Electronic Supplementary Material (ESI) for Materials Chemistry Frontiers.

Supplementary Information

Selective Recovery of Copper from Lithium-Ion Battery E-Waste with a Sustainable Sulfur Polymer.

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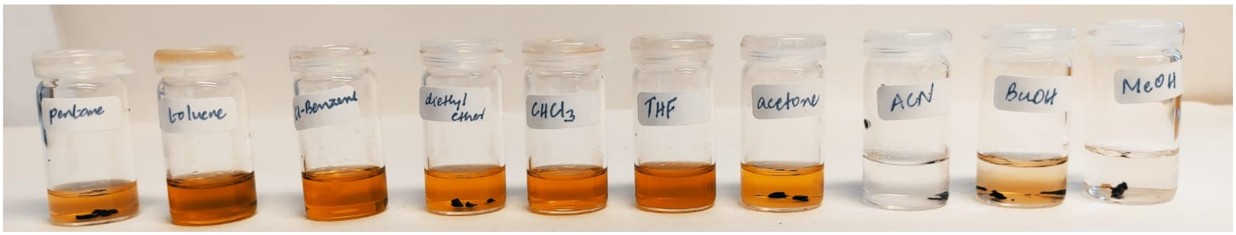


Figure S1: Solubility of Poly(S-50 %-OA) with increasing solvent polarity 10 mg in 2 mL solvent. From left to right the solvents are pentane, toluene, chloro-benzene, diethyl ether, chloroform, tetrahydrofuran, acetone, acetonitrile, butanol and methanol.

Table S1: Assignment of vibrational modes of monomers (oleylamine, sulfur) and Poly(S-50%-OA) in cm^{-1}

Vibrational modes (frequency range cm^{-1})	Frequency (cm^{-1})	
	Monomers	Poly(S-50%-OA)
N-H stretching (3400-3300) primary amine	3320	3172
alkene C-H stretching (3100-3000)	3006	No peak
C-H_2 stretching (3000-2840)	2920, 2850	2920, 2850
C=C stretching (1662-1626)	1650	No peak
C-H bending (1465) (alkane; methylene group)	1466	1454
C-N stretching (1250-1020)	1062	1086
C=C bending (980-960)	965	weak signal
C-H bending (810±20) 1,4 disubstituted	820	844
N-H bending (out of plane)	720	720
S-S (465)	465	465

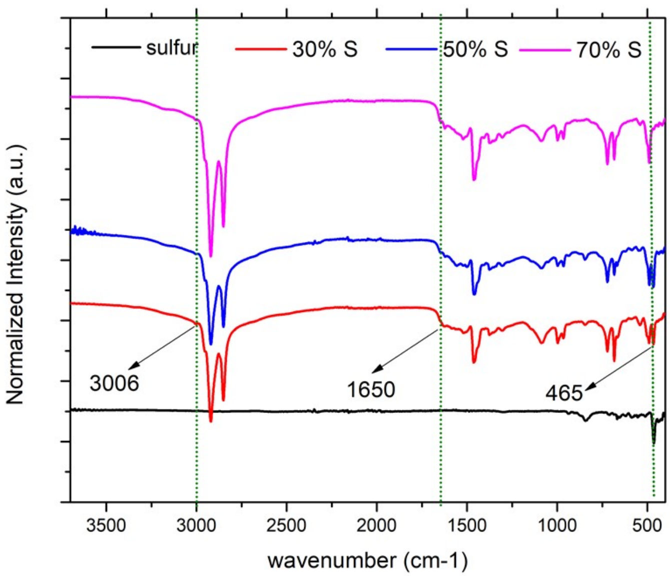


Figure S2: AT-FTIR spectra of sulfur-oleylamine copolymer with varied sulfur content (wt %) in comparison with sulfur. Green, blue, red and black line denotes Poly(S-30 %-OA), Poly(S-50 %-OA), Poly(S-70 %-OA), and elemental sulfur respectively.

