



## Synthesis and Characterization of Multiwalled Carbon Nanotubes Decorated by ZnO and Ag<sub>2</sub>O for Using to Remove Methyl Green and Erythrosin B Dyes from Their Aqueous Solutions

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### ABSTRACT

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A new nanocomposite for multiwalled carbon nanotubes with zinc oxide and silver oxide was prepared by utilizing hydrothermal method with methanol as solvent. Zinc oxide (ZnO) and silver oxide (Ag<sub>2</sub>O) were synthesized using co-precipitation method under basic medium. They were identified by several techniques such as UV-Vis, X-ray powder diffraction (XRD), scanning electron microscopy (SEM) and EDX analysis. The crystal size of the prepared nano compounds was revealed 17.6, 26.8, 20.3 and 21.5nm for MWCNT (after their functionalized by utilizing acids mixture from sulfuric and nitric acid by ratio 3:1(v/v)), ZnO, Ag<sub>2</sub>O and MWCNTs/ZnO & Ag<sub>2</sub>O nanocomposite respectively. The batch adsorption was used for removing two different class as cationic and anionic dyes from its aqueous solutions under various conditions such as pH level, temperature, contact time and agitation speed, the data exhibited a high value to remove dyes methyl green (MG) and erythrosin B (EB) onto the surface nanocomposite were 96.4 and 99.71% respectively. Adsorption equilibrium isotherm appeared the Langmuir model is more fitted than Freundlich to remove erythrosin B dyes with adsorption capacity 184.9 mg/g, while the adsorbed of methyl green dye more fitted with Freundlich isotherm and adsorption capacity is 836.9 mg/g. Thermodynamic parameters ( $\Delta G^\circ$ ,  $\Delta H^\circ$  and  $\Delta S^\circ$ ) have been computed and revealed the negative values for the free energy.

## 1. INTRODUCTION

Carbon nanotubes have several unique properties, including electronic, chemical, mechanical strength, optical activity, large surface area, high porosity, light mass density, and hollow structure. They can be described as a graphite sheet twisted up within a nanoscale tube. Furthermore, CNTs can be divided into two main classes: single-wall carbon nanotubes (SWCNTs) and multiwalled carbon nanotubes (MWCNTs) [1-3].

Multiwalled carbon nanotubes have additional important features such as internal sites, interstitial channels, and grooves on their outer surface. Moreover, they exhibit non-covalent forces such as hydrogen bonding,  $\pi$ - $\pi$  stacking, electrostatic forces, van der Waals forces, and hydrophobic properties [4]. Consequently, these unique properties make MWCNTs excellent adsorbent surfaces, allowing strong interactions with various pollutants, including both organic and inorganic contaminants [2].

The release of various pollutants into ecosystems has increased due to anthropogenic activities such as industrial development in sectors like oil production, building materials, cosmetics, food, clothing, and dyes. Additionally, urban growth has led to a rise in domestic waste discharge into the environment without proper treatment [5-7].

Nano oxides have attracted significant research interest due to their chemical properties, applications, and small particle size, making them widely used for removing organic and inorganic pollutants from aqueous solutions. Particularly, zinc oxide (ZnO), silver oxide (Ag<sub>2</sub>O), titanium oxide (TiO<sub>2</sub>), iron oxide (Fe<sub>2</sub>O<sub>3</sub>), and selenium dioxide (SeO<sub>2</sub>) have been utilized for water treatment applications, targeting pollutants such as heavy metals, dyes, pharmaceuticals, domestic waste, and oil spills through the batch adsorption method [1, 8].

Methyl Green (MG) and erythrosin B (EB) dyes are organic compounds belonging to two different dye classes: triarylmethane and xanthene, respectively. They have high solubility in water and exhibit toxicity and carcinogenic effects [9, 10].

Consequently, the present work aims to synthesize a new nanocomposite from functionalized multiwalled carbon nanotubes with nano oxides such as zinc oxide and silver oxide by the hydrothermal method. The objective is to obtain a high surface area and smaller particle size than in previous studies and then use the nanocomposite to remove MG and EB dyes from aqueous solutions with high efficiency using the batch adsorption method.