH pathways	Strong (SnS surface precip.)

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METAL / ION	BONDING MECHANISM	BOND STRENGTH
ADDITIONAL PRIORITY CONTAMINANTS		
U (VI)	Strong bidentate inner-sphere ≡Fe–O–UO_2 surface complex; goethite/ferrihydrite among best sorbents for uranyl; pH 5–8 optimal	Very Strong / Chemisorption
V (V)	Bidentate inner-sphere vanadate complexation at≡Fe–OH; iron oxyhydroxidenhas very high affinity for V(V); pilot-scale validated	Very Strong / Chemisorption
Phosphate	Very strong bidentate inner-sphere ≡Fe–O–PO_3H; competing anion with As/V — higher capacity than activated alumina	Very Strong
F^- / Fluoride	Inner-sphere ≡Fe–F and ≡Al–F surface complexes; Fe loading adds additional active sites for fluoride	Strong / Chemisorption
Ni (II)	Inner-sphere ≡Fe–O–Ni complexation; Fe-oxide sites substantially better for Ni vs. Al-OH	Strong / Chemisorption
Zn (II)	Inner-sphere bidentate ≡Fe– O Zn; iron oxide has well-documented high affinity for Zn^{2+}	Strong / Chemisorption
Cu (II)	Inner-sphere bidentate coordination ≡Fe–O–Cu; copper strongly sorbs to iron oxide surfaces	Strong / Chemisorption
Sb (V)	Strong inner-sphere ≡Fe–O–Sb complex (analogous to arsenate); Fe-OH sites markedly improve Sb removal	Strong / Chemisorption
Mo (VI)	Inner-sphere molybdate at ≡Fe–OH_2^+; Fe-oxide markedly more effective than plain AA for Mo	Strong / Chemisorption

Activated Alumina

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METAL / ION	BONDING MECHANISM	BOND STRENGTH
ADDITIONAL PRIORITY CONTAMINANTS		
U (VI)	Inner-sphere surface complexation of UO_2^{2+} at ≡Al–OH; pH-dependent — optimal near pH 6–8; electrostatic + specific coordination bond	Strong / Chemisorption
V (V)	Inner-sphere ligand exchange of vanadate (VO_4^{3-}) / VO_2^+ at ≡Al–OH_2^+ sites, similar to arsenate pathway; optimal pH 4–7	Strong / Chemisorption
Phosphate	Strong inner-sphere ligand exchange at ≡Al–OH (competes with As/V); forms ≡Al–O–PO_3H	Strong / Chemisorption

All three products provide moderate boron removal (≤~40–65%at optimal pH8–9).For demanding boron targets consider supplemental media or pH adjustment pre-treatment.