

Table S1. Reagents used in the flotation tests

Reagent type	Name	Abbreviation	Solvent	Reagent grade	Provider
Carboxylic acids / Carboxylates	RA935	RA935	NaOH solution	Commercially pure	Wuhan Xianghui Ore Dressing Technology Co.,Ltd.
	Oxidized paraffin soap	OPS	H ₂ O	Commercially pure	Beining Lv Feng Chemical Plant
	Refined tall oil	RTO	NaOH solution	Commercially pure	Shanghai Lisen Chemical Co.,Ltd.
	Tall oil fatty acid	TOFA	NaOH solution	Commercially pure	Shanghai Lisen Chemical Co.,Ltd.
	Sodium oleate	NaOl	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Sodium linoleate	NaL	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Phthalic acid	PA	NaOH solution	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
Hydroxamic acid	Salicylhydroxamic acid	SHA	NaOH solution	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Octyl hydroxamic acid	OHA	NaOH solution	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	H205	H205	NaOH solution	Commercially pure	Baotou Menghua Reagents Co.,Ltd.
	P-tert-butyl Benzohydroxamic acid	PBA	NaOH solution	Commercially pure	Baotou Menghua Reagents Co.,Ltd.
	Alkyl hydroxamic acid	AHA	H ₂ O	Commercially pure	Tieling Flotation Reagents Co.,Ltd.

Reagent type	Name	Abbreviation	Solvent	Reagent grade	Provider
Sulfonate	Sodium dodecyl benzene sulfonate	SDBS	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Sodium dodecyl sulfonate	SDS	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
Phosphoric acids	Bis(2-ethylhexyl)phosphate	P204	NaOH solution	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	2-ethylhexyl phosphate mono-2-ethylhexyl ester	P507	NaOH solution	Commercially pure	Wuhan Geeyyeschem Chemical Co., Ltd
Other	Sodium hydroxide	NaOH	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Sodium carbonate	Na ₂ CO ₃	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Magnesium fluosilicate	MgSiF ₆	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Water glass	WG	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Ethanolamine	EA	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Polysorbate-80	Tween 80	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.
	Polysorbate	Tween 80	H ₂ O	Chemically pure	Shanghai Macklin Biochemical Co.,Ltd.

Table S2. The specific descriptions of flotation condition tests.

Test type		Inhibitor dosage test	Activator dosage test	Grinding fineness test
Process		One roughing, one scavenging.	One roughing, two cleanings.	One roughing, one scavenging, two cleanings.
Reagent dosage	Roughing	Na ₂ CO ₃ : 1 kg/t. WG: 1.4/ 2.0/ 2.6/ 3.2 kg/t. MgSiF ₆ : 300 g/t. Collector: 400 g/t.	Na ₂ CO ₃ : 1 kg/t. WG: 2 kg/t. MgSiF ₆ : 300/ 600/ 900/ 1200 g/t. Collector: 400 g/t.	Na ₂ CO ₃ : 1 kg/t. WG: 2 kg/t. MgSiF ₆ : 900 g/t. Collector: 400 g/t.
	Scavenging	Collector: 200 g/t.		Collector: 200 g/t.
	Cleaning		WG: 200 g/t (each cleaning).	
Other conditions		Fineness of 90% passing 0.038 mm. Pulp temperature: 40 °C. Pulp concentration: 30%. pH: 8.6 ± 0.2.	Fineness of 90% passing 0.038 mm. Pulp temperature: 40 °C. Pulp concentration: 30%. pH: 8.6 ± 0.2.	Fineness of 50%/ 70%/ 85%/ 90%/ 94% passing 0.038 mm. Pulp temperature: 40 °C. Pulp concentration: 30%. pH: 8.6 ± 0.2.

Table S3. Mineralogical composition of the as-prepared HIMS concentrates.

Mineral	Aeschnite	Albite	Allanite	Almandine	Apatite	Arfvedsonite	Bastnaesite	Calcite	Chlorite
%Wt.	0.333	6.912	0.206	3.28	0.009	21.382	0.122	0.028	0.09
Mineral	Columbite	Fergusonite	Fluorite	Hematite	Hingganite	Ilmenite	Kaolinite	Melanotekite	Monazite
%Wt.	1.359	0.022	0.035	2.866	2.349	2.704	3.79	0.424	0.732
Mineral	Orthoclase	Pyrite	Pyrochlore	Pyrolusite	Quartz	Rutile	Thorite	Titanite	Zircon
%Wt.	13.849	0.007	0.241	0.056	22.704	0.218	0.673	0.175	15.439