

# Engineering Hybrid 2D MoS<sub>2</sub>–MoO<sub>3</sub> Nanostructures for High-Efficiency Flexible Paper Supercapacitors

Christeena Thomas

Reshmi R

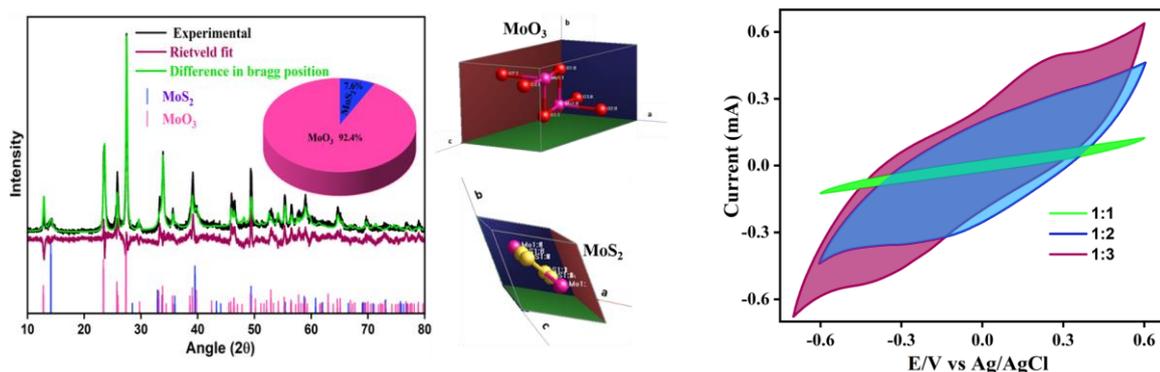
Optoelectronic and Nanomaterials Research Laboratory (ONRL), Department of Physics, Union Christian College, Aluva, Kerala, 683102, India.

[christeenathomas@uccollege.edu.in](mailto:christeenathomas@uccollege.edu.in)

## Abstract

The rapidly growing demand for efficient, sustainable, and high-power energy storage systems has intensified research on advanced electrode materials for supercapacitors, which offer fast charge–discharge capability, high power density, and long cycling stability [1], [2]. In this context, rational design of hybrid nanostructures that integrate complementary material properties is considered a promising strategy to overcome the intrinsic limitations of single-component electrodes. In this study, a hybrid MoS<sub>2</sub>–MoO<sub>3</sub> nanostructured system is synthesized and comprehensively investigated for its structural, morphological, elemental, and electrochemical properties. Rietveld refinement of X-ray diffraction data shown in Figure 1 a confirmed the coexistence of monoclinic  $\alpha$ -MoO<sub>3</sub> (space group P12<sub>1</sub>/m1) and hexagonal 2H-MoS<sub>2</sub> (space group P6<sub>3</sub>/mmc), indicating high crystallinity and phase purity of the composite. Field-emission scanning electron microscopy revealed a hierarchical morphology composed of MoS<sub>2</sub> nanoflowers and MoO<sub>3</sub> nanobrick-like structures, providing a high surface area and abundant electroactive sites, while energy-dispersive X-ray spectroscopy confirmed the uniform distribution of Mo, S, and O. Electrochemical performance was evaluated using polymer electrolytes with different PVA: KOH ratios, showing a substantial enhancement in charge storage behavior. The corresponding Cyclic Voltammograms are shown in Fig 1 b. The specific capacitance increased from 0.979 F g<sup>-1</sup> for the 1:1 ratio to 7.76 F g<sup>-1</sup> for 1:2 and reached a maximum value of 10.1 F g<sup>-1</sup> at a 1:3 ratio, attributed to improved ionic conductivity and efficient electrode–electrolyte interaction. The synergistic integration of layered MoS<sub>2</sub> and structurally stable MoO<sub>3</sub>, along with optimized electrolyte composition, leads to enhanced electrochemical performance, highlighting the strong potential of this hybrid nanostructure as a promising electrode material for future supercapacitor applications.

Figures



**Figure 1: a) XRD reietveld analysis of hybrid MoS<sub>2</sub>- MoO<sub>3</sub> nanostructure b) Cyclic voltammograms of the samples with varying concentrations of PVA:KOH ratios**

References

- [1] Karthikeyan, S., Narenthiran, B., Sivanantham, A., Bhatlu, L. D. & Maridurai, T. Supercapacitor: Evolution and review. in *Materials Today: Proceedings* vol. 46 3984–3988 (Elsevier Ltd, 2020).
- [2] Simon, P. & Gogotsi, Y. Materials for electrochemical capacitors. *Nat Mater* 7, 845–854 (2008).