Metal–Oxide–Nanosize and Polymer–Modified MWCNTs for Enhanced Removal of Hydrocarbons and Dyes from Water

Thamer Adnan Abdullah[1*], Zainab J. Abdul-Zahra[1], Mukhtar Ali Hussein[1], Rashed T. Rasheed[1], Karol Kułacz[2*]

[1]Collage of Applied Sciences, Department of Applied Chemistry, University of Technology, Baghdad, Iraq
[2]University of Wrocław, Faculty of Chemistry, ul. F. Joliot–Curie 14, 50–383 Wrocław, Poland
[*]Corresponding

Abstract

The elimination of hydrocarbons and dyes from water using solid adsorbents has been widely studied in recent years, as these materials may serve as an effective alternative to significantly reduce environmental pollution caused by such contaminants in aquatic environments. However, this requires novel solid adsorbent materials with good selectivity, large adsorption capacity, fast adsorption rates, as well as good mechanical strength and regeneration properties. In this research, the potential for employing metal oxides, multiwalled carbon nanotubes (MWCNTs) functionalized with metal oxides and/or polymer nanocomposites as adsorbents for decontaminating water from hydrocarbons and dyes was investigated. The polymer-modified magnetite-MWCNTs (using polyethylene, polystyrene, or P-NIPAM) were prepared by the solution mixing method. Various types of adsorbents, such as single or binary metal oxides, pristine multi-walled CNTs, metal oxide nanoparticles-modified multi-walled CNTs, and polymer-modified Fe/MWCNTs, were characterized using various analytical techniques. XRD, TEM, SEM, EDX, AFM, FTIR, Raman, TG/DTA, and BET analyses were performed to characterize the structure, composition, and morphology of the freshly prepared adsorbents. The adsorption efficiencies of both fresh and modified MWCNT adsorbents for hydrocarbon and dye removal were investigated through GC, UV–Vis, and HPLC experiments, using hydrocarbons such as kerosene, toluene, and methylene blue (MB dye) as model compounds for adsorption tests. Kinetic models were applied to study the rate of adsorption, revealing that the adsorption followed pseudo-first-order, pseudo-second-order, and intra-particle diffusion models. Additionally, Langmuir and Freundlich isotherm models were applied to the adsorption isotherm data. The adsorption of saturated and aromatic hydrocarbons and cationic dyes on carbon nanotube-type adsorbents, along with the proposed mechanisms of this process, were explored.

Keywords: nanoparticles; metal oxide doped MWCNTs; polymers modified Fe_3O_4/MWCNTs; nanoadsorbents; water treatment, methylene blue removal from water