

Eminent Carbon-Dioxide Scavenger Fabrication from Graphene Oxide-Metal Schiff's Base Nanocomposite

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Abstract

The ever-increasing concentration of atmospheric carbon dioxide (CO₂) emanates mainly from the massive combustion of fossil fuel in various industries, and it has been the main cause of global climatic change and environmental decay. This challenge has compelled extensive research efforts into a quest for adequate, cost-effective, and regenerable carbon capture materials that can work under ambient conditions. Herein, graphene oxide-metal-Schiff base nanocomposites were designed, synthesized, and studied as effective adsorbents for CO₂ capture. GO was prepared from graphene powder via a modified Hummers method to produce a layer-rich structure with oxygen-containing functional groups.

Two kinds of Schiff base ligands TSA and TTC were synthesized using p-toluidine as the amine precursor, condensing with two different aldehyde source salicylaldehyde and thiophene-2-carbaldehyde. Further, both the Schiff bases were complexed with transition metal ions via in situ method. In this study, Schiff base ligands were coordinated with Fe³⁺, Co²⁺, and Cu²⁺ ions and then supported on graphene oxide sheets to result in GO-metal-Schiff base nanocomposites.

The prepared materials were comprehensively characterized by FT-IR spectroscopy, UV-Vis spectroscopy, XRD, NMR, and scanning electron microscopy. FT-IR and UV-Vis analyses confirmed Schiff base formation, metal coordination, and ligand-to-metal charge transfer interactions. XRD patterns confirm the structural features of graphene oxide and successful modifications after functionalization, while NMR spectroscopy provides clear evidence for the azomethine bond. SEM images revealed characteristic sheet-like morphologies of graphene oxide decorated with uniformly distributed metal-containing nanoparticles. CO₂ adsorption studies conducted at temperatures of 25°C and 50°C were examined using TG analysis, which exhibited a significant increase in adsorption capacity for the functionalized GO nanocomposites up to 1.12 mmol g⁻¹ at 25°C. This was attributed to the synergistic effect of graphene oxide's high surface area and the presence of metal-Schiff base active sites, promoting strong interactions between these active sites and CO₂ molecules. Further the kinetic studies revealed that of the three models, pseudo-first order (Pf), pseudo-second order (P₂) and Avrami (A_v) kinetics models, the CO₂ adsorption was better described by the Avrami model. Thus, the results of this study demonstrate that GO-based metal-Schiff base nanocomposites are promising, cost-effective, and regenerable materials for near-future carbon capture systems.

Keywords

Graphene oxide, Nanocomposites, Schiff base, Transition metal, Carbon-dioxide Scavenger.