

## Supplementary Materials

**Supplementary Table S1.** Material inventory when recovering Ni-Co-containing saggars.

Process	Sort	Material	Standard	Quantity	Unit	Note
Physical separation	Input	Electricity		29.7 MJ		
		Water		148 kg		
		Saggar bodies	Moisture content 10%	1000 kg		Main raw material
	Output	Polishing powder	Moisture content 30%	171.4 kg		For reduction and leaching
		Ceramic aggregate		977.8 kg		For sale
Reduction and leaching	Input	Electricity		17.82 MJ		
		Polishing powder	Moisture content 30%	171.4 kg		From physical separation
		Reducing agent		12 kg		
		Sulfuric acid	98%	216 kg		
	Output	Water		376 kg		
		Acidic leaching liquor		647 kg		For cascade separation
		Leaching residue	Moisture content 60%	128.4 kg		Solid waste
Cascade separation	Input	Acidic leaching liquor		647 kg		From reduction and leaching
		Electricity		14.256 MJ		
		Potassium sulfate		20 kg		
		Potassium hydroxide	Industrial grade	55.6 kg		
		Potassium sulfate mother liquor	Saturated solution	59.6 kg		From crystallization
	Output	Steam		12 kg		
		Water		85.6 kg		
		Crude Ni-Co-Mn precursor		5.8 kg		For purification
		Filter liquor		693.2 kg		For crystallization

Crystallization	Input	Aluminum hydroxide	Industrial grade	1.2 kg	For sale
		Alum	Industrial grade	166.2 kg	For sale
		Magnesium hydroxide	Industrial grade	1.4 kg	For sale
		Electricity		59.4 MJ	
		Filter liquor		693.2 kg	From crystallization
	Output	Potassium carbonate	Industrial grade	66 kg	
		Steam		198 kg	
		Water	Pure water	96.4 kg	
		Concentrated mother liquor		59.6 kg	For cascade separation
		Crude lithium carbonate		35.2 kg	For purification
Purification	Input	Condensed water		656.8 kg	Recycling
		Potassium sulfate	Industrial grade	104 kg	For sale
		Ammonia water	25%	9 kg	
		Carbon dioxide		11 kg	
		Crude lithium carbonate		35.2 kg	From crystallization
	Output	Crude Ni-Co-Mn precursor		5.8 kg	From cascade separation
		Electricity		7.2 MJ	
		Sodium hydroxide		6 kg	
		Steam		10 kg	
		Sulfuric acid	98%	10 kg	
		Water		16 kg	
		Calcium			
		Magnesium slag		1.8 kg	Solid waste

Water		58 kg	For treatment
Lithium carbonate	Battery grade	28.2 kg	For sale
Ni-Co-Mn precursor	Battery grade	5 kg	For sale

**Supplementary Table S2.** Data quality assessment of the life cycle data of Ni-Co-containing saggar recovery.

Unit: %	Completely representative	Partly representative	Not representative
Technique	91.2	8.8	0
Location	61.8	38.2	0
Time	100	0	0

**Supplementary Table S3.** Monte Carlo analysis of the Ni-Co-containing saggar recovery results.

	Unit	Mean	SD	CV (%)
Mass - Input	kg	2.99E+05	1.76E-06	5.89E-10
Mass - Output	kg	3.00E+05	1.56E-06	5.20E-10
Midpoint - GWP	kg CO <sub>2</sub> eq.	3.33E+02	1.03E-06	3.09E-07
Midpoint - PMFP	kg PM <sub>2.5</sub> eq.	6.74E-01	1.82E-06	2.70E-04
Midpoint - FFP	MJ eq.	1.55E+02	1.84E-06	1.19E-06
Midpoint - WCP	m <sup>3</sup>	2.94E+02	0.00E+00	0.00E+00
Midpoint - FETP	kg 1,4 DB eq.	5.13E-02	1.77E-06	3.45E-03
Midpoint - FEP	kg P eq.	5.63E-04	2.52E-06	4.48E-01
Midpoint - HTP	kg 1,4-DB eq.	5.82E+00	4.60E-07	7.90E-06
Midpoint - IRP	kBq Co-60 eq. to air	3.17E+01	1.58E-06	4.98E-06
Midpoint - LOP	Annual crop eq.·y	4.75E+00	5.64E-07	1.19E-05
Midpoint - METP	kg 1,4-DB eq.	4.51E+02	0.00E+00	0.00E+00
Midpoint - ME	kg N eq.	1.80E-02	1.35E-06	7.50E-03
Midpoint - SOP	kg Cu eq.	3.77E+00	2.49E-06	6.60E-05
Midpoint - OFP	kg NO <sub>x</sub> eq.	8.17E-01	1.64E-06	2.01E-04
Midpoint - ODP	kg CFC-11 eq.	1.21E-04	2.49E-06	2.06E+00
Midpoint - AP	kg SO <sub>2</sub> eq.	2.33E+00	1.54E-06	6.61E-05
Midpoint - TETP	kg 1,4-DB eq.	7.37E+01	7.75E-07	1.05E-06
Endpoint	Weighted person equivalents	4.50E+02	2.16E-06	4.80E-07