Supplemental Information

Engineering a Tandem Leaching System for Highly-Selective Recycling of Valuable Metals from Spent Li-ion Batteries

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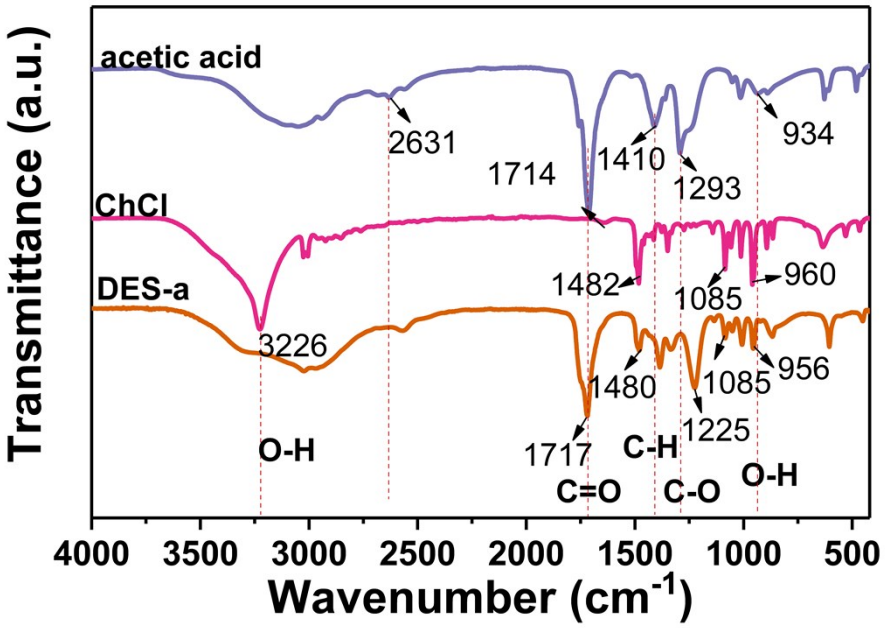

Fig. S1 FT-IR spectra of acetic acid, ChCl, and DES-a.

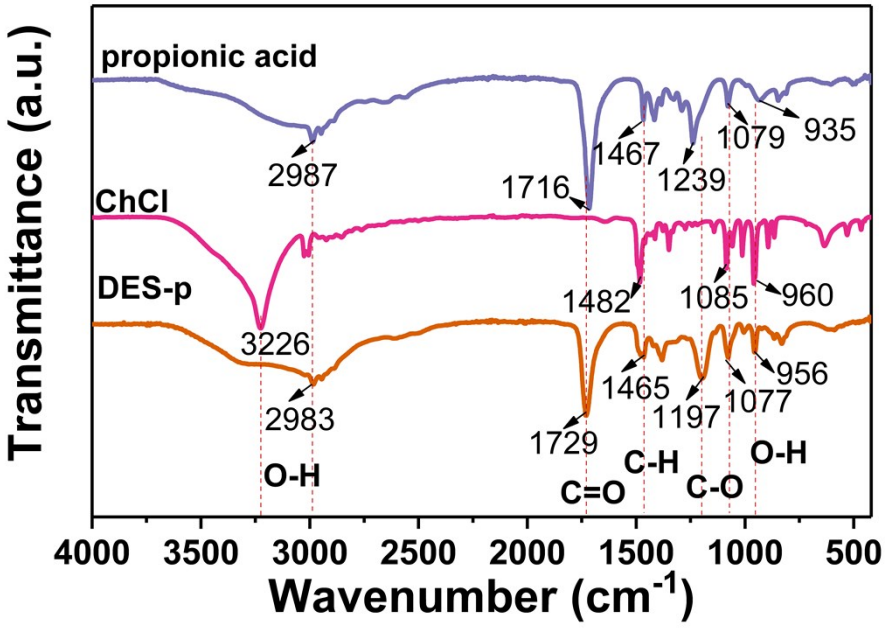

Fig. S2 FT-IR spectra of propionic acid, ChCl, and DES-p.

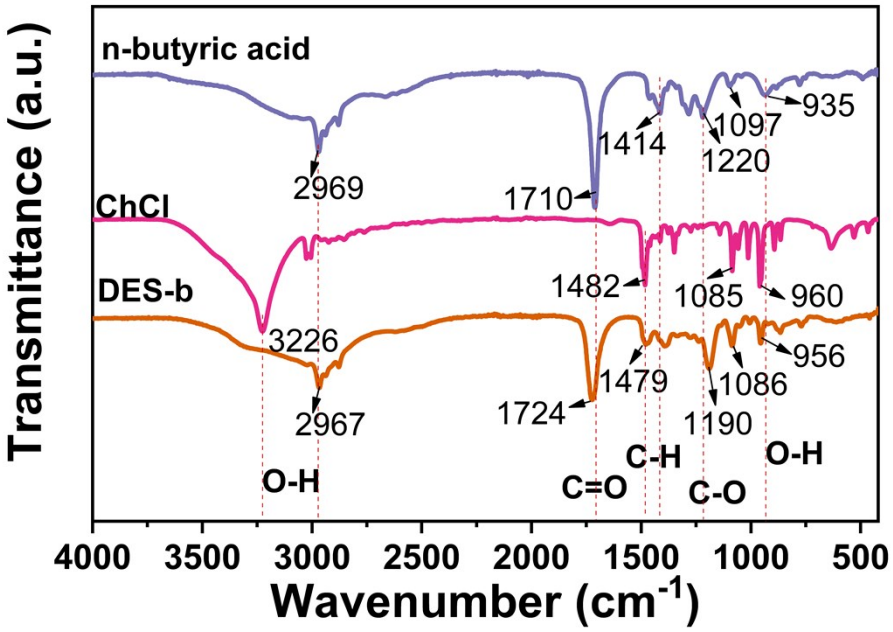

Fig. S3 FT-IR spectra of n-butyric acid, ChCl, and DES-b.

