Environmental Processes (2023) 10:21
https://doi.org/10.1007/s40710-023-00637-8

RESEARCH

# Li-ion Spent Carbon-Loaded Magnesium-Zirconium Hydroxide Composite for Adsorption of Methylene Blue: Kinetics and Isotherm Modelling

**Prashanth Kallambadi Sadashivappa[1] · Kumarswamy Yogesh Kumar[2] · Madihalli Srinivas Raghu[3] · Walid Nabgan[4] · Prasanna Kumar[5] · Praveen Martis[6] · Vinayak Adimule[7] · Fahad A. Alharthi[8] · Sathyanarayana rao Akshatha[9] · Byong-Hun Jeon[10] · Lakshminarayana Parashuram[11]**

Received: 29 October 2022 / Accepted: 5 May 2023 / Published online: 15 May 2023


## Abstract

The primary aim of the present investigation is to understand the efficiency of mesoporous graphene oxide incorporating Mg/Zr-hydroxide for the adsorption of methylene blue dye. Carbon from used Li-ion batteries was used to make graphene oxide, which is a way to reuse spent carbon that is safe for the environment. The structural and morphological features of the adsorbent were analysed in detail. The prepared adsorbents showed a specific surface area of 237.8 $m^2$/g and 364.7 $m^2$/g, respectively, for Mg/Zr-hydroxide (MZ) and graphene oxide-doped Mg/Zr-hydroxide (MZC). Raman's studies confirmed that the conversion of graphitic carbon into graphene oxide correlated to a change in the ratio of peak area of D-band and G-band (ID/IG) value from 0.65 to 1.21. The investigation comprised batch adsorption experiments under diverse experimental conditions like varied dye concentrations (10, 20, and 30 mg/L), pH (2–8), temperature (30–50 °C), and 90 min of adsorption studied with the adsorbent load of 20 mg. The cumulative effects of dye concentration, adsorbent load, and pH were evaluated. The dye adsorption achieved was 165.56 mg/g and 177.61 mg/g for MZ and MZC, respectively. Incorporation follows pseudo-second-order kinetics ($R^2 = 0.99$) and the Freundlich isotherm model was found to be the best fit. The composites showed competitive regeneration capacity, proving that these composites are robust adsorbents for the removal of dye contamination in water.

## Highlights

- Graphitic carbon obtained from spent Li-ion batteries was effectively used.
- A facile method for the incorporation of carbon into the Mg/Zr hydroxide matrix is presented.
- Combination of Mg, Zr and graphene oxide form carbon effective in dye adsorption.
- Synergy between Mg/Zr (positive) and carbon yields enhanced adsorption ability.
- Good reusability and retention of catalytic ability after several cycles was observed.

**Keywords** Adsorptive removal · Layered hydroxide · Spent carbon · Wastewater remediation · Cationic dye