

**Methanesulfonic acid: a sustainable acidic solvent for recovering
metals from jarosite residue of the zinc industry**

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Electronic Supplementary Information

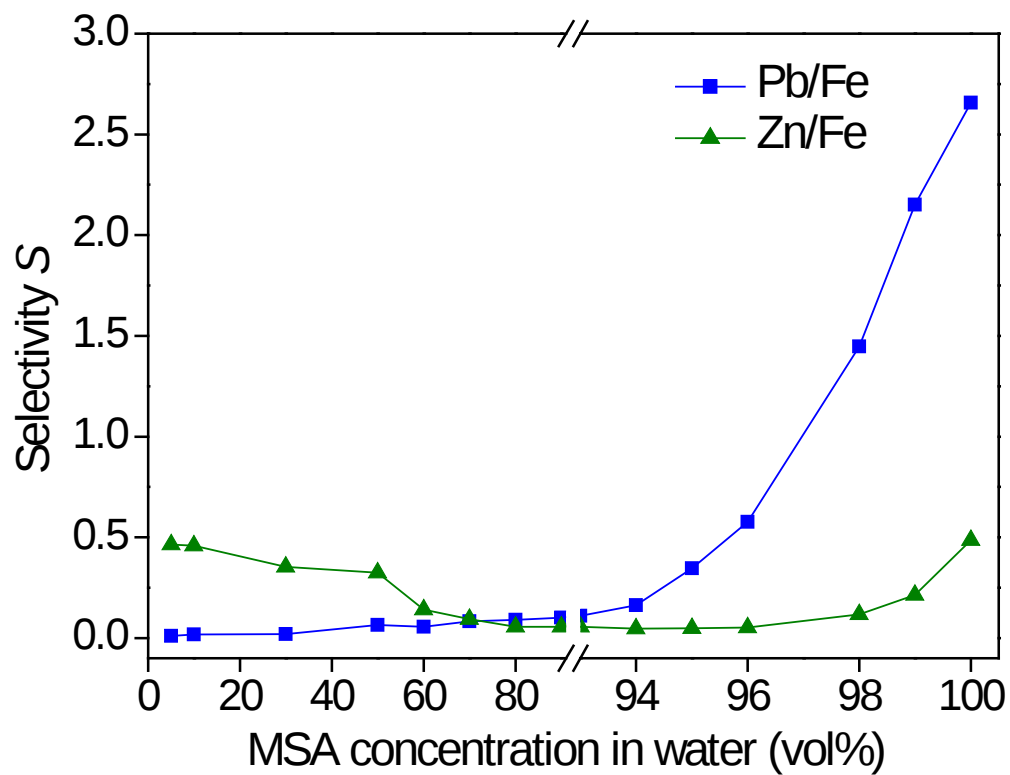


Figure S1: Effect of the MSA concentration on the selectivity S (Pb/Fe or Zn/Fe ratio) towards Pb and Zn over Fe in the pregnant leach solution (PLS).

Electronic Supplementary Information

Table S1: Concentrations of lead, zinc and iron (mg L^{-1}) in the PLS after leaching jarosite with different concentrations of MSA in water.

MSA (vol%)	Fe (mg L^{-1})	Zn (mg L^{-1})	Pb (mg L^{-1})
5	1215	564	13
10	1708	784	30
30	3063	1085	59
50	3551	1153	233
60	5320	755	295
70	8188	768	677
80	14965	827	1367
90	14902	831	1518
93	15004	836	1646
94	10600	499	1730
95	4948	237	1712
96	3109	161	1796
98	1295	152	1874
99	921	196	1981
100	767	373	2038

[§] Leaching parameters: L/S ratio 10 mL g^{-1} , contact time 2 h, 60 °C, 600 rpm.

