

Abstract

Marine environments accelerate the corrosion of mild steel, posing significant operational challenges across global industries. This study investigates the corrosion inhibition potential of *Musanga cecropioides* leaf extract (MCLE) as a green, eco-friendly alternative to synthetic inhibitors. Phytochemical analysis revealed the presence of bioactive compounds such as alkaloids, flavonoids, tannins, Saponins, and terpenoids, which facilitate corrosion protection by forming adherent protective films on steel surfaces. Gravimetric weight loss measurements conducted over a period of 85 hrs assessed the inhibitor's performance across varying concentrations (0.2– 0.8 g/L) in seawater. Maximum inhibition efficiency of 95.1% was achieved at 0.8 g/L after 68 hours of immersion. Adsorption behavior followed the Langmuir isotherm model with a correlation coefficient (R^2) of 0.99087, confirming monolayer adsorption and suggesting physisorption as the dominant mechanism ($\Delta G_{ads} = -13.8$ kJ/mol). Optimization using Response Surface Methodology (RSM) and Central Composite Design (CCD) yielded a statistically robust quadratic model ($R^2 = 0.8492$, adjusted $R^2 = 0.7953$, Adeq Precision = 11.1362). Validation experiments confirmed model accuracy, showing a low uncertainty error of 1.66% between predicted and experimental inhibition efficiency. These findings demonstrate that *Musanga cecropioides* leaf extract offers a highly effective, sustainable, and economically viable solution for mitigating mild steel corrosion in marine environments.