

## **ABSTRACT**

*The growing demand for high-capacity energy storage systems has driven the development of lithium–sulfur batteries employing sulfur-based composite cathode materials. However, the intrinsically low electrical conductivity of sulfur and the dissolution of polysulfides continue to limit their performance. Therefore, new approaches are required, including the utilization of multi-walled carbon nanotubes (MWCNTs) and porous carbon to address these challenges. This study aims to evaluate the effect of varying sulfur-to-MWCNT mass ratios on the electrochemical performance of S/MWCNT/AC composite cathodes. The composites were synthesized with mass ratios of S1 (1:3:1), S2 (2:2:1), and S3 (3:1:1) through dry mixing followed by a fusion heating process. The resulting composites were characterized using X-ray diffraction (XRD) and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM–EDX), and their electrochemical performance was evaluated through cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic charge–discharge (GCD) measurements. The results indicate that the sample with a 2:2:1 mass ratio exhibits the most optimal electrochemical performance, as evidenced by an extremely low charge-transfer resistance ( $R_{ct} \approx 10^{-6} \Omega$ ), the highest interfacial capacitance ( $1 \times 10^6 \text{ nF}$ ) from EIS analysis, CV results indicating the highest specific capacitance of 42.47 F/g at a scan rate of 100 mV/s, and the lowest IR-drop value (0.006 V) obtained from GCD analysis. This composition achieves an ideal balance between active sulfur and the conductive MWCNT–AC network, leading to improved electrochemical performance. Therefore, the S2 (2:2:1) ratio can be considered a promising configuration for the development of S/MWCNT/AC-based battery cathodes.*

**Keywords:** *sulfur, MWCNT, activated carbon, composite cathode, mass ratio, electrochemical performance.*