

Abstract

This study evaluates the thermodynamic behavior and adsorption mechanism of methanolic *Acacia mearnsii* bark extract (MAMBE) as a green corrosion inhibitor for stainless steel (SS304) in synergy with KI in 1 M HCl solution. Using weight loss measurements, thermodynamic calculations, and adsorption studies, the study assesses both the individual and combined effectiveness of MAMBE and potassium iodide (KI). MAMBE alone achieved a maximum inhibition efficiency of 62.2 % at 1.2 g/L, which dramatically increased to 98.2% when supplemented with 0.3 g/L KI, indicating a strong synergistic effect ($s > 1$). Thermodynamic parameters, including activation energy (E_a), enthalpy change (ΔH°), entropy change (ΔS°), and Gibbs free energy change (ΔG°), were analyzed to understand the nature of adsorption and spontaneity. MAMBE and KI alone showed E_a values below 80 kJ/mol with positive ΔH° , indicating endothermic adsorption. The MAMBE and KI combination presented a higher E_a of 105 kJ/mol, suggesting a more robust corrosion barrier. The ΔG° values (-6.653 to -21.765 kJ/mol) confirmed spontaneous, predominantly physical adsorption. Adsorption followed the Langmuir isotherm model, and thermogravimetric analysis revealed MAMBE's thermal stability up to 110°C, highlighting its excellent thermal resistance and potential as an effective eco-friendly corrosion inhibitor.