

Electronic Supplementary Materials

Interfacial and Structural Transformations in Ni-Rich Cathodes: A Roadmap Toward Chemical Stability

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Table S1 Comparative impact of improvement strategies on capacity retention relative to the pristine material

Cathode	Strategies	Test condition	Initial discharge capacity (mAh/g)		Capacity retention (%)		Ref.
			Pristine	Modified	Pristine	Modified	
LLZO-NMC811	Mechanofusion-based garnet coatings	3-4.3V 1C 500 cycles	-	-	49	84	1
Carbon-Shell-NCA	Mechanofusion based coating	3-4.3V 0.5C 250 cycles	-	203	71	84	2
ZnO-NMC811	SALD Coating	2.7-4.3V 1C 100 cycles	161	182	51.72	77.47	3
Al ₂ O ₃ -NMC622	FTS Coating	3-4.3V 1C 400 cycles	-	-	51.3 (PEALD)	91	4
N83-CeO ₂	Controllable Coating	3-4.5V 1C 200 cycles	209.1	202.1	64.2	77	5
POV-NCM851005	Coating	3-4.3V 0.5C 100 cycles	212	201	70	87	6
InPO ₄ -NCM83	Coating	2.8–4.8V 1C 200 cycles	-	-	43	80	7
LiNbO ₃ -SC-NMC83	Coating	2.9-4.3V 1C 1000 cycles	130	150	71	88	8
Mo-SC-NMC811	Doping	2.8–4.3V 1C 300 cycles	-	-	59.6	83.2	9
Zr-NMC811	Doping	3-4.3V 1C 200 cycles	-	-	27.2	83.19	10
Nb/Ti-NMC	Co-doping	2.7-4.3V 1C 300 cycles	200	200	77.6	92.7	11
LaF ₃ -NMC	Doping	3-4.3V 1C 100 cycles	-	-	83.5	97.9	12
W-Al-NMC	Co-doping	2.5-4.5V 1C 250 cycles	-	205.95	-	84.35	13
Po ₄ ³⁻ -NMC622	Gradient doping	3-4.5V 1C 100 cycles	160	180.7	79.1	92.4	14
Se/Ti- SC-NMC90	Co-doping	2.8-4.5V 1C 500 cycles	200	200	61.4	87.6	15
Ta/Ti-NMC811	Co-doping strengthen GB	2.8–4.3V 1C 150 cycles	201.3	192.5	20.68	96.66	16
Mn shell-SC-NMC83	Acid Etching constructs the Mn shell	2.8–4.3V 0.5C 200 cycles	212.7	203.2	57.7	81.4	17
CNT-NMC	All dry CNT coating	2.75–4.3V 0.3C 500 cycles	222	221.6	60.4	75	18
NMC811	FEC optimization	3-4.2V 1C 800 cycles	-	-	5	53	19
NMC811	Dual-anion modulation	2.5-4.6V 1C 500 cycles	-	184.9	1	77.6	20
NMC811	Water-resistant	3-4.4V 2C	150	180	55	84.7	21

Cathode	Strategies	Test	Initial discharge capacity (mAh/g)		Capacity retention (%)		Ref
					(170 cycles)		
	fluoride-free electrolytes	300 cycles					
NMC811	Bulky co-solvents	2.5-4.35V 1C 200 cycles	154	190.6	35.4	81.3	22
NMC811	Compartmentalized electrolytes	2.5-4.3V 1C 520 cycles	-	-	61.7	85.1	23
LNMO	Li ₂ SO ₄ coatings	2.7-4.5V 0.2C 100 cycles	186	224.5	81	94.2	24
NMC82	Polymer coatings for sulfide-based solid-state battery	2.75-4.25V 0.2C 100 cycles	163	190	84	95	25
NMC622	Elastic interphases	2.5-4.3V 1C 500 cycles	167.2	153.8	40.9	82.8	26
NMC622	Bio-based elastomeric binders	2.5-4.5V 0.5C 400 cycles	170.3	176.7	36.5	79.5	27

