COMMUNICATION

Parameter Optimization and Yield Prediction in Cathode Coating Separation Process for Direct Recycling of End-Of-Life Lithium-ion Batteries †

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Figure S1. Battery modules disassembled for DOE

Figure S2. Equipment requirement (a) Battery module discharger, (b) High temperature oven and (c) Ultrasonic cleaner

Table S1. Plackett-Burman Screening Experiment Design and Result

RunOrder	Soaking Media(A)	Soaking Time hour (B)	Soaking Temperature ℃ (C)	Sonicating Time min (D)	Sonicating Temperature ℃ (E)	Yield % (Y)
1	DMAC	3	60	10	40	63.7
2	DMF	1	90	10	40	50.4
3	DMAC	3	90	10	60	70.2
4	DMF	1	60	10	60	52.6
5	DMAC	1	60	10	40	49.5
6	DMF	3	60	20	60	61.7
7	DMF	1	90	20	40	75.2
8	DMAC	3	90	20	40	95.1
9	DMF	3	90	10	60	64.9
10	DMF	3	60	20	40	80.3
11	DMAC	1	60	20	60	93.4
12	DMAC	1	90	20	60	90.2

Table S2. Analysis of Variance of Screening Experiment

Source	DF	Adj SS	Adj MS	F-Value	P-Value
A	1	494.08	494.08	6.27	0.046
B	1	50.43	50.43	0.64	0.454
C	1	167.25	167.25	2.12	0.195
D	1	1742.43	1742.43	22.12	0.003
E	1	29.45	29.45	0.37	0.563
Error	6	472.57	78.76		
Total	11	2956.22			

Table S3. Pre-set Process Parameters

Parameters	Soaking Media	Soaking Time	Soaking Temperature	Sonicating Temperature	Sonicating Frequency
Unit	NA	Hour	℃	℃	kHz
Level	DMAC	5	90	60	40

Table S4. Taguchi L16 (4^3) Orthogonal Array

RunOrder	Sonication time(A)	Sheet Size(B)	Solid-liquid Ratio(C)	Yield(Y)
1	1	0.52312	5	25.4
2	1	1.04625	10	23.5
3	1	2.09250	15	21.9
4	1	4.18500	20	23.0
5	3	0.52312	10	30.8
6	3	1.04625	5	36.4
7	3	2.09250	20	31.2
8	3	4.18500	15	39.7
9	5	0.52312	15	37.8
10	5	1.04625	20	34.2
11	5	2.09250	5	57.9
12	5	4.18500	10	51.7
13	7	0.52312	50	52.3
14	7	1.04625	15	60.9
15	7	2.09250	10	69.8
16	7	4.18500	5	79.9

Table S5. Taguchi Experiment Analysis of Variance for S/N Ratio

Source	DF	Seq SS	Adj SS	Adj MS	F-Value	P-Value	P% Contribution
A	3	166.807	166.807	55.6023	155.43	0.000	86.55
B	3	9.443	9.443	3.1478	8.8	0.013	4.90
C	3	14.343	14.343	4.7810	13.36	0.005	7.44
Error	6	2.146	2.146	0.3577			1.11
Total	15	192.74					100

DF: degrees of freedom; Seq SS: sequential sum of squares; Adj SS: adjusted sum of squares; Adj MS: adjusted mean squares.

Table S6. Regression Analysis Verification Tests

Experiment No.	Sonication Time	Sheet Size	Solid-liquid Ratio	Predicted Value(%)	Experiment Value(%)	Error(%)
1	3	0.523	15	28.26	26.75	5.36
2	5	1.485	10	58.58	58.99	0.22
3	7	2.092	5	70.56	73.73	4.49