Enabling Full 1.6 V Operation through Rational Electrode Matching in Ni_2Co-LDH//Carbon Asymmetric Supercapacitors

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Abstract

Enhancing the energy density of supercapacitors while maintaining high power delivery is critical for next-generation electrochemical energy storage systems. Asymmetric supercapacitors (ASCs), integrating battery-type and capacitive electrodes, provide an effective route to extend the cell voltage and improve energy output.[1] However, incomplete utilization of the available potential window—particularly the low-potential region—often limits the attainable capacitance and energy density.[2] Herein, we report a rational electrode pairing and mass-balancing strategy to fully exploit the operating voltage window in an aqueous ASC system. Ni_2Co layered double hydroxide (Ni_2Co-LDH), a two-dimensional material with rich redox-active sites, served as the positive electrode, while high surface area carbon with rapid ion transport kinetics was employed as the negative electrode, exhibiting pronounced faradaic redox activity. Based on charge balance ($q^+ = q^-$) optimization and potential window alignment, the assembled Ni_2Co-LDH//carbon device achieved stable operation across an extended voltage window of 0-1.6 V. The optimized ASC delivered an areal energy density of 0.26 mWh cm^{-2} at a power density of 3.2 mW cm^{-2}, demonstrating efficient coupling of diffusion-controlled and surface-controlled charge storage mechanisms. This work highlights the critical role of voltage window engineering and electrode mass optimization in maximizing energy density and provides a scalable strategy for the design of high-performance asymmetric supercapacitors.

References

[1] Aisha Siddiqa, Nagaraju D. H., and Mahesh Padaki, Energy and Fuels, 36 (2022), 13286-13295
[2] C. Jing, X. Guo, L. Xia, Y. Chen, X. Wang, X. Liu, B. Dong, F. Dong, S. Li, and Y. Zhang, Chem. Eng. J., 379 (2020), 122305

Figures

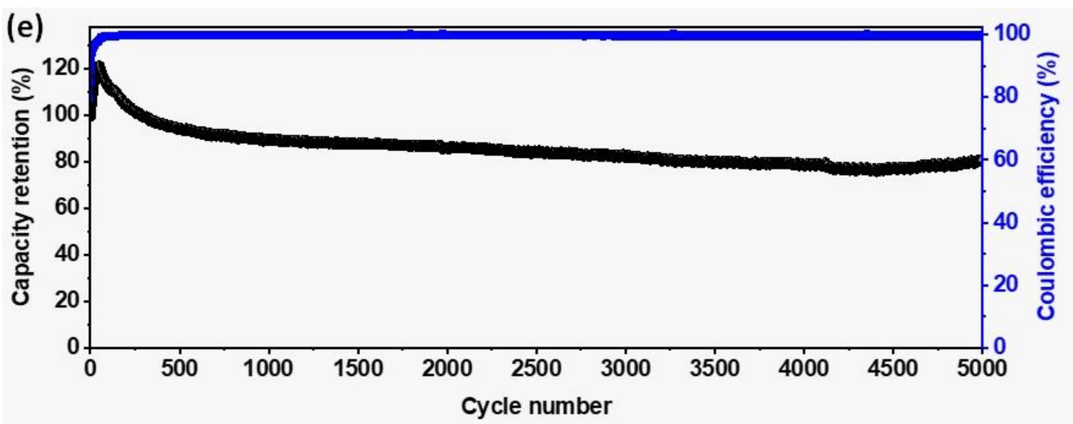

Figure 1: Rate capabilities and efficiency of Ni_2Co-LDH//carbon device.