Supporting Information

Synergetic recycling and conversion of spent Li-ion battery leachates into high-efficiency oxygen evolution catalysts

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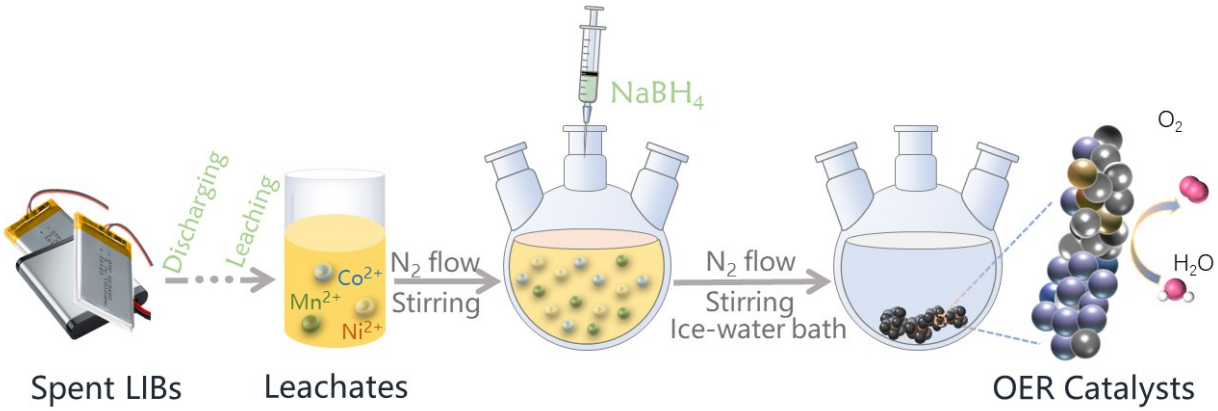

Fig. S1. Schematic illustration on synthesis magnetic NCMB OER electrocatalysts from the spent LIBs leachates via a facile boriding process.

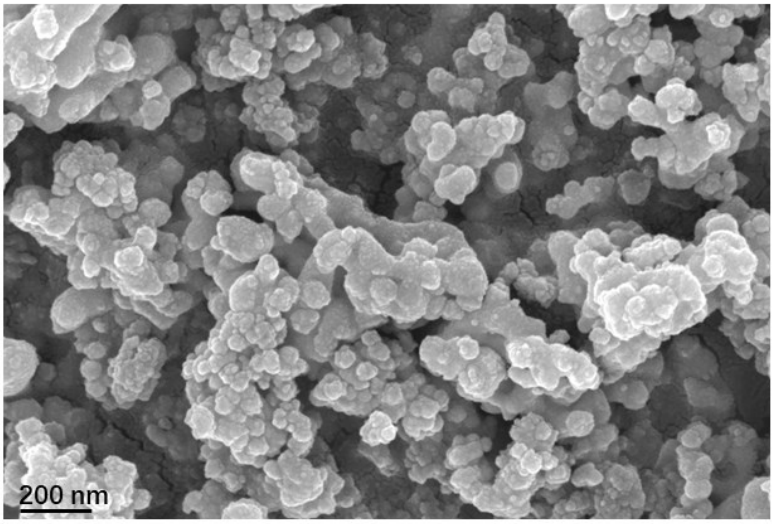

Fig. S2. SEM image of NCMB-1.

