

Corrosion Inhibition of Mild Steel in 1 M HCL Using *Moringa oleifera* Extract at Varying Temperatures

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Structured Abstract

Background: Corrosion of mild steel in acidic media is a widespread industrial problem, particularly in oil refineries, water treatment facilities, and chemical processing plants. The use of hydrochloric acid (HCl) for cleaning, pickling, and descaling exacerbates corrosion, leading to reduced structural integrity, safety hazards, and increased operational costs. Although synthetic corrosion inhibitors are available, they often pose health and environmental risks. This study addresses the urgent need for a green, non-toxic, and biodegradable inhibitor by evaluating the corrosion inhibition performance of *Moringa oleifera* leaf extract on mild steel in 1.0 M HCl at varying temperatures.

Methods: The corrosion behaviour was investigated through Linear Polarization Resistance (LPR) to determine the corrosion current density (i_{corr}) and inhibition efficiency (IE%) at two different concentrations (100 ppm and 400 ppm) across three temperature levels: 25°C, 35°C, and 45°C. UV-Visible Spectroscopy was used to monitor changes in absorbance before and after immersion, revealing an interaction between the extract and the metal surface. Additionally, surface morphology and elemental composition were examined using Field Emission Scanning Electron Microscopy (FESEM) and Energy Dispersive X-ray Spectroscopy (EDX).

Results: The extract demonstrated increased efficiency at higher temperatures and concentrations. At 400 ppm and 45°C, the inhibition efficiency peaked at 82.96%. UV-Vis spectra showed a significant increase in absorbance at 210.98 nm after immersion, indicating active adsorption of phytochemicals onto the steel surface. FESEM images showed smoother surfaces and fewer corrosion pits in treated samples, and EDX analysis revealed higher carbon and nitrogen content, suggesting the formation of a stable organic protective layer. Oxygen and chlorine levels were significantly lower compared to the untreated sample, confirming reduced corrosion activity.

Conclusion: *Moringa oleifera* extract has proven effective in inhibiting mild steel corrosion in acidic environments, especially at elevated temperatures. Its adsorption follows the Langmuir isotherm, forming a monolayer barrier that limits metal-ion interactions. Given its performance, environmental friendliness, and cost-effectiveness, *Moringa oleifera* is a viable alternative to conventional synthetic inhibitors for industrial corrosion control.

Keywords: Corrosion inhibitor, *Moringa oleifera*, mild steel, hydrochloric acid, green inhibitor

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