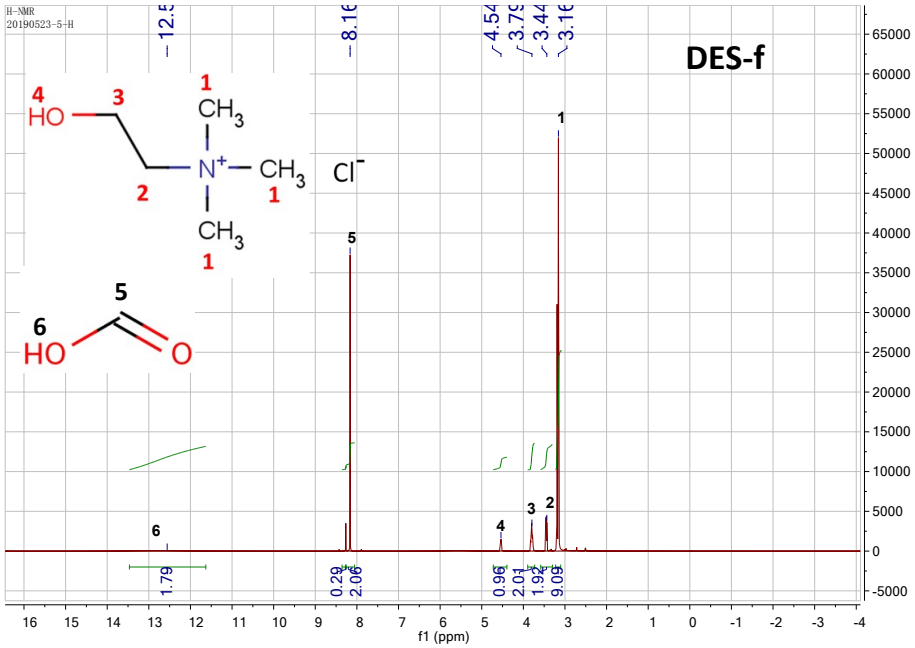

Fig. S4 ^{1}H-NMR of DES-f

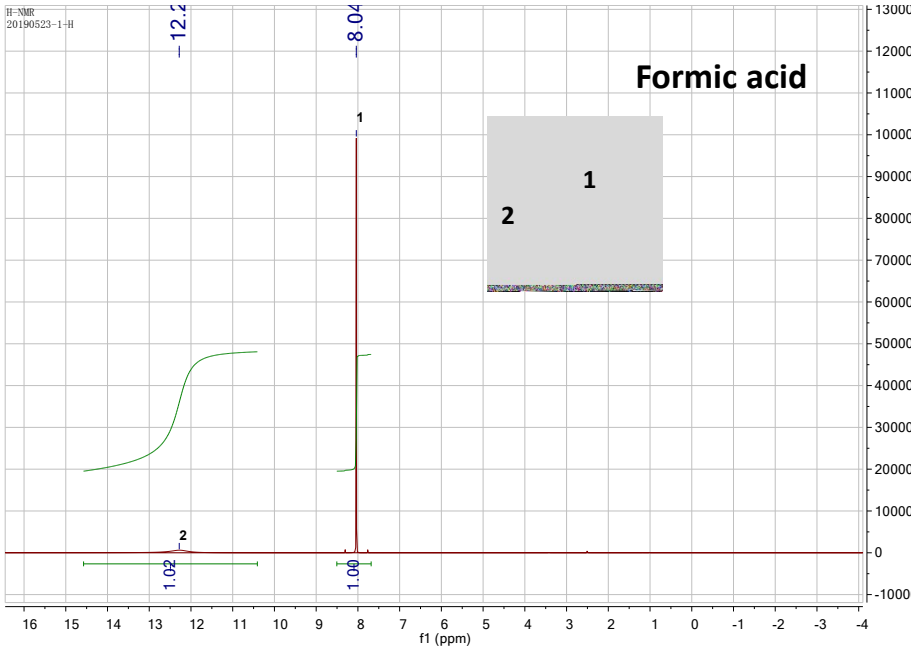

Fig. S5 ^{1}H-NMR of formic acid

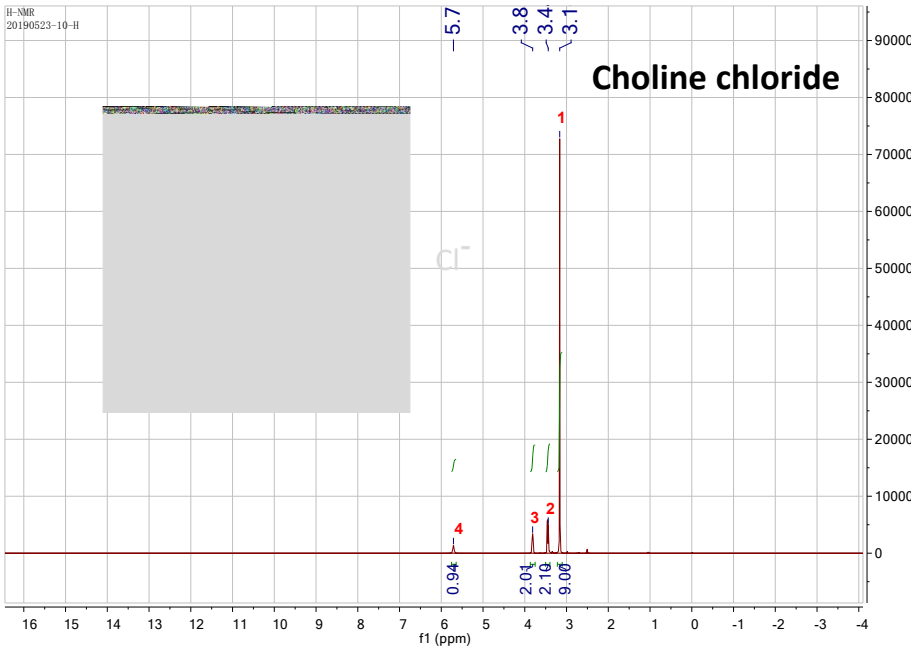

Fig. S6 ^{1}H-NMR of ChCl

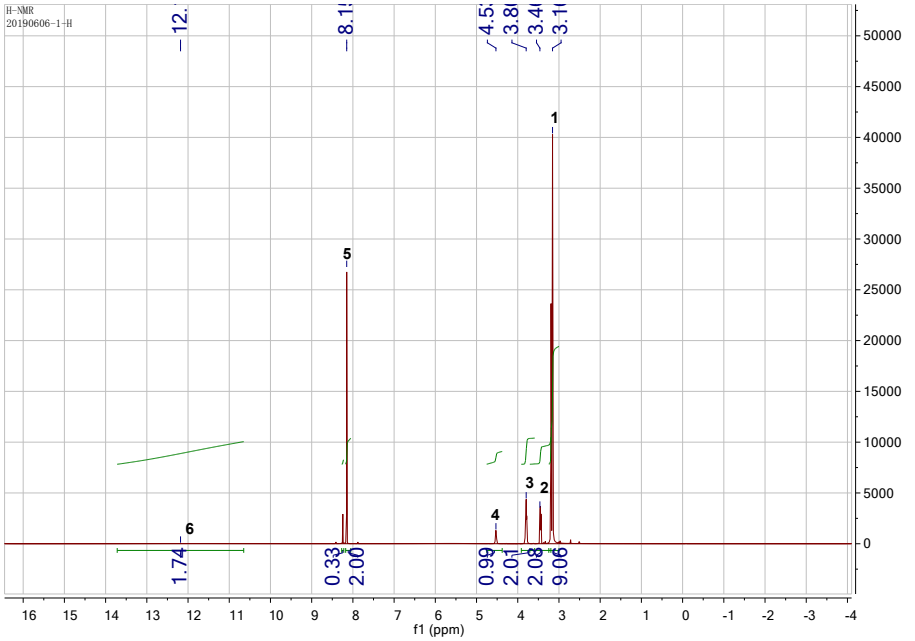

Fig. S7 [1]H-NMR of DES-f obtained at 25°C and maintained for 90 min

