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Supplementary Material

Recycling of Li, Co from spent $LiCoO_2$ cathode materials through a low temperature urea-assisted sulfation roasting approach

Yichuan Kong [a], Yongzhi Duan [a], Yuezhi Zhang [a], Yulin Min [a,b], Hongxiu Lu [c], Penghui Shi [a,b,*]

[a] Shanghai Key Laboratory of Materials Protection and Advanced Materials in Electric Power, Shanghai University of Electric Power, Shanghai 200090, PR China

[b] Shanghai Institute of Pollution Control and Ecological Security, Shanghai 200090, PR China

[c] Department of Biomedicine and Health, Shanghai Vocational College of Agriculture and Forestry, Shanghai, 201699, PR China

* Corresponding author. Tel.: +86 18801618059; E–mail addresses: shipenghui@shiep.edu.cn (P. Shi).

Table S1. Several representative cases of salt-thermal methods for recycling valuable metal elements from cathode materials by roasting approaches

Roasting agent	Reaction condition	Products and recovery efficiency	Ref.
$NiSO_4$	NCM111 : $NiSO_4{\cdot}6H_2O$ = 2 : 1 (mole ratio), 550 °C, 60 min, air.	Li_2SO_4, NiO, $Ni_{0.66}Co_{0.66}Mn_{0.66}O_3$; 96.42% for Li, M< 3.62% (M = Ni, Co, and Mn)	1
$ZnSO_4$	$LiMn_2O_4$: $ZnSO_4{\cdot}6H_2O$ = 1 : 1 (mole ratio), 550 °C, 60 min, air.	Li_2SO_4, nano $ZnMn_2O_4$ as Li^+ anode 832 mA h g^{-1} at 90st cycle at 0.1 A g^{-1}	2
$CoSO_4$	$LiCoO_2$: $CoSO_4{\cdot}7H_2O$ = 1 : 1 (mole ratio), 550 °C, 60 min, air.	Li_2SO_4, nano-octahedral Co_3O_4 as Li^+ anode 987.2 mA h g^{-1} at 100st cycle at 0.05 A g^{-1}	2
$NaHSO_4$	$LiCoO_2$: $NaHSO_4$ = 1 : 1.4 (mass ratio) 600 °C, 30 min, air	$LiNaSO_4$, Co_3O_4 72.56% for Li, 0.53% for Co	3
$(NH_4)_2SO_4$	$LiCoO_2$: $(NH_4)_2SO_4$ = 1 : 2.2 (mole ratio) 600 °C, 45 min, air	$Li_2Co(SO_4)_2$, $CoSO_4$; 99.5% for Li, 8.53% for Co	4
$(NH_4)_2SO_4$	$LiCoO_2$: $(NH_4)_2SO_4$ = 1 : 4 (mass ratio) 400 °C, 120 min, Ar	Li_2SO_4, $CoSO_4$, $Li_2Co(SO_4)_2$; over 98% for both Li and Co	5

$(NH_4)_2SO_4$	NCM622 : $(NH_4)_2SO_4$ = 1 : 4 (mass ratio) 350 °C, 90 min, air	Li_2SO_4, $NiSO_4$, $CoSO_4$, $MnSO_4$; 99.2%, 99.4%, 98.8%, and 98.5% for Li, Ni, Co, Mn	6
Na_2CO_3	LFP : Na_2CO_3 : graphite = 1 : 1 : 2 (mole ratio), 900 °C, 4 h, N_2	Fe, $NaLi_2PO_4$, $LiNa_5(PO_4)_2$, Li for 96.4%; Fe_3O_4	7

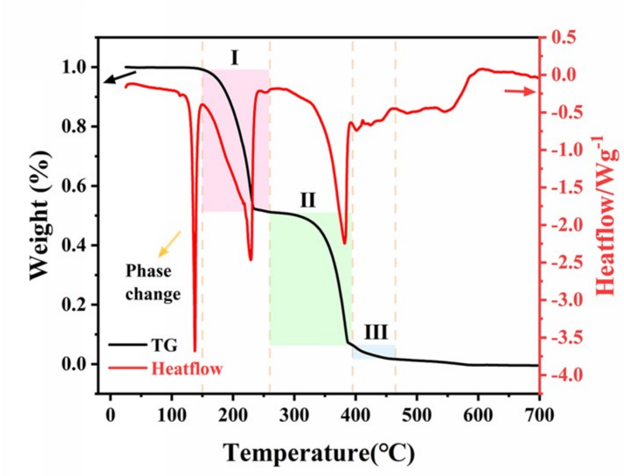

Fig. S1. TG curves of pure urea.