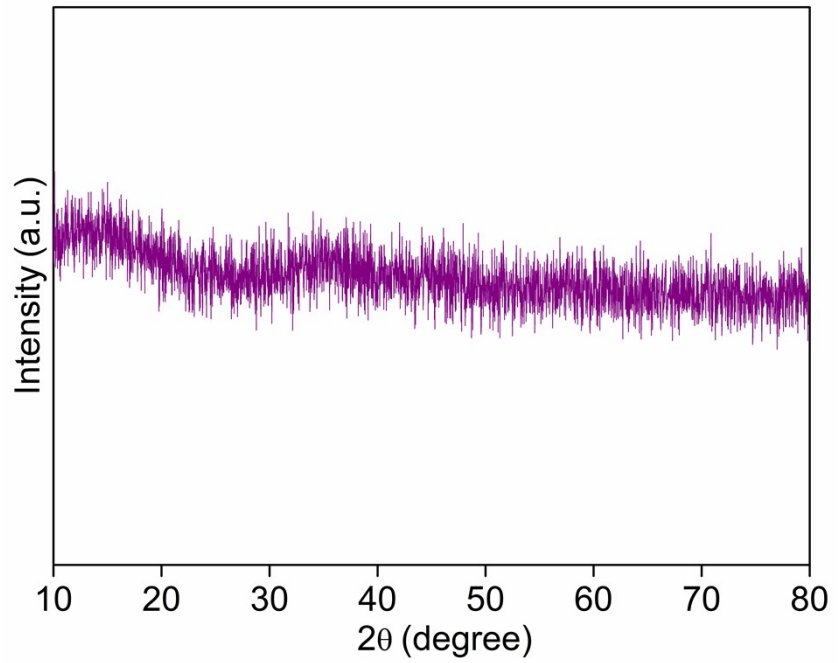

Fig. S3. XRD pattern of NCMB-1.

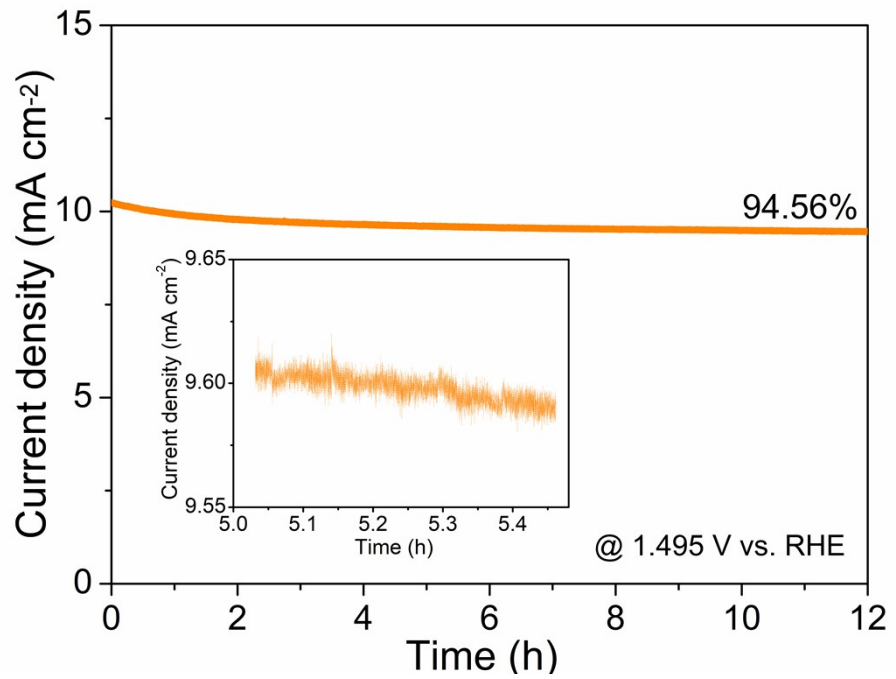

Fig. S4. Chronoamperometric i-t curve of NCMB-1 at an applied potential of 1.495 V vs. RHE (inset is a part of the stability curve).

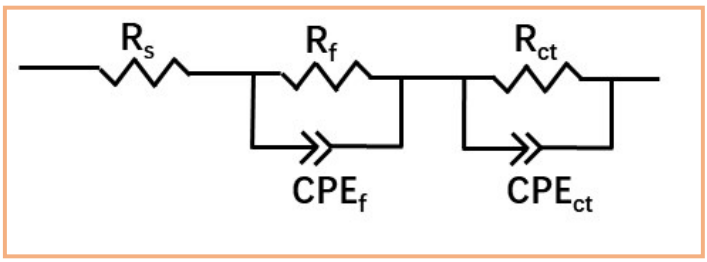

Fig. S5. Equivalent circuit model for EIS data fitting.