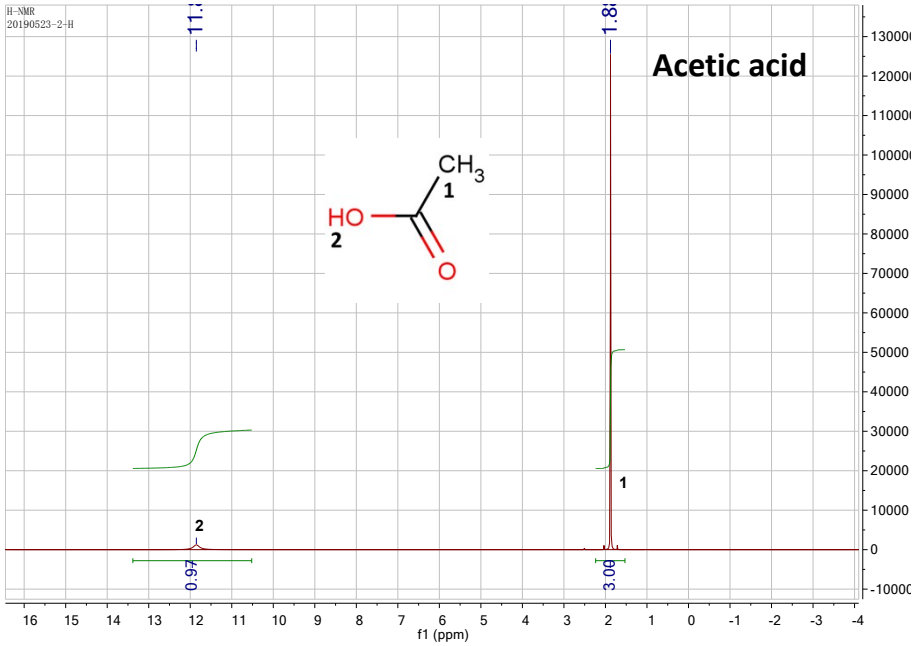

Fig. S8 [1]H-NMR of acetic acid

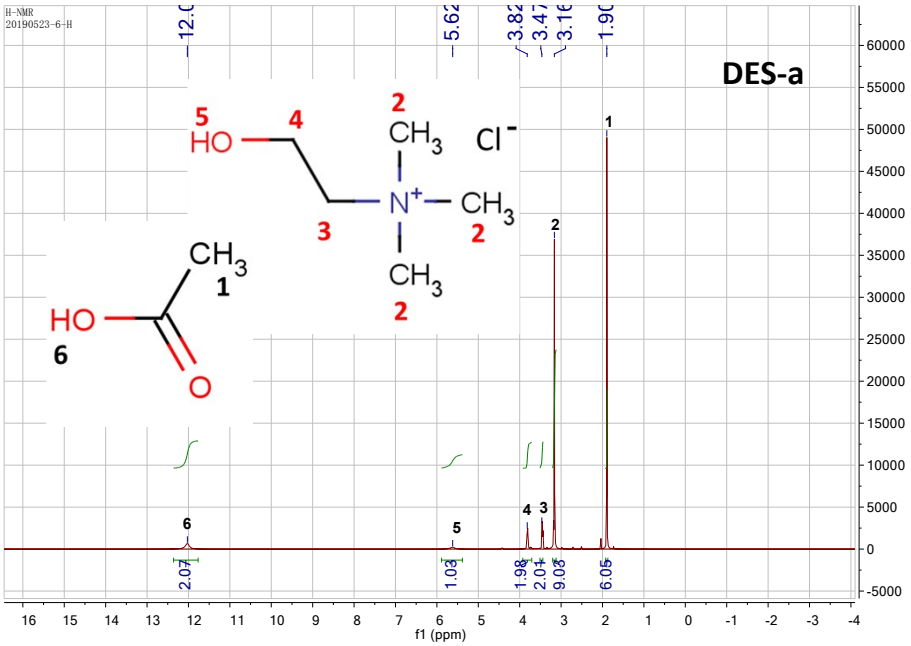

Fig. S9 ^{1}H-NMR of DES-a

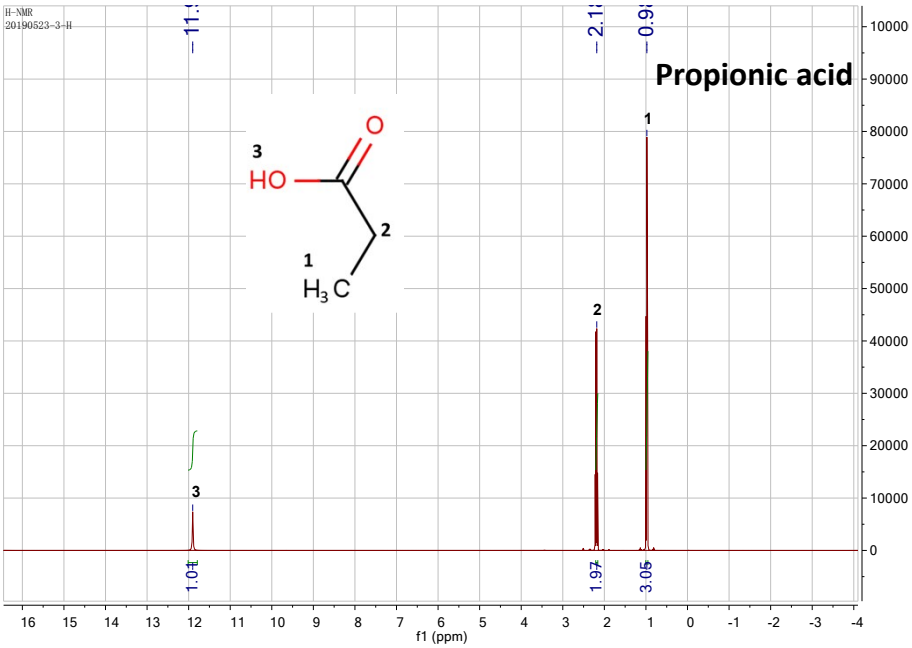

Fig. S10 ^{1}H-NMR of propionic acid

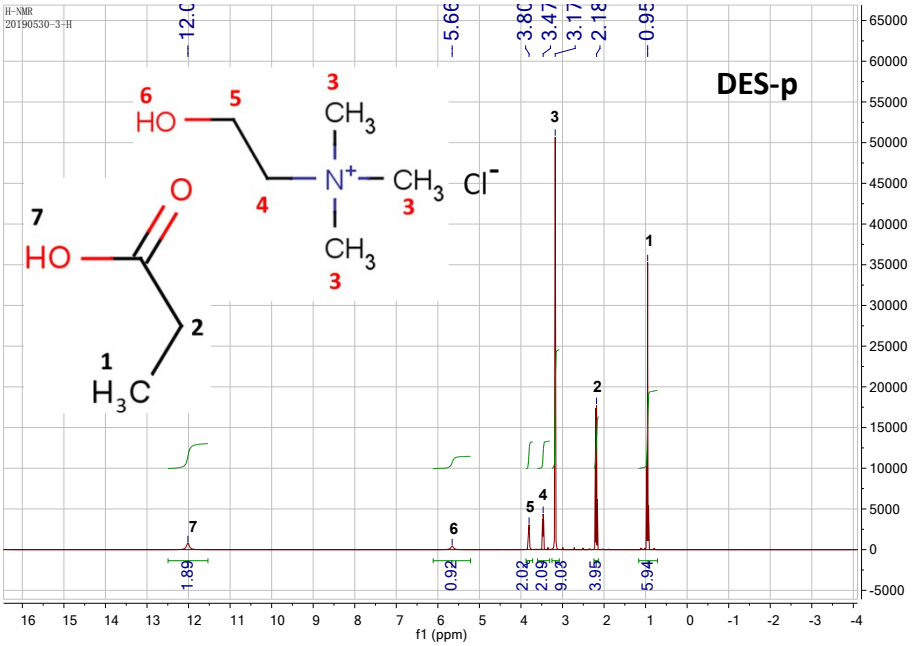

Fig. S11 ^{1}H-NMR of DES-p

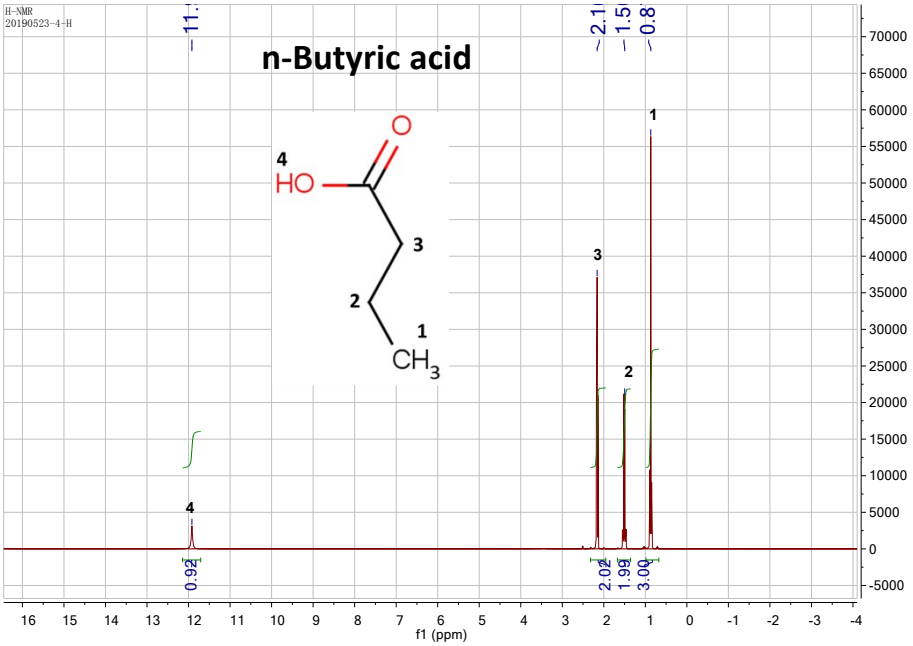

