Electric potential-determined redox intermediates for effective recycling of spent lithium-ion batteries

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Fig. S1 Behaviors of synergistic metal leaching from NCM622 and LFP cathode by Fe$_2$(SO$_4$)$_3$ and NH$_4$Fe(SO$_4$)$_2$ (LFP/NCM622=1.8; NH$_4$Fe(SO$_4$)$_2$·12H$_2$O/mixed cathode powder = 3:1, or Fe$_2$(SO$_4$)$_3$/mixed powder=1.1:1 (all in g/g) at 50°C for 30 min)
Fig. S2 Comparison of leaching efficiency by adding water with Fe$_2$(SO$_4$)$_3$ as solid powder and by preparing Fe$_2$(SO$_4$)$_3$ aqueous solution in advance, NH$_4$Fe(SO$_4$)$_2$·12H$_2$O also added for comparison (LFP/NCM622=1.8, Fe$_2$(SO$_4$)$_3$/mixed powder=1.2:1, NH$_4$Fe(SO$_4$)$_2$·12H$_2$O/mixed cathode powder = 3:1 (all in g/g) at 50°C for 10 min)
Fig. S3 Leaching efficiencies of metals under different LFP/NCM622 mass ratios
Fig. S4 Leaching efficiencies of phosphate with different added amount of NH$_4$Fe(SO$_4$)$_2$·12H$_2$O. The phosphate was hardly extracted at all time.
Fig. S5, Leaching efficiencies of Li, Mn, Co, Ni and P under optimized condition (LFP/NCM622=1.8 (g/g), NH$_4$Fe(SO$_4$)$_2$·12H$_2$O/mixed cathode powder =3:1 (g/g), 50g/L, 50°C, 30min).
Fig. S6 Comparison of leaching effects using \( \text{NH}_4\text{Fe(SO}_4\text{)}_2\cdot12\text{H}_2\text{O} + \text{LFP} \)
alone, \( \text{NH}_4\text{Fe(SO}_4\text{)}_2\cdot12\text{H}_2\text{O} + \text{NCM} \) alone, and \( \text{NH}_4\text{Fe(SO}_4\text{)}_2\cdot12\text{H}_2\text{O} + \) mixed powder.
Fig. S7 Solution after reaction between LFP and NH₄Fe(SO₄)₂·12H₂O.

1,10-Phenanthroline is added and the red color verifies the generation of Fe²⁺.
Fig. S8 Fitting results of a) Li, b) Mn, c) Co and d) Ni according to surface diffusion model.
Fig. S9 Fitting results of a) Li, b) Mn, c) Co and d) Ni according to mass transfer model.
Fig. S10 Activation energy calculation of Li, Mn, Co and Ni according to Arrhenius equation in the range of 30-60°C
Fig. S11 XRD pattern of recovered FePO$_4$·2H$_2$O after washing the residue with H$_3$PO$_4$+NH$_4$H$_2$PO$_4$ at PH=2-2.5
Fig. S12 XPS analysis of recovered MnCoNi oxide after 900°C calcination