Synergistic $Ti_3C_2T_x$ MXene-Reduced Graphene Oxide Anodes for Next Generation High-Performance Asymmetric Supercapacitors

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Abstract

The growing demand for next-generation energy storage systems to support flexible, lightweight, and sustainable electronics has intensified research into high-energy supercapacitors (SCs). Among emerging electrode materials, two-dimensional MXenes have attracted considerable attention owing to their exceptional electrical conductivity, tunable surface terminations, and layered architecture, which collectively facilitate rapid ion diffusion and efficient charge transport. While substantial progress has been achieved in cathode material development, the critical role of anode materials in maintaining charge balance, expanding the operating voltage window, and enhancing overall device performance remains comparatively underexplored [1, 2].
To address this challenge, the present study systematically investigates a series of MXene-carbon hybrid electrodes with varied structural configurations to identify an optimized anode material for asymmetric supercapacitor applications. Among the investigated composites, the MXene-reduced graphene oxide (M-RGO) electrode exhibited superior electrochemical performance, delivering a high specific capacitance of 376 F g^{-1}at a current density of 1 A g^{-1}, along with excellent rate capability and electrochemical stability. The enhanced performance is attributed to the synergistic interaction between MXene nanosheets and RGO, which effectively suppresses restacking, improves electrical conductivity, and promotes efficient ion-accessible surface area.
Building on this optimized anode, an asymmetric supercapacitor (ASC) was fabricated using M–RGO as the negative electrode and MXene-MnO_2 as the positive electrode. The assembled device operated stably over a wide potential window of 1.6 V and delivered a gravimetric capacitance of 173 F g^{-1} at 1 A g^{-1}. Notably, the ASC achieved a high energy density of 62 Wh kg^{-1} at a power density of 320 W kg^{-1}, highlighting its capability to bridge the performance gap between conventional supercapacitors and batteries. These results underscore the promise of MXene-based hybrid anode engineering as an effective strategy for developing high-performance, next-generation asymmetric supercapacitors suitable for advanced energy storage applications

References

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