Fig. S12 ^{1}H-NMR of n-butyric acid

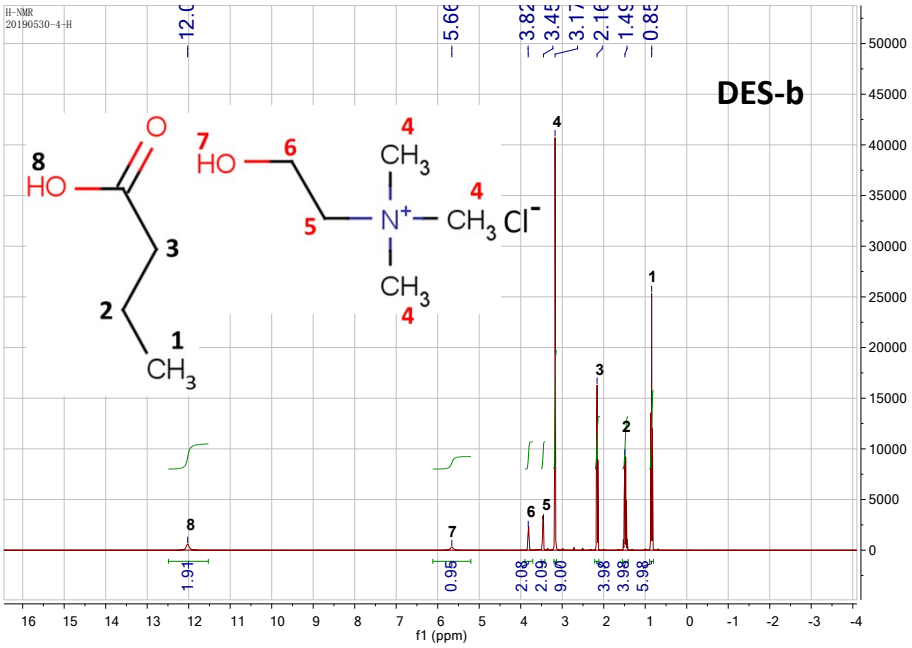

Fig. S13 ^{1}H-NMR of DES-b

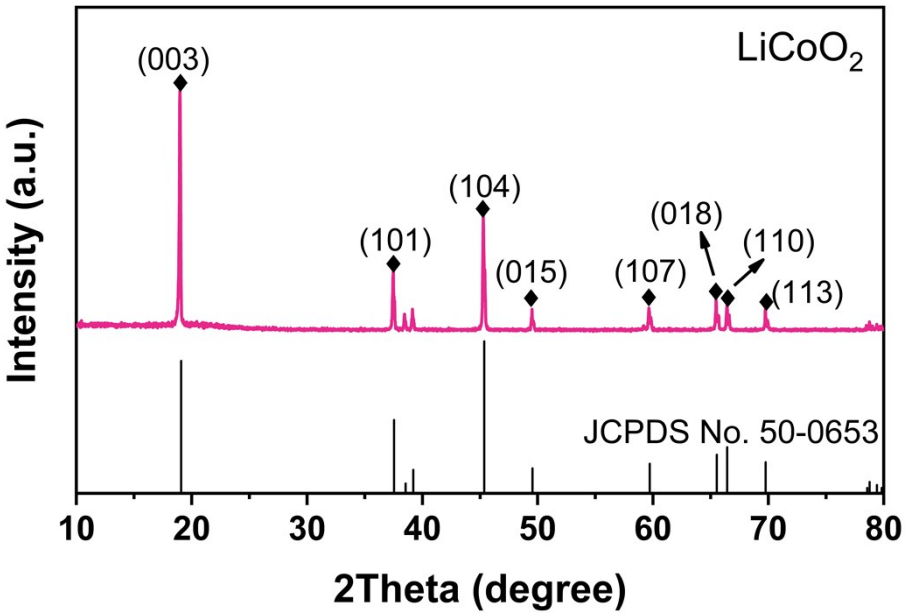

Fig. S14 XRD patterns of pristine LCO.

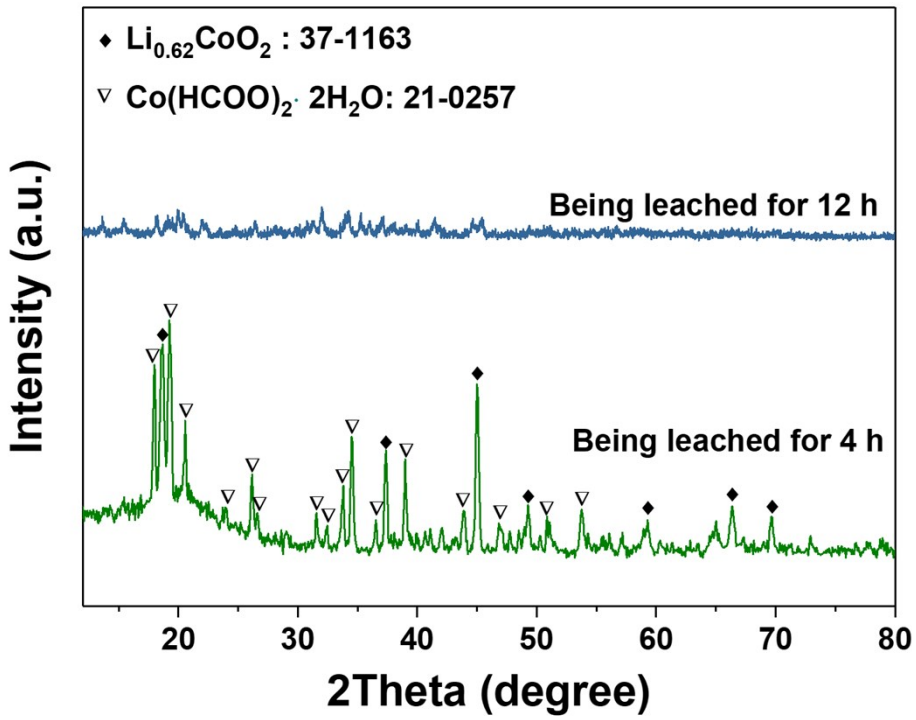

Fig. S15 XRD patterns of LCO residue being leached by formic acid at 90°C for 4 and 12 h.

