

## Mesoporous WO<sub>3</sub> Nanoplates: Smart Materials for Integrated Photonic Energy Storage and Catalysis

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We report the design and synthesis of a multifunctional transition metal oxide material engineered for next-generation photo-assisted lithium-ion batteries and photocatalysis. Utilizing a facile hydrothermal method, we produced highly crystalline, porous tungsten trioxide (WO<sub>3</sub>) nanoplates with a monoclinic structure and an optical bandgap of ~2.78 eV. The material exhibits broad UV-visible light absorption and high thermal and chemical stability, making it a compelling candidate for integrated energy storage and harvesting applications. Structural and spectroscopic analyses confirm uniform morphology, high purity, and robust light-matter interaction. When employed as a free-standing electrode, WO<sub>3</sub> delivers a remarkable capacity of 1150 mAh g<sup>-1</sup> at 0.1C under illumination, far surpassing its theoretical limit, and maintains 800 mAh g<sup>-1</sup> at 1C over 400 cycles. These enhancements are attributed to the synergy of the material's high surface area, efficient lithium-ion diffusion, and photogenerated charge carrier activity, as revealed by electrochemical impedance spectroscopy and photoluminescence decay analysis. Photocatalytic activity was evaluated by studying the photodegradation of methylene blue and showed 97% of dye was degraded within only 45 mins. These findings position nanostructured WO<sub>3</sub> as a smart, dual-functional material with high potential for advanced energy-photonic devices, where efficient charge transport and light responsiveness are critical.