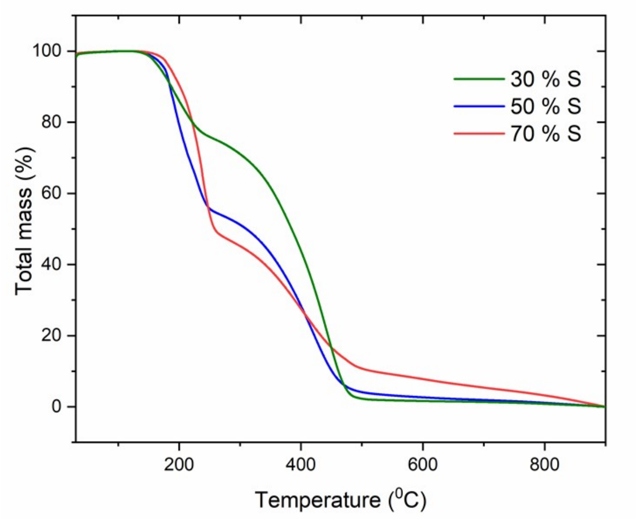
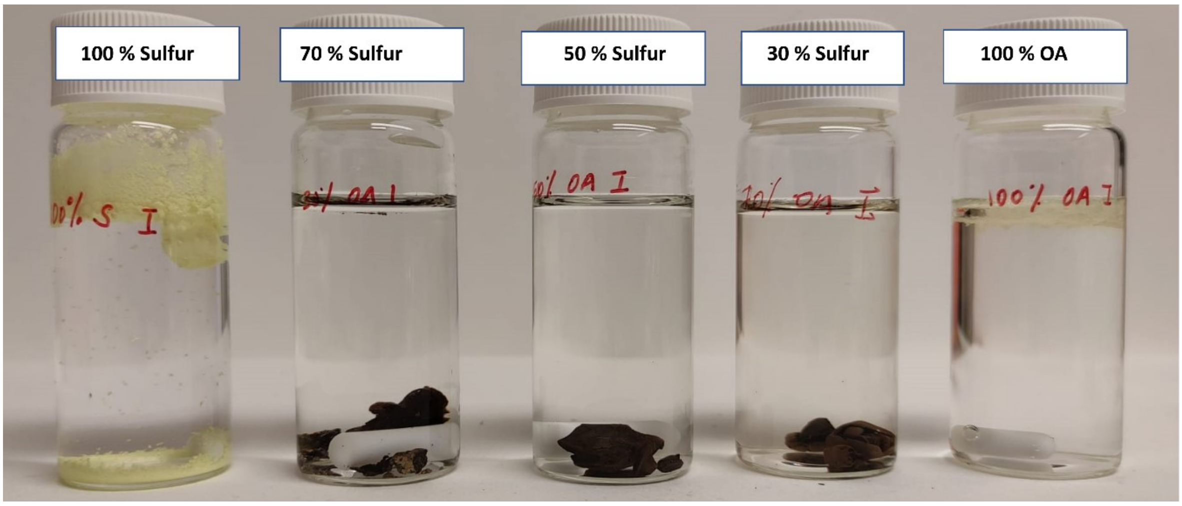


Figure S3: Thermogravimetric analysis (TGA) of sulfur-oleylamine copolymer with varied sulfur content (wt %). Green, blue and red line denotes Poly(S-30 %-OA), Poly(S-50 %-OA) and Poly(S-70 %-OA) respectively.