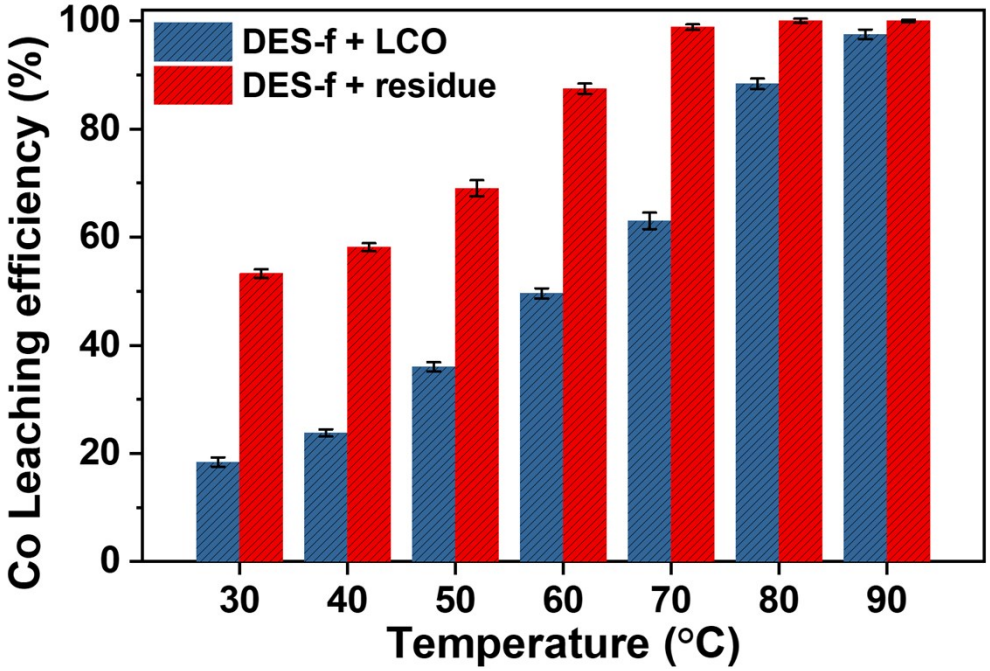

Fig. S16 Co leaching efficiencies over LCO and the residue by DES-f at different temperatures. Leaching conditions: m(cathode) = 0.1 g; m(DES) = 5 g; t = 12 h.

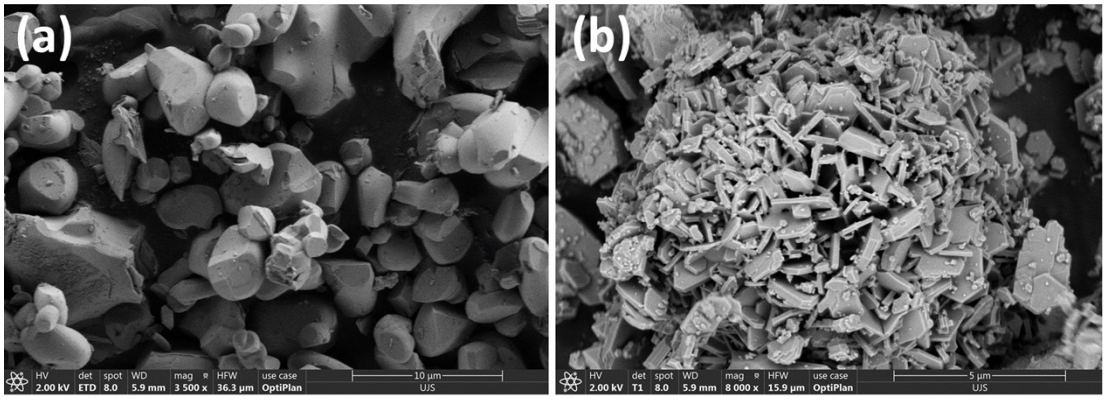

Fig. S17 SEM of (a) original LCO; (b) residues obtained after formic acid leaching.

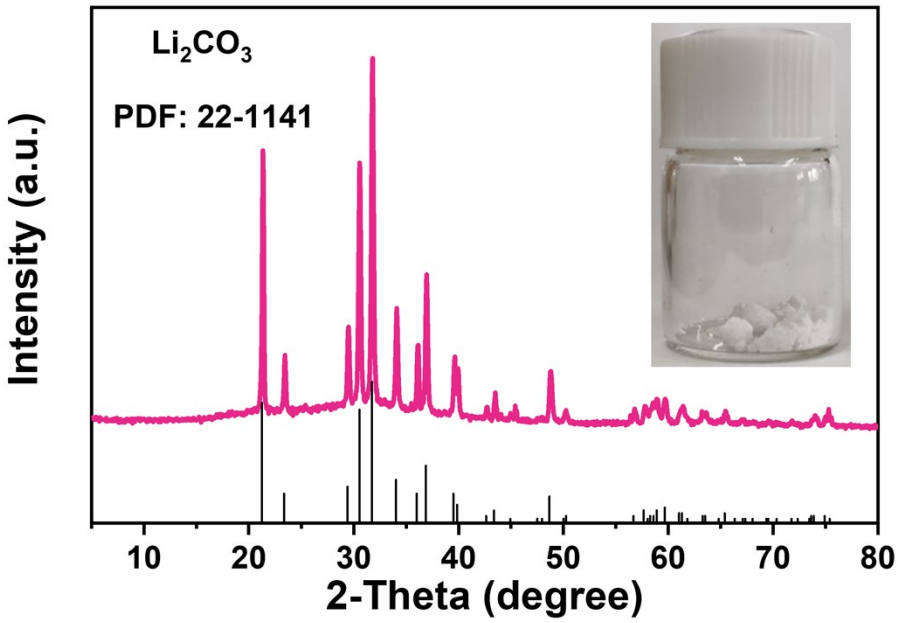

Figure S18 XRD pattern of recycled Li_2CO_3 from formic acid extractant. Inset is the optical photograph of recycled Li_2CO_3.

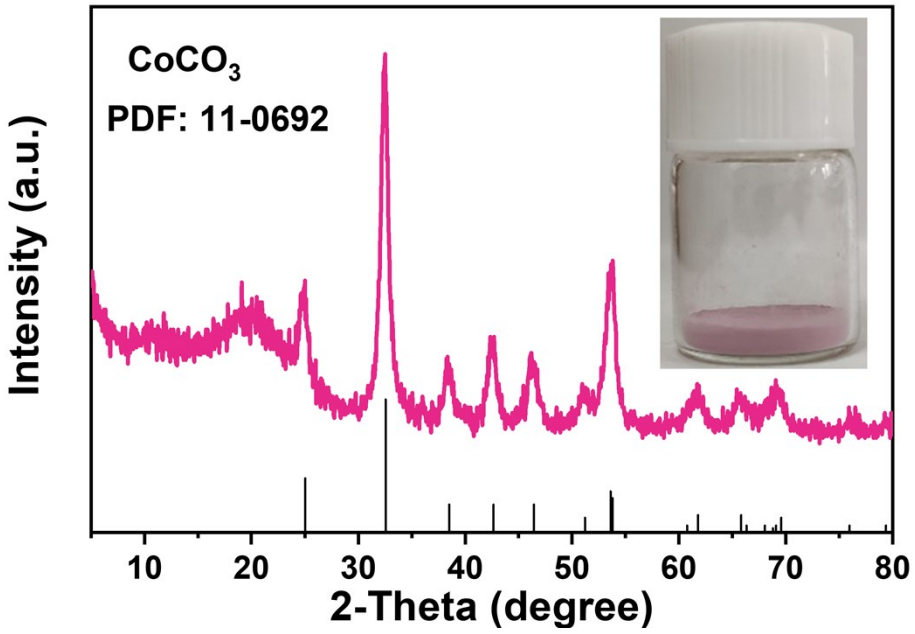

Fig. S19 XRD pattern of recycled $CoCO_3$ from DES-f extractant. Inset is the optical photograph of recycled $CoCO_3$.