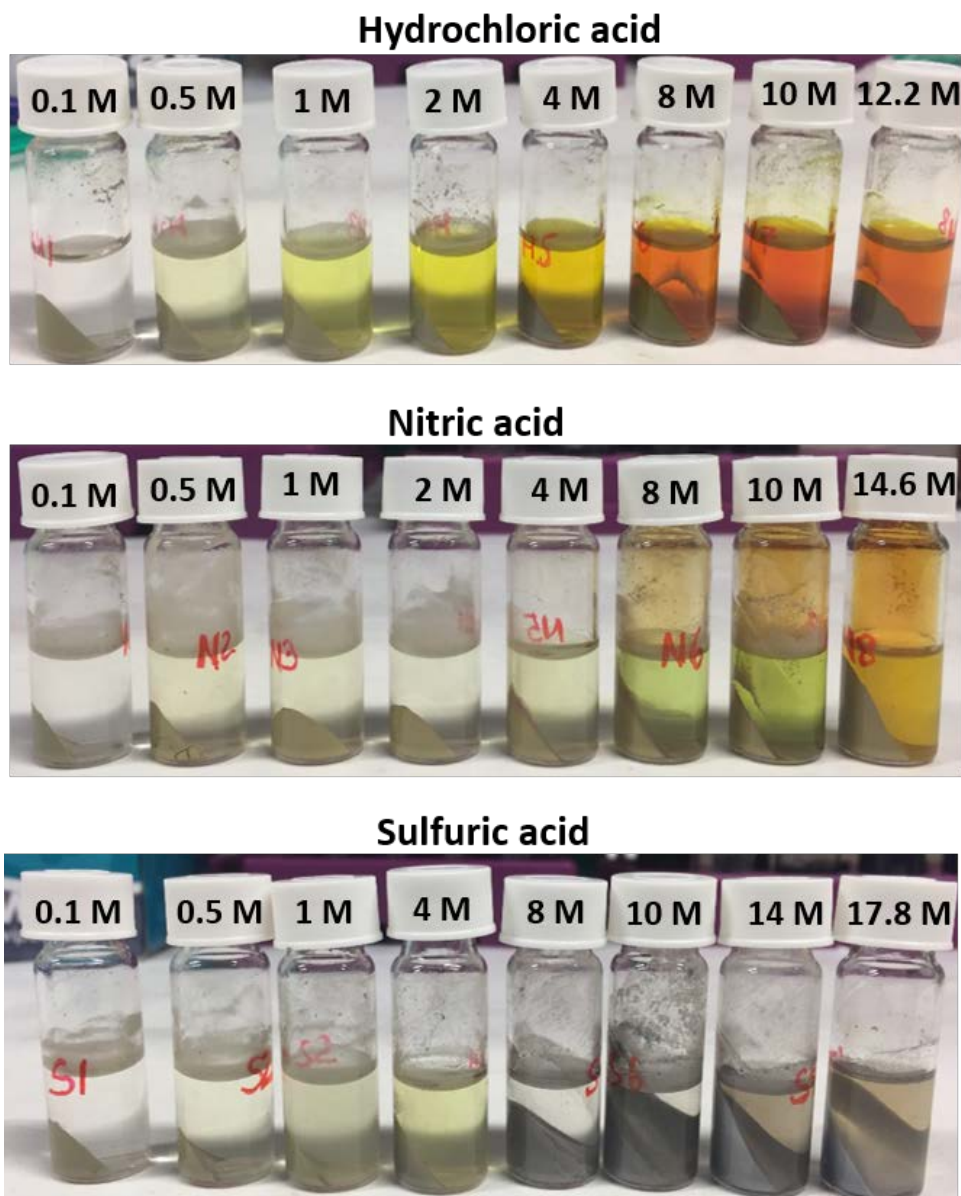


Figure S2: Liquid (PLS) and solid phases (leaching residue and precipitate) after leaching of jarosite by mineral acids (H_2SO_4 , HCl , HNO_3). Leaching parameters: L/S ratio 10 mL g^{-1} , contact time 2 h, 60°C , stirring speed 600 rpm.

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Table S2: Concentrations of lead, zinc and iron (mg L^{-1}) in the PLS after leaching jarosite with different concentrations of sulfuric, nitric and hydrochloric acid.[§]

mol L^{-1}	Hydrochloric acid			Nitric acid			Sulfuric acid		
	Fe (mg L^{-1})	Zn (mg L^{-1})	Pb (mg L^{-1})	Fe (mg L^{-1})	Zn (mg L^{-1})	Pb (mg L^{-1})	Fe (mg L^{-1})	Zn (mg L^{-1})	Pb (mg L^{-1})
0.1	747	694	6	673	577	73	825	598	137
0.5	2177	772	120	2705	976	26	2577	675	50
1	3975	790	460	3391	922	102	4268	728	45
2	9104	1127	1793	4387	978	201	-	-	-
4	15003	1368	2746	5675	979	893	12118	892	490
8	-	-	-	7276	1510	1631	235	272	98
10	15990	1326	4349	8156	1842	1752	246	313	225
12	16353	1815	4359	-	-	-	-	-	-
14							93	111	133
14.6				2232	1821	1821	-	-	-

[§]Leaching parameters: contact time 2 h, stirring speed 600 rpm.

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Table S3: Concentrations of lead, zinc and iron (mg L^{-1}) in the PLS after leaching jarosite with pure MSA at different temperatures and liquid-to-solid ratios.[§]

Temp.	Metal	L/S 15 (mg L^{-1})	L/S 20 (mg L^{-1})	L/S 30 (mg L^{-1})	L/S 40 (mg L^{-1})
60 °C	Fe	536	409	293	224
	Zn	199	183	135	96
	Pb	1464	1375	950	733
100 °C	Fe	709	618	410	324
	Zn	490	423	290	231
	Pb	1977	2060	1402	1084
130 °C	Fe	1028	872	629	486
	Zn	805	648	402	305
	Pb	2475	2180	1455	1092
160 °C	Fe	1703	1899	1145	949
	Zn	1266	963	621	463
	Pb	2885	2294	1522	1106

[§]Leaching parameters: contact time 2 h, stirring speed 600 rpm.