References

1. P. Bunyanidhi, N. Phattharasupakun, C. Tomon, S. Duangdangchote, P. Kidkhunthod and M. Sawangphruk, *Journal of Power Sources*, 2022, **549**, 232043.
2. S. Vadivel, N. Phattharasupakun, J. Wutthiprom, S. duangdangchote and M. Sawangphruk, *ACS Applied Materials & Interfaces*, 2019, **11**, 30719-30727.
3. V. T. Anh, H.-A. Tran Vu, V. H. Nguyen, H. X. Nang, L. T. Do, V.-D. Dao and N. H. Vu, *Materials Chemistry and Physics*, 2025, **336**, 130544.
4. S. Behera, C. K. Panda, S. Lee, I. Kim, H.-J. Lee, J. Hwang, S.-G. Yoon, D. W. Kim, S. C. Jang, W. Hong, J.-W. Jung and H.-S. Kim, *Chemical Engineering Journal*, 2025, **522**, 167123.
5. S. Su, W. Zeng, Y. Qin, J. Wu, J. Ke, Y. Sun and X. Lin, *ACS Applied Nano Materials*, 2025, **8**, 3039-3049.
6. B. Nascimento Nunes, M. Ibrahim, R. Zhang, W. Zhao, Z. Zhang, A. Kondrakov and T. Brezesinski, *Batteries & Supercaps*, 2025, **8**, e202400601.
7. H. Zhang, Y. Wu, Y. Kuang, X. Xu, F. Li, J. Chen, S. Tang, J. Zhao, J. Liu and Y. Huo, *Advanced Functional Materials*, n/a, e16644.
8. W. Zhao, R. Zhang, F. Ren, L. Karger, S. L. Dreyer, J. Lin, Y. Ma, Y. Cheng, A. S. Pal, M. Velazquez-Rizo, A. Ahmadian, Z. Zhang, P. Müller, J. Janek, Y. Yang, A. Kondrakov and T. Brezesinski, *ACS Nano*, 2025, **19**, 8595-8607.
9. M. Fan, S. Li, Z. Chen, Y. Zhang, S. Shi, R. Zhang, J. Wang, K. Lei and S. Zheng, *ACS Applied Energy Materials*, 2025, **8**, 7293-7299.
10. S. Tubtimkuna, N. Phattharasupakun, P. Bunyanidhi and M. Sawangphruk, *Advanced Materials Technologies*, 2022, **7**, 2200436.
11. M. Jiang, P. Wang, Q. Chen, Y. Zhang, Q. Wu, L. Tan, T. Ning, L. Li and K. Zou, *Chinese Chemical Letters*, 2025, **36**, 110040.
12. S. Li, Y. Zhang, L. Zhao, H. Ji, Z. Fu, J. Tan, J. Bao, Y. Li, Q. Zhang, Y. Tang and H. Wang, *Chemical Communications*, 2025, **61**, 9904-9907.
13. H. Li, N. Wang, Y. Song, K. Dong, Y. Xing, M. Zhang, Y. Wang, W. Liu and Y. Jin, *Chemical Engineering Journal*, 2025, **518**, 164882.
14. M. Oh, K. Hwang, J. Lim, Y. Chi, H. Kang, H. Nam, H. Sohn and S. Yoon, *Journal of Alloys and Compounds*, 2025, **1035**, 181491.
15. Y. Chu, G. Liang, Y. Mu, Q. Zhang, Y. Hu, A. Lai, H. Gu, Q. Zhang, L. Zeng and C. Yang, *ACS Nano*, 2025, **19**, 13842-13853.
16. G. Qu, X. Chen, F. Yang, Z. Yang, G. Liu, J. Lee, R. Fong, J. Tian, R. Wen, C. Wang and Y. Huang, *Small*, 2025, **21**, 2502609.

17. X. Ma, Z. Meng, J. Hou, Z. Yao, Z. Wang, F. Dogan, Z. Yang, M. Sultanov, G. Gao, H. Guo, Y. Han, J. Wen and Y. Wang, *Batteries & Supercaps*, 2025, **8**, e202400501.
18. V.-C. Ho, T. N. Huynh, H.-G. Jung, J. H. Kim, S.-M. Oh, Y.-J. Kim and J. Mun, *Sustainable Materials and Technologies*, 2025, **43**, e01287.
19. S. Duangdangchote, N. Phattharasupakun, P. Chomkhuntod, P. Chiochan, S. Sarawutanukul, C. Tomon, N. Joraleechanchai and M. Sawangphruk, *Chemical Communications*, 2021, **57**, 6732-6735.
20. C. Zhang, S. Wu, Y. Xiong, S. Liu, Y. Zhang, H. Wan, Y. Li, R. Zeng and J. Liu, *ACS Applied Energy Materials*, 2025, **8**, 11089-11098.
21. C. Liu, T. Yang, Q. Yu, S. Wu, H.-W. Li, Z. Jiang and Y. Li, *ACS Sustainable Chemistry & Engineering*, 2025, **13**, 8951-8958.
22. H. Zeng, C. Chen, C. Xu, K. Tan, L. Yang, S. Zhang and M. Wu, *Nano Energy*, 2025, **141**, 111121.
23. J. Sun, B. Wen, Y. Li, H. Wang and M. De Volder, *Small*, 2025, **21**, 2410149.
24. T.-H. Kim, J. H. Moon, J. Shin, S. A. Mohamed, J. Kim, H. Kang, Y. Lee, H. Kang and E. Cho, *Journal of Power Sources*, 2025, **649**, 237390.
25. P. Karanth, J. H. Prins, A. Gautam, Z. Cheng, J. Canals-Riclot, S. Ganapathy, P. Ombrini, A. Ladam, S. Fantini, M. Wagemaker and F. M. Mulder, *Journal of Materials Chemistry A*, 2025, **13**, 18518-18531.
26. Z.-W. Li, F. Lin, X.-D. Zhang, X.-S. Zhang, R. Wen, X. Li and Z.-J. Zheng, *Advanced Functional Materials*, 2025, **35**, 2415035.
27. F. Lin, Z.-W. Li, Z. Wang, X.-D. Zhang, W. Lei and Z.-J. Zheng, *Small*, 2025, **21**, 2500548.