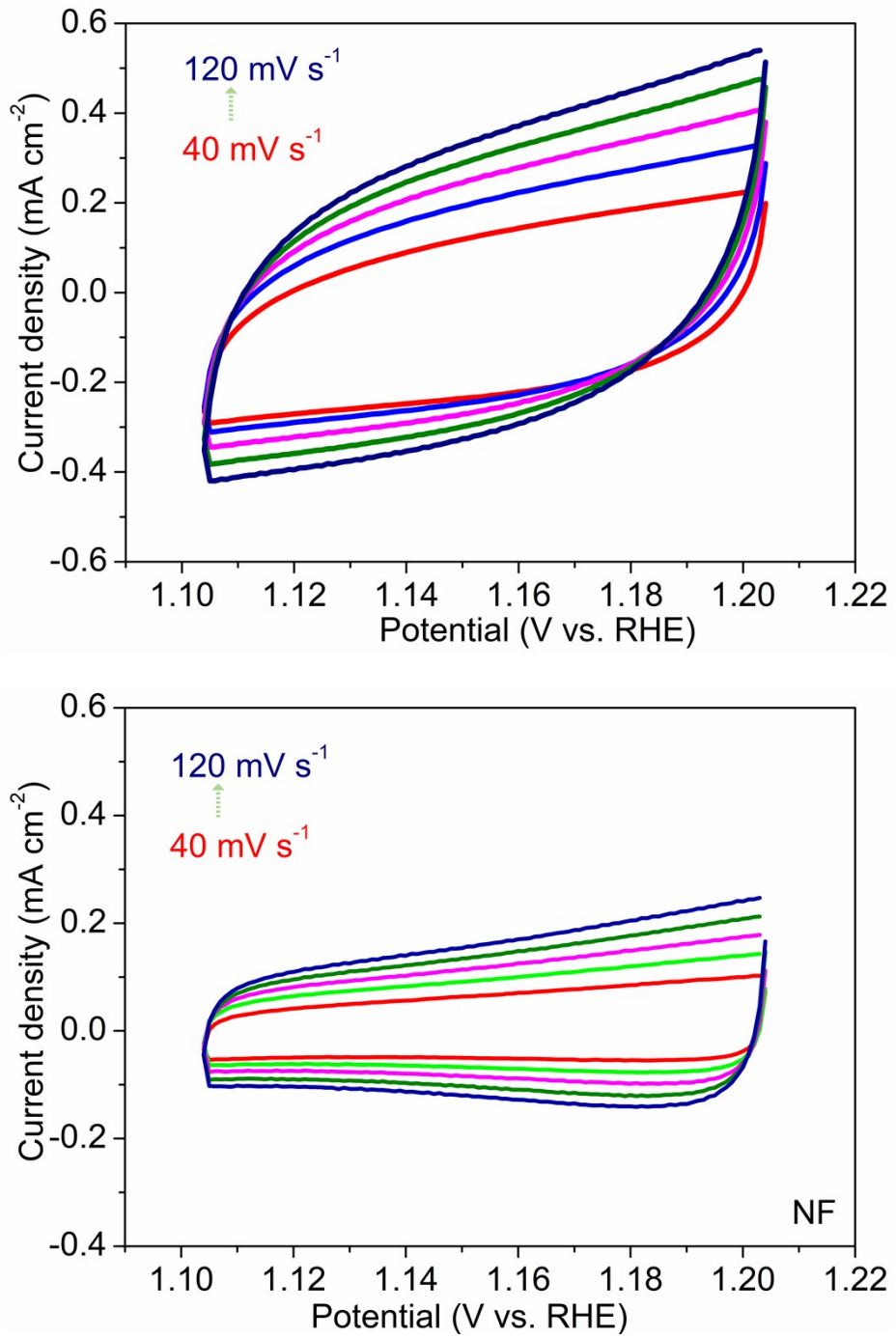

Fig. S6. CV measurements of NCMB-1(upper part), and NF (lower part) at different scan rate for C_{dl} determination.