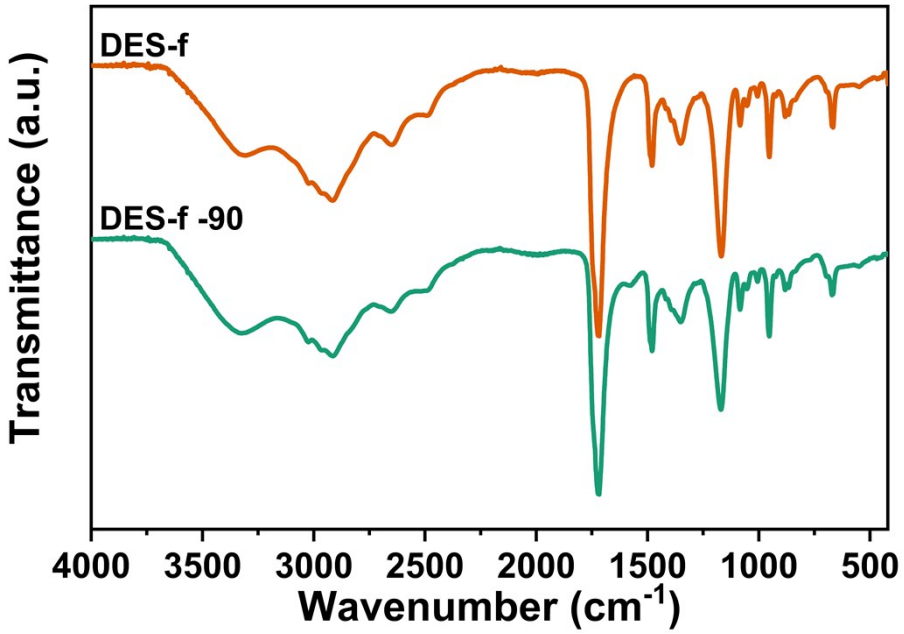

Fig. S20 FT-IR spectra of DES-f and the recycled DES-f after leaching process at 70°C.

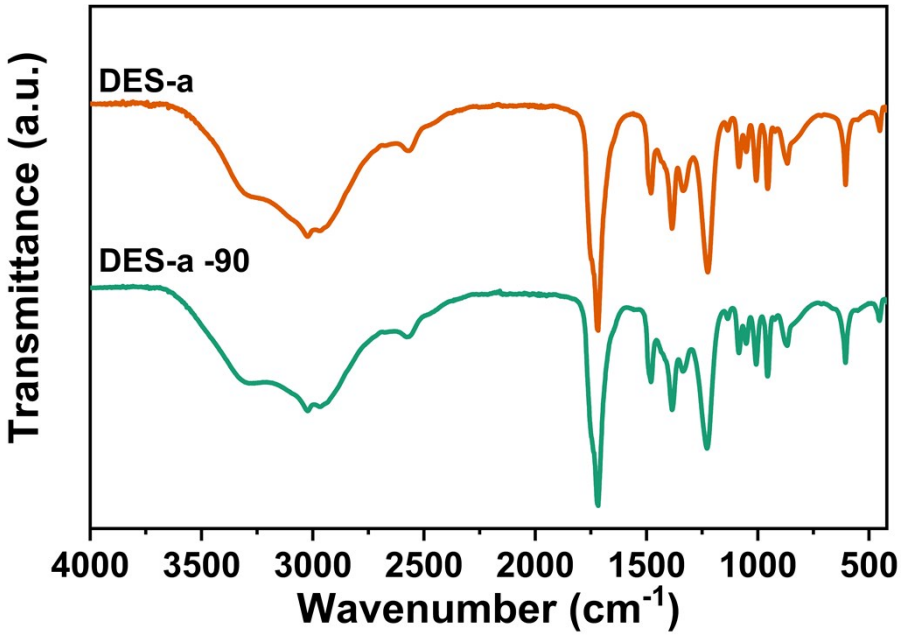

Fig. S21 FT-IR spectra of DES-a and the recycled DES-a after leaching process at 70 °C.

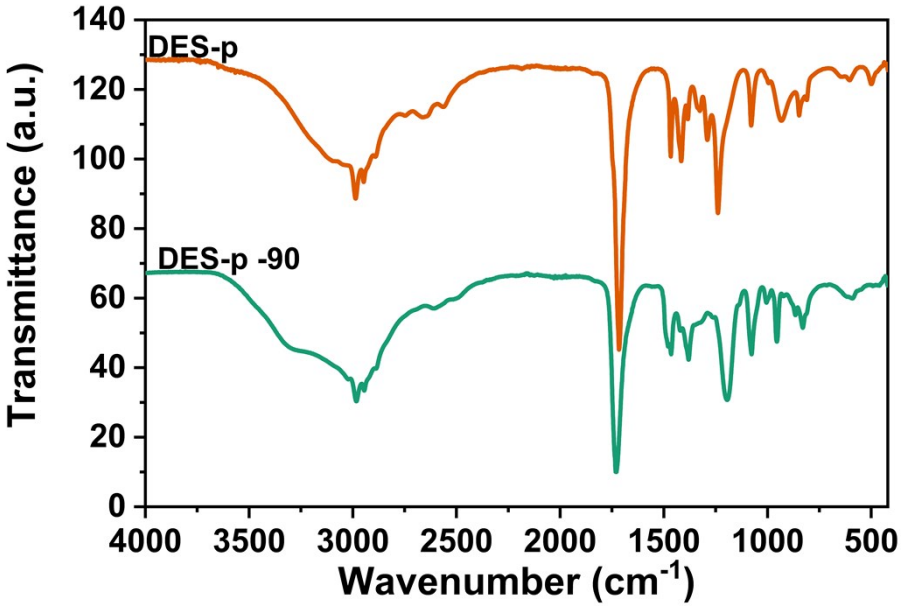

Fig. S22 FT-IR spectra of DES-p and the recycled DES-p after leaching process at 70 °C.