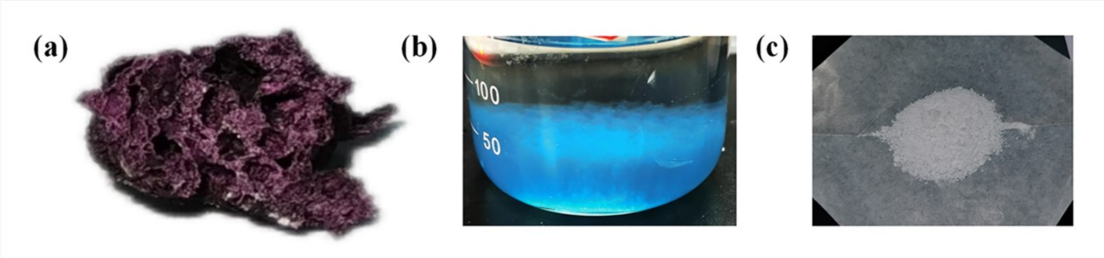

Fig. S2. Physical picture of (a) the sample after urea-assisted sulfation roasting; (b) the precipitated $CoCO_3$; (c) the concentrated precipitated Li_2CO_3.

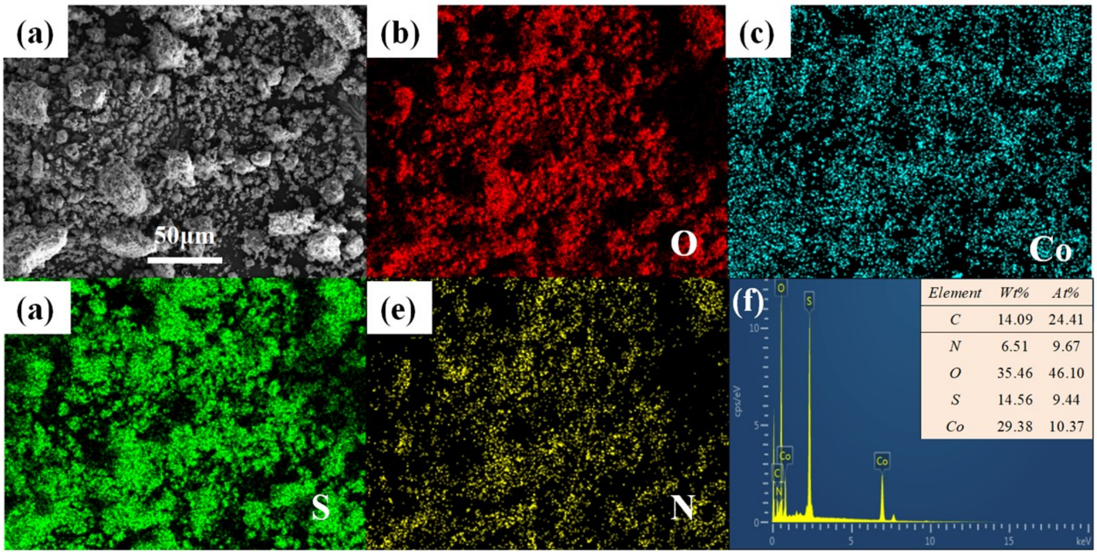

Fig. S3. SEM images of (a) roasted sample; (b-e) the corresponding EDS mapping and (f) content distribution for C, N, O, S and Co in roasted sample.

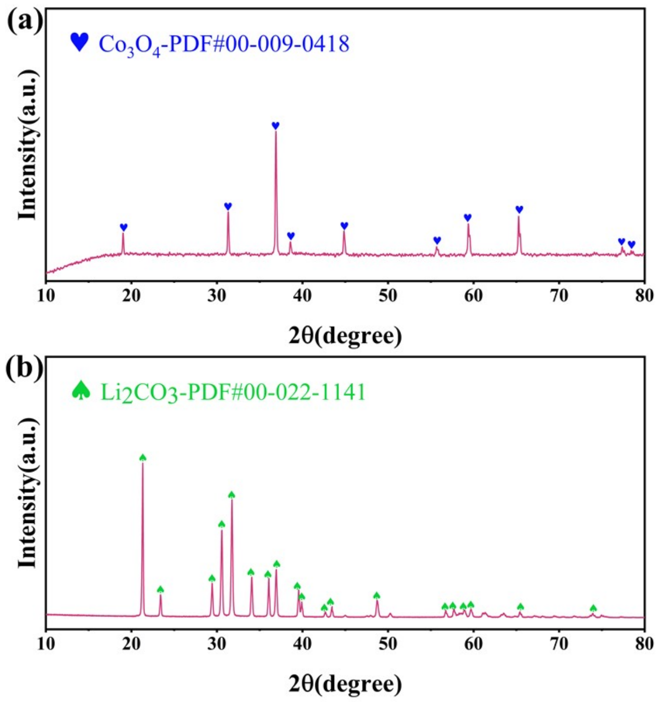

Fig. S4. XRD patterns of (a) Co_3O_4 obtained by calcination; (b) concentrated and dried Li_2CO_3.

Reference

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