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Table S4: Concentrations of lead, zinc and iron (mg L^{-1}) in the PLS after leaching jarosite with pure MSA for different time periods.[§]

Time (min)	Fe (mg L^{-1})	Zn (mg L^{-1})	Pb (mg L^{-1})
1	474	242	1262
2	553	317	1646
5	621	361	1835
10	699	404	1942
15	740	428	1999
30	830	488	2063
60	835	532	1988
90	859	589	2097
120	860	660	2237
240	782	736	2127
360	760	792	2106

[§]Leaching parameters: L/S ratio 20 mL g^{-1} , 130°C , stirring speed 600 rpm.

Table S5: Concentrations of lead, zinc and iron (mg L^{-1}) in the PLS after leaching jarosite with pure MSA by fresh and recycled MSA[§]

Cycle no.	Fe (mg L^{-1})	Zn (mg L^{-1})	Pb (mg L^{-1})
fresh MSA	860	660	2237
1 st cycle	870	606	2225
2 nd cycle	1143	535	1988
3 rd cycle	1321	546	1891

[§] Leaching parameters: L/S ratio 20 mL g^{-1} , contact time 2 h, 130°C , 600 rpm.

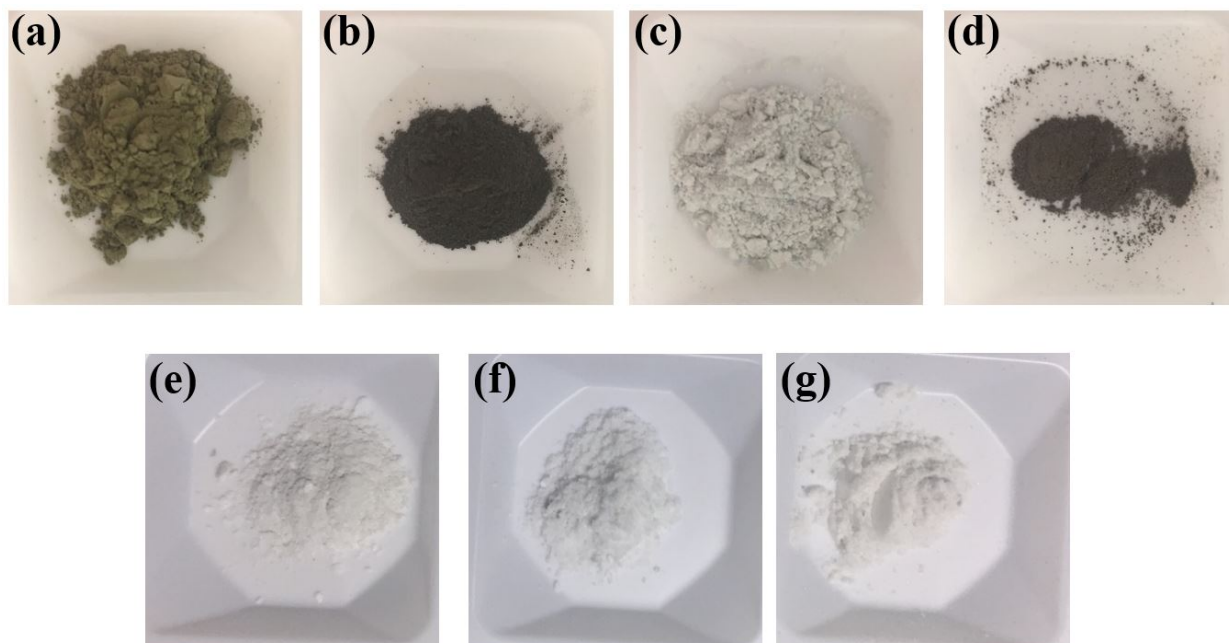


Figure S3: Photographs of the starting material (a) jarosite, and (b) leaching residue, (c) white precipitates and (d) distillation residue from MSA leaching of jarosite, and precipitates from MSA leaching of metallic (e) iron, (f) zinc and (g) lead.

Table S6: Concentrations of lead, zinc and iron (mg L^{-1}) in the PLS after leaching jarosite with pure MSA at different scales.[§]

Scale	Amount of jarosite used (g)	Fe (mg L^{-1})	Zn(mg L^{-1})	Pb (mg L^{-1})
Small scale	0.1	860	660	2237
Upscale (lab set-up)	10	801	573	2077
Upscale (mini pilot plant)	25	933	635	2060

[§] Leaching parameters: L/S ratio 20 mL g^{-1} , contact time 2 h, 130°C , 600 rpm.