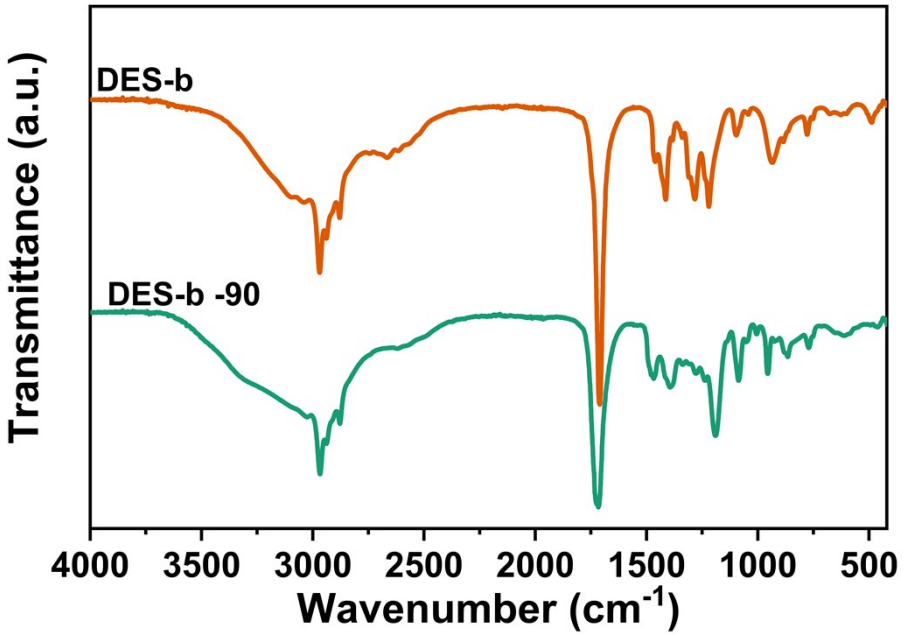

Fig. S23 FT-IR spectra of DES-b and the recycled DES-b after leaching process at 70 °C.

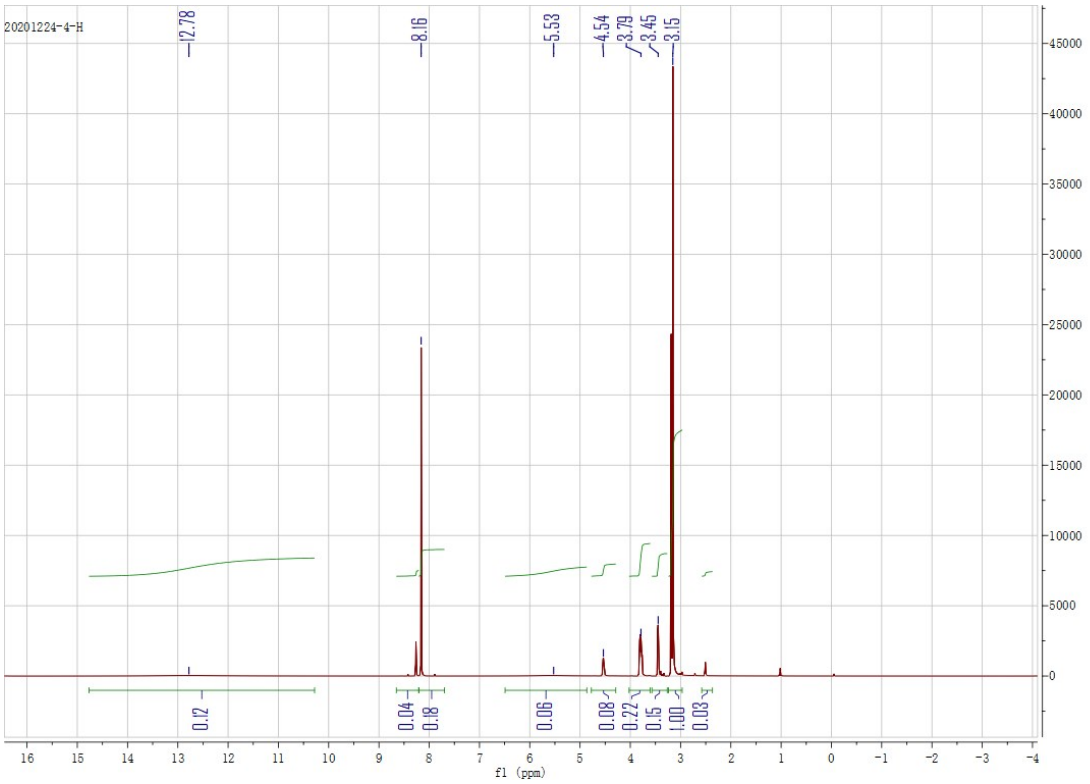

Fig. S24 ^{1}H-NMR spectra of DES-f that being treated at 70 °C for 2 h.

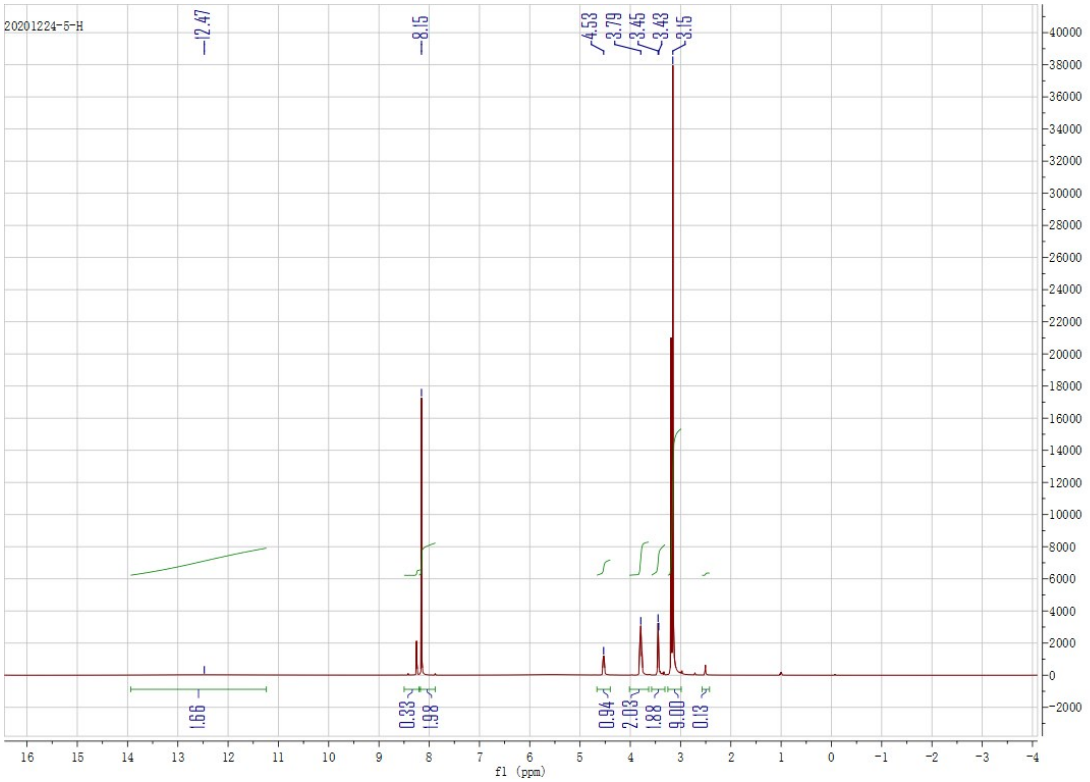

Fig. S25 [1]H-NMR spectra of DES-f that being treated at 70 °C for 4 h.

