# Supplemental materials

Low-temperature chlorination roasting technology for the simultaneous recovery of valuable metals from spent LiCoO2 cathode material

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| Fig. S1. The XRD pattern of spent LiCoO2 cathode powders.   |  |  | | --- | --- | |  |  | | Fig. S2. (a) TG and (b) DTG curves of the mixture at different heating rates. | | |

Table S1. Calculated activation energy at different conversions by the model-free methods

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *α* | FWO | | KAS | | Starink | | Friedman | |
| *Ea*  (kJ/mol) | *r*2 | *Ea*  (kJ/mol) | *r*2 | *Ea*  (kJ/mol) | *r*2 | *Ea*  (kJ/mol) | *r*2 |
| 0.1 | 97.25 | 0.982 | 94.05 | 0.979 | 94.3 | 0.979 | 89.946 | 0.958 |
| 0.2 | 96.43 | 0.991 | 92.96 | 0.989 | 93.22 | 0.990 | 87.02 | 0.996 |
| 0.3 | 94.85 | 0.996 | 91.13 | 0.995 | 91.41 | 0.995 | 85.47 | 0.999 |
| 0.4 | 92.41 | 0.998 | 88.43 | 0.998 | 88.71 | 0.998 | 81.12 | 1 |
| 0.5 | 90.49 | 1.000 | 86.27 | 1.000 | 86.56 | 1.000 | 77.85 | 0.996 |
| 0.6 | 84.16 | 1.000 | 79.48 | 1.000 | 79.78 | 1.000 | 67.18 | 0.998 |
| 0.7 | 81.49 | 1.000 | 76.52 | 1.000 | 76.82 | 1.000 | 60.24 | 0.997 |
| 0.8 | 79.13 | 1.000 | 73.86 | 1.000 | 74.18 | 1.000 | 66.88 | 0.999 |
| 0.9 | 79.51 | 1.000 | 74.03 | 1.000 | 74.36 | 1.000 | 71.4 | 0.999 |
| Average | 88.41 | 0.996 | 84.08 | 0.996 | 84.371 | 0.996 | 76.35 | 0.994 |

Table S2. Kinetic parameters of common models calculated by model-fitting methods

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| --- | --- | --- | --- | --- | --- |
| Model | Variable | 5°C/min | 10°C/min | 20°C/min | Average |
| R2 | (kJ/mol) | 40.45 | 36.42 | 34.71 | 37.19 |
| ln | 6.21 | 5.59 | 5.51 | 5.77 |
| *r*2 | 0.861 | 0.854 | 0.899 | 0.871 |
| R3 | (kJ/mol) | 50.91 | 45.63 | 43.39 | 46.64 |
| ln | 8.37 | 7.38 | 7.13 | 7.63 |
| *r*2 | 0.921 | 0.914 | 0.94 | 0.925 |
| D1 | (kJ/mol) | 74.61 | 67.97 | 64.23 | 68.94 |
| ln | 14.19 | 12.72 | 11.97 | 12.96 |
| *r*2 | 0.732 | 0.715 | 0.762 | 0.736 |
| D2 | (kJ/mol) | 102.12 | 94.85 | 88.83 | 95.27 |
| ln | 20.27 | 18.44 | 17.01 | 18.57 |
| *r*2 | 0.938 | 0.934 | 0.948 | 0.940 |
| D3 | (kJ/mol) | 135.97 | 127.97 | 119.09 | 127.68 |
| ln | 27.06 | 24.8 | 22.52 | 24.79 |
| *r*2 | 0.963 | 0.958 | 0.968 | 0.963 |
| D4 | (kJ/mol) | 113.84 | 106.32 | 99.3 | 106.49 |
| ln | 21.64 | 19.65 | 17.928 | 19.74 |
| *r*2 | 0.919 | 0.912 | 0.932 | 0.921 |
| F1 | (kJ/mol) | 73.05 | 67.28 | 63.18 | 67.84 |
| ln | 14.9 | 13.63 | 12.81 | 13.78 |
| *r*2 | 0.982 | 0.975 | 0.975 | 0.977 |
| F2 | (kJ/mol) | 139.46 | 132.22 | 122.55 | 131.41 |
| ln | 31.18 | 29.06 | 26.57 | 28.94 |
| *r*2 | 0.981 | 0.976 | 0.964 | 0.974 |
| F3 | (kJ/mol) | 205.86 | 197.17 | 181.92 | 194.98 |
| ln | 46.77 | 43.8 | 39.64 | 43.40 |
| *r*2 | 0.963 | 0.961 | 0.949 | 0.958 |

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| Fig. S3. Color of the roasted products changes with temperature. |

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| Fig. S4. The two-step method. |