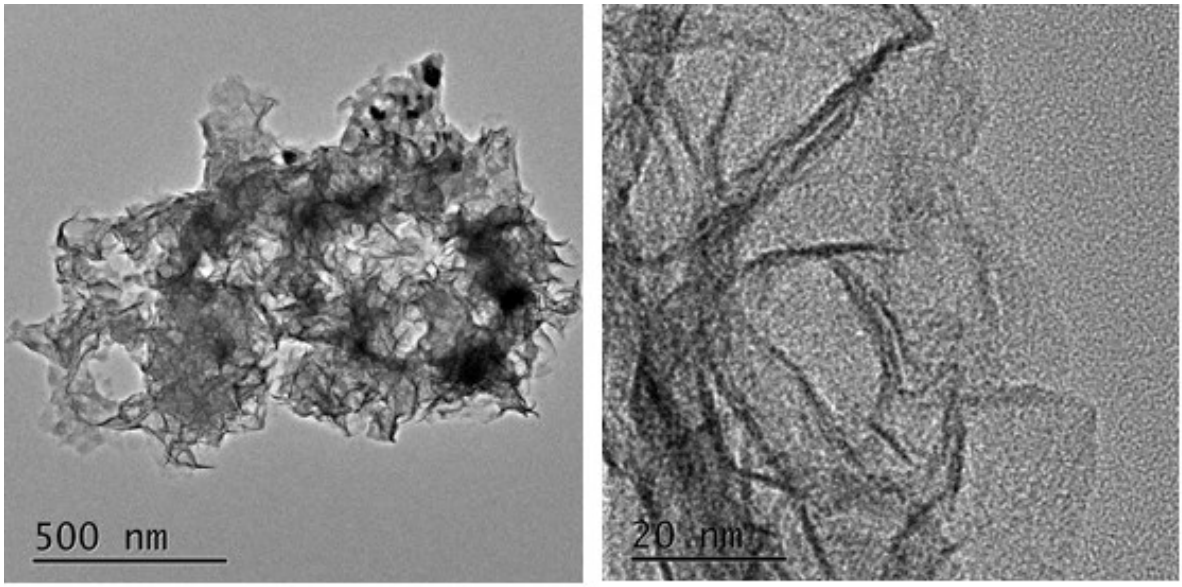

Fig. S7. TEM images of NCMB-2 after the OER test.

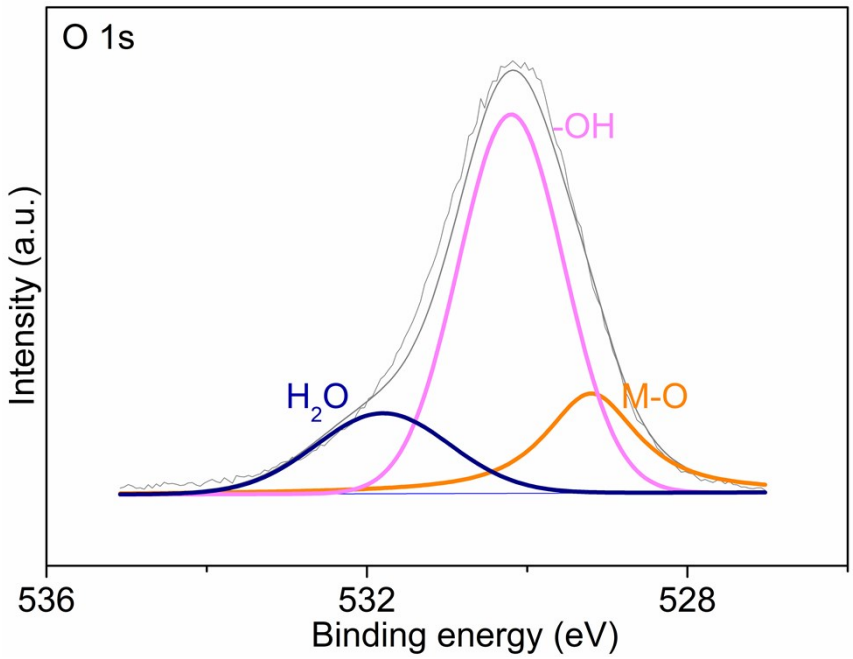

Fig. S8. High-resolution XPS scans of NCMB-2 in the O 1s regions after the OER test.

Table S1. Metal ions concentration in leachate precursors.

Sample	Concentration (g L^{-1})				
	Ni	Co	Mn	Al	Li
$LiNi_{0.5}Co_{0.2}Mn_{0.3}O_2$ derived leachate	18.53	7.19	10.56	7.24	3.09
$LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ derived leachate	32.61	4.38	4.01	5.12	3.68

Table S2.1. Experimental parameters adjusted during ICP-MS analysis of ions.

Parameter	Value
RF Power	1.50 KW
Plsama flow	15.0 L min^{-1}
Auxiliary flow	1.00 L min^{-1}
Nebulizer flow	0.10 L min^{-1}
Sample uptake delay	30 s
Instrumental stabilizaton delay	30 s
Reolicate read time	5 s
Reolicate read	3 times

Table S2.2. Experimental parameters adjusted during ICP-OES analysis of ions.