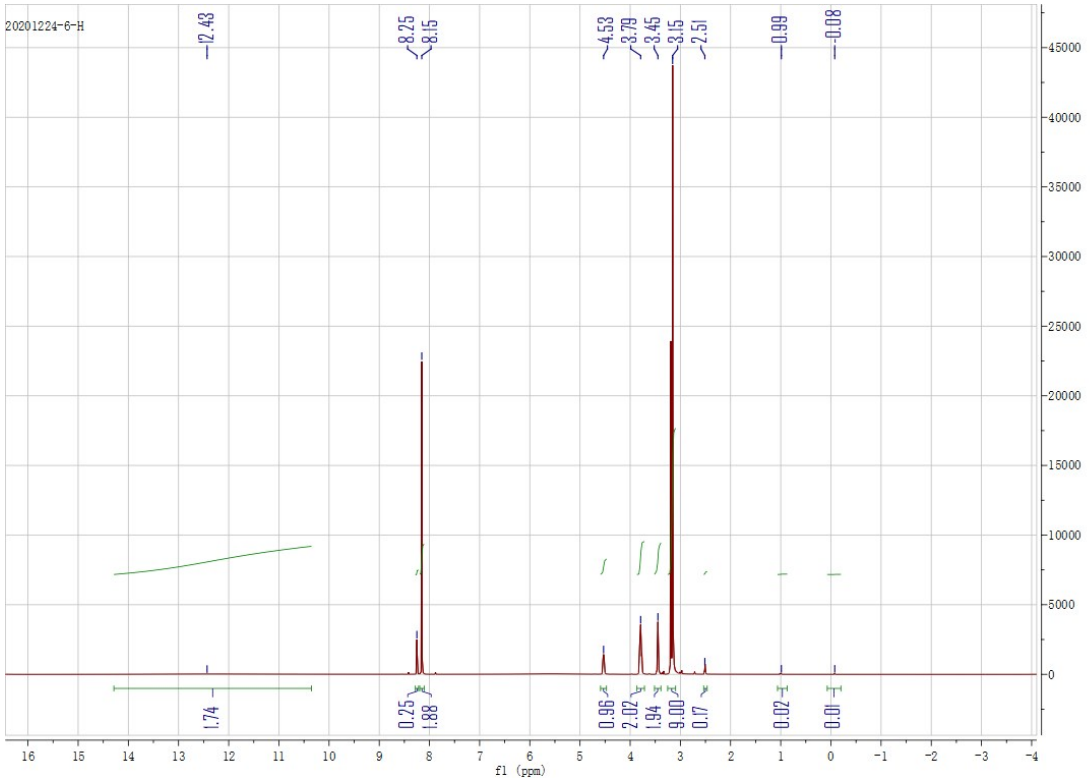

Fig. 26 [1]H-NMR spectra of DES-f that being treated at 70 °C for 8 h.

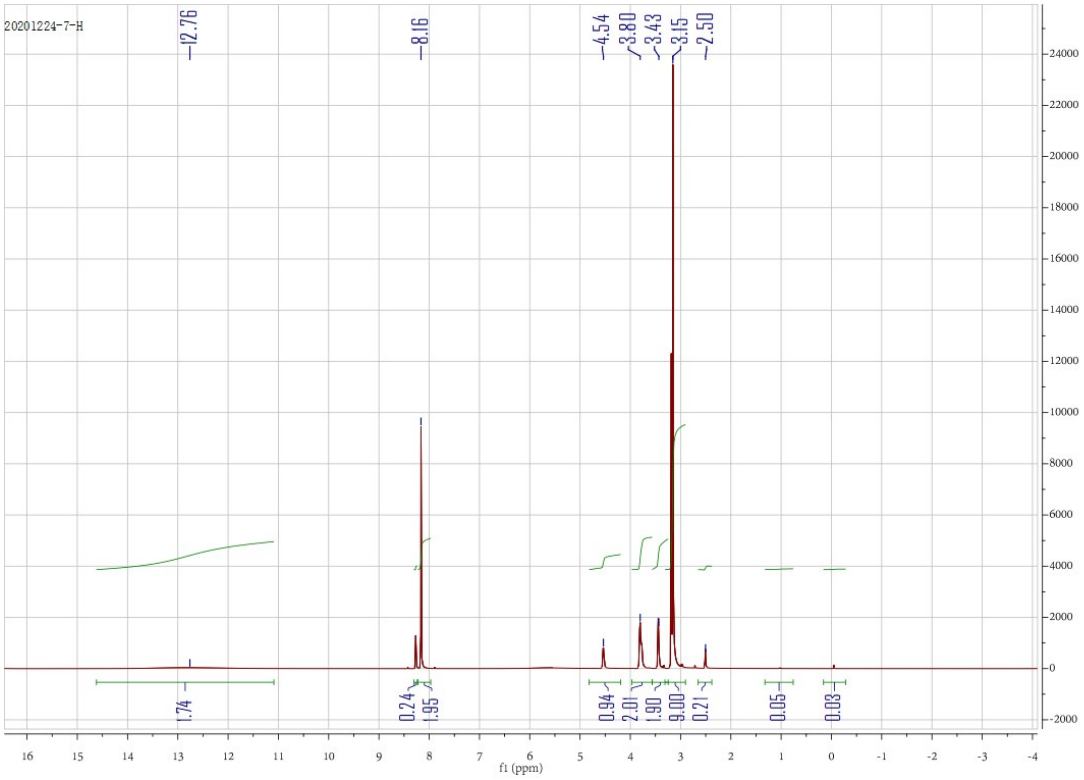

Fig. 27 ^{1}H-NMR spectra of DES-f that being treated at 70 °C for 12 h.

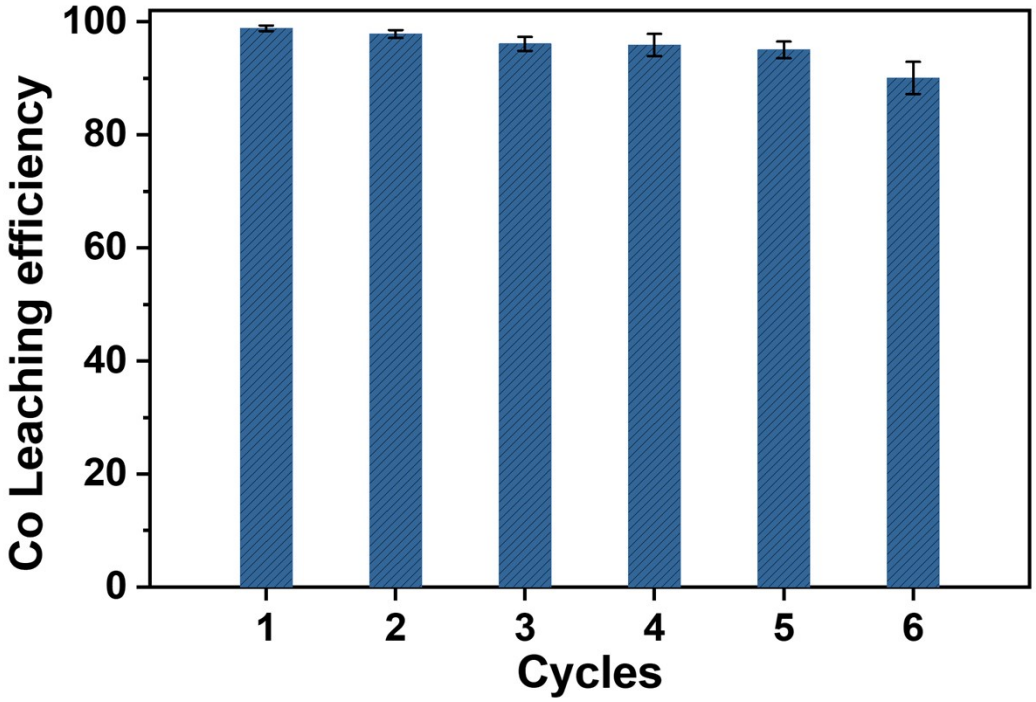

Fig. S28 Recyclability of the DES-f.

Leaching conditions: m(cathode) = 0.1 g; m(DES) = 5 g; t = 12 h.