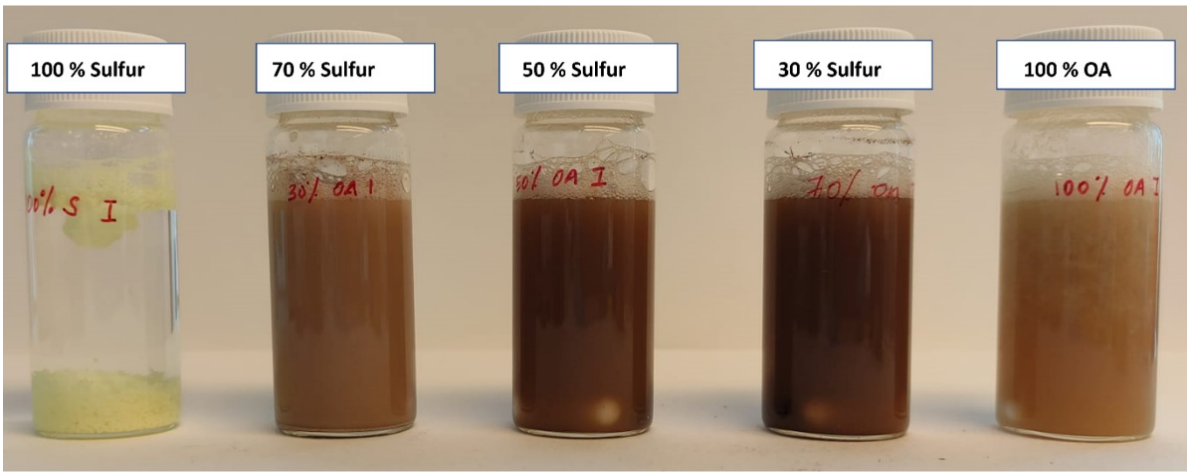


Figure S4: Photograph of batch experiment on selectivity studies before and after adsorption are shown above and below respectively. 25 mg L^{-1} 20 mL aqueous mixed metal solutions treated with 100 % sulfur, Poly(S-70 %-OA), Poly(S-50 %-OA), Poly(S-30 %-OA), 100 % oleylamine are shown from left to right.

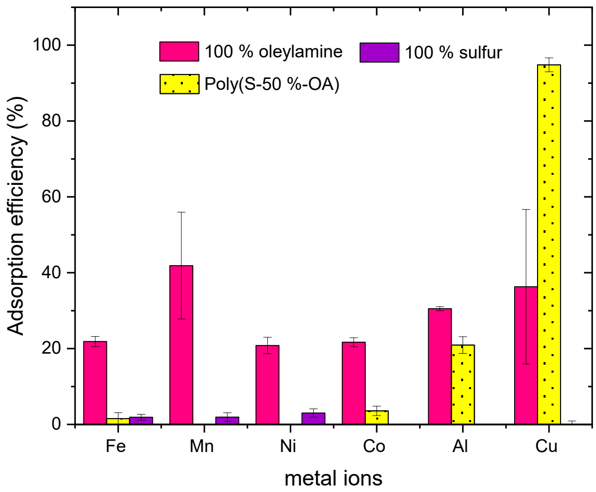
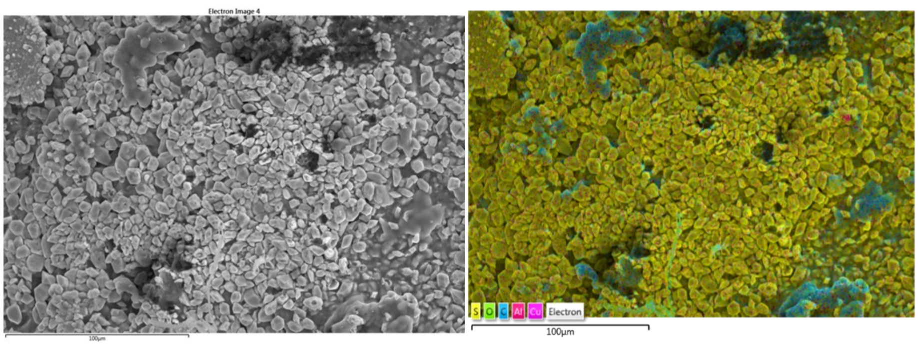


Figure S5: Metal selectivity profile in terms of adsorption efficiency (%). 100 % sulfur and 100 % oleylamine are monomers, done as control experiments.