Parameter	Value
RF Power	1.3 kW
Plsama flow	15.0 L min^{-1}
Auxiliary flow	1.50 L min^{-1}
Nebulizer flow	0.75 L min^{-1}
Sample uptake delay	60 s
Sample pump rate	15 rmp
Sample rinse time	5 s
Instrumental stabilizaton delay	15 s
Standards	Quantitative
% slope deviation	10
No of standards	15
Correlation coefficient	0.995000
Curve type	Quadratic & linear

Table S3. A summary of metal recovery from spent LIBs with state-of-the-art techniques.

Battery type	Recovery method	Recovery rate (%)			References
		Ni	Co	Mn	
$LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$, $LiCoO_2$, $LiMnO_2$	Precipitation, solvent extraction	98.7	98.2	97.1	*Waste Manage., 2015, 38, 349-356.*
$LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$	Step-wise precipitation	97	97	98	*J. Alloy Compd., 2020, 847, 156489.*
$LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$	Selective dissolution, step-wise precipitation	99.7	96.5	93.5	*ACS Sustainable Chem. Eng., 2019, 7, 15, 12718-12725.*
Mixed spent LIBs	Multi-step directional precipitation	99.6	99.2	99.5	*RSC Adv., 2021, 11, 268-277.*
Spent LIBs	Step-wise precipitation	~89	98.93	~92	*Chem. Eng. J., 2015, 281, 418-427.*
Spent LIBs	Solvent extraction, step-wise precipitation	~99	-	~98	*Sep. Purif. Technol., 2019, 209, 725-733.*
$LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$	Selective leaching, adsorption separation	96.23	94.57	-	*ACS Sustainable Chem. Eng., 2017, 5, 12, 11489-11495.*
Spent LIBs	Step-wise precipitation	98.5	96.8	-	*J. Clean. Prod., 2016, 112, 3562-3570.*
Spent LIBs	Step-wise precipitation	-	90	95	*J. Clean. Prod., 2017, 147, 37-43.*
$LiNi_{0.5}Co_{0.2}Mn_{0.3}O_2$	**One-step boriding**	**99.93**	**99.91**	**99.90**	**This study**
$LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$	**One-step boriding**	**99.91**	**99.92**	**99.84**	**This study**

Table S4. A summary of OER properties for reported electrocatalysts supported on nickel foam.

Catalyst	Electrolyte	Overpotential @j (mV@ mA cm^{-2})	References
$CoMoS_x$/NF	1 M KOH	442@500	*Angew. Chem. Int. Ed., 2020, 59, 1659.*
Co-MOF/NF	1 M KOH	270@10	*Small, 2019, 15, 1906086.*
Co@NC/NF	1 M KOH	330@10	*Adv. Energy Mater., 2018, 8, 1702838.*
CoNW/NF	1 M KOH	534@100	*Green Chem., 2019, 21(24): 6699-6706.*
HfN/NF	1 M KOH	358@10	*Angew. Chem. Int. Ed., 2019, 58, 15464.*
HOF-$Co_{0.5}Fe_{0.5}$/NF	1 M KOH	278@10	*Appl. Catal. B: Environ., 2019, 258, 117973.*
NiO/Co_3O_4	1 M KOH	262@10	*ACS Catal., 2020, 10: 12376-12384.*
$Ni_3FeAl_{0.91}$-LDHs/NF	1 M KOH	304@20	*Nano Energy, 2017, 35: 350-357.*
NiCo-POM/NF	0.1 M KOH	360@10	*Angew. Chem. Int. Ed. 2017, 56, 4941.*
CoTe nanoarrays/NF	1 M KOH	350@100	*Small Methods, 2019, 3(5): 1900113.*
Ni_xB/NF	1 M KOH	280@20	*Adv. Energy. Mater., 2017, 7,*

			1700381.
NCMB-1	1 M KOH	271@10	**This study**
		330@100	
		399@500	
NCMB-2	1 M KOH	263@10	**This study**
		318@100	
		372@500	

Table S5. Calculated charge transfer resistance (R_f, R_{ct}) and solution resistance (R_s) (in Ohm, Ω) of the materials deposited on NF obtained from the Nyquist plot during the EIS experiments.

	R_s	R_f	R_{ct}
NCMB-1	1.2	0.59	15.8
NCMB-2	1.4	5.8	13.1
NF	1.7	0.97	177.1