

Evaluation of Anticorrosion Properties Exhibited by Series of Transition Metal Schiff's Base/GO Nanocomposite

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Abstract

The degradation of metal surfaces due to corrosion poses a critical threat to the structural integrity and longevity of industrial materials, especially under harsh environmental conditions. To address this issue, research has increasingly focused on hybrid materials that combine the chemical versatility of Schiff base ligands with the unique physicochemical properties of graphene oxide (GO). In this context, the current study aims to design and characterize the novel nanostructured materials based on the integration of transition metal Schiff base complexes with GO sheets. Two Schiff base ligands N-(4-chlorobenzylidene)-p-toluidine (TCBA) and N-(5-bromo-2-hydroxybenzylidene)-p-toluidine (TBSA) were synthesized and subsequently complexed with Fe³⁺, Ni²⁺ and Mn²⁺ ions. The resulting metal complexes were grafted onto graphene oxide to produce GO-Schiff base metal nanocomposites (GO-Mn-TBSA, GO-Ni-TBSA, GO-Fe-TBSA, GO-Ni-TCBA, and GO-Fe-TCBA). Structural confirmation and functional group analysis were performed using FT-IR, UV-Vis, XRD, and SEM. All these GO-Schiff base metal composites have been assessed for its corrosion inhibition efficiency, using the specimens of mild steel with different weight percentages (wt %), under acidic condition and were observed to possess a good anti corrosion property. Among the composites tested, GO-Mn-TBSA and GO-Ni-TCBA exhibited the highest efficiencies. Adsorption studies using Langmuir, Freundlich, Temkin, and Frumkin isotherms revealed that the Frumkin model best described the adsorption behavior of GO-Schiff base metal nanocomposites on mild steel, indicating monolayer adsorption. For GO-Ni-TCBA, the inhibition efficiency increased from 32.07% to 69.05% with increasing inhibitor concentration, accompanied by a rise in surface coverage (θ) from 0.3207 to 0.6905. While for GO-Mn-TBSA inhibition efficiency increased from 22.54% to 73.04% as the inhibitor concentration increased, with corresponding surface coverage (θ) increasing from 0.2254 to 0.7304. For the nanocomposites GO-Ni-TCBA and GO-Mn-TBSA, the adsorption equilibrium constant, K_{ads} was found to be 0.1249 and 0.1122, yielding a standard free energy of adsorption (ΔG°_{ads}) of -4.80 kJ mol⁻¹ and -4.53 kJ mol⁻¹. The negative ΔG°_{ads} value confirms spontaneous adsorption, while its low magnitude indicates a predominantly physisorption-driven mechanism. The increased surface coverage with concentration confirms effective adsorption of the nanocomposite on the mild steel surface, forming a protective barrier that significantly reduces corrosion in acidic conditions.

Keywords

Graphene oxide, Nanocomposites, Schiff base, Transition metal, Anti-corrosion properties, adsorption isotherm, Gibbs free energy.