	Initial pH	Final pH
Control	4±0.5	4±0.5
100 % sulfur	4±0.5	4.33±0.5
Poly(S-70 %-OA)	4±0.5	5.70±0,5
Poly(S-50 %-OA)	4±0.5	4.94±0,5
Poly(S-30 %-OA)	4±0.5	4.99±0,5
100 % OA	4±0.5	8.96±0,5

Table S2: pH of the solution before and after adsorption by the sulfur-oleylamine copolymer



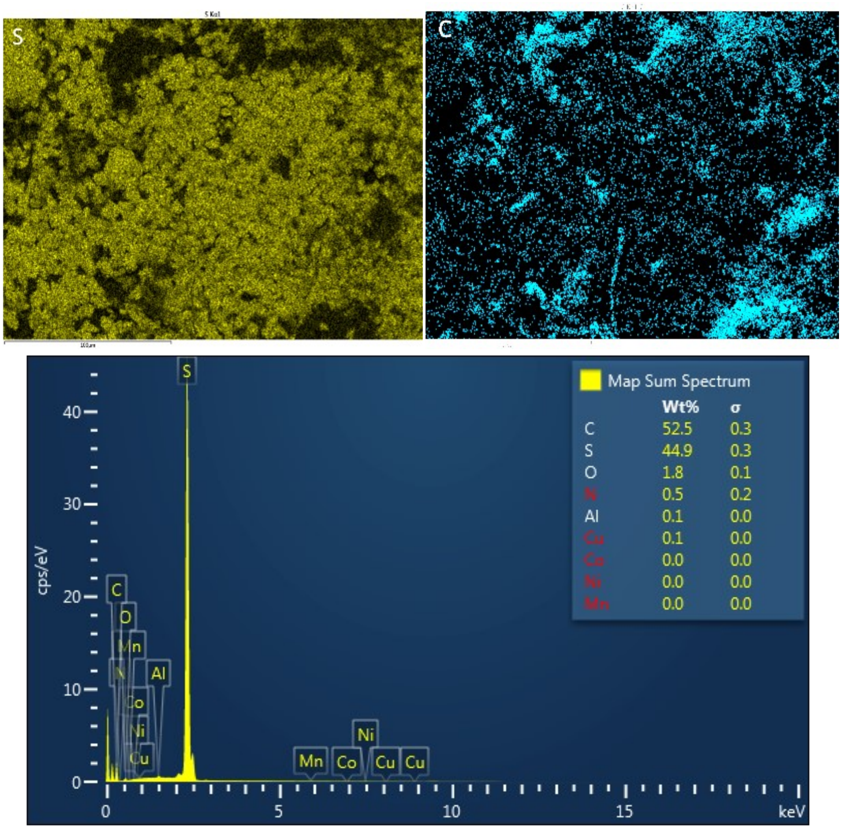


Figure S6: SEM-EDX mapping of the sulfur-oleylamine copolymer adsorbent after adsorption.

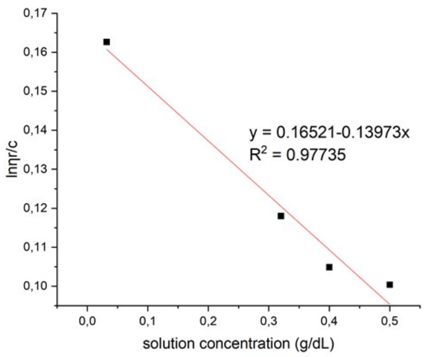


Figure S7: Intrinsic viscosity plot of the 50:50 sulfur:oleylamine polymer using THF as the solvent.

Figure S7 shows the intrinsic viscosity as a function of 50:50 sulfur:oleylamine polymer-THF solution concentration, and an intrinsic viscosity [η] of 0.165 dL g^{-1} could then be obtained with R^2 value of 0.97735. The viscosity average molecular weight was estimated using the Mark–Houwink–Sakurada (MHS) equation (eqn (1)): [1,2,3]

$$[\eta] = K\, M\eta^{a} \qquad (1)$$

where [η] is the intrinsic viscosity, Mη the viscosity-average molecular weight, and K and a, are the constants for a given solute–solvent system. K (2.3×10^{-4}) and a (0.67) are determined by the given Poly(3-Methylene-6-methyl-1,5-dithiacyclooctane)-THF system.[4] By applying of eqn (1), the molecular weight of the sulfur polymer is estimated to be ca. 18329 Da.

References

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