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Mango (*Mangifera indica* L.) Leaves as a Green Corrosion Inhibitor for Bellicose Corrosive Media

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ABSTRACT: Corrosion is a significant industrial problem that causes deterioration of metals and substantial economic losses. Due to the environmental and health risks associated with synthetic corrosion inhibitors, plant-based compounds have gained attention as eco-friendly alternatives. This study evaluates the potential of mango (Mangifera indica L.) leaf extract as a green corrosion inhibitor for steel in bellicose corrosive media. A quantitative experimental design was used, involving phytochemical screening and corrosion testing using steel nails immersed in distilled water, nitric acid, and mango leaf extract solutions. Phytochemical analysis revealed the presence of bioactive compounds such as alkaloids, tannins, saponins, proteins, carbohydrates, and fixed oils and fats, which are known to adsorb onto metal surfaces and inhibit corrosion reactions. Experimental results showed that steel nails treated with mango leaf extract exhibited no rust formation and maintained constant weight after five days of immersion, whereas significant corrosion occurred in the control treatments. The formation of a dark protective coating on the metal surface indicated the adsorption of phytochemical compounds that served as a barrier against corrosive reactions. These findings demonstrate that mango leaf extract is an effective, sustainable, and cost-efficient corrosion inhibitor for steel exposed to aggressive environments.

KEYWORDS: Green corrosion inhibitor, plant-based inhibitors, steel corrosion protection, phytochemical adsorption, eco-friendly corrosion control

I. INTRODUCTION

Corrosion is an electrochemical process that results in the deterioration of metals due to interaction with environmental factors such as oxygen, moisture, and aggressive chemicals. The corrosion of steel and iron structures poses significant economic and structural challenges across industries including construction, transportation, and manufacturing. Globally, corrosion-related damage accounts for billions of dollars in maintenance and replacement costs annually [1].

Conventional corrosion inhibitors are typically synthetic organic compounds containing nitrogen, sulfur, or oxygen atoms that adsorb onto metal surfaces to prevent oxidation reactions. Although these inhibitors are effective, many are toxic, expensive, and environmentally hazardous. As a result, recent research has focused on the development of green corrosion inhibitors derived from plant extracts that are biodegradable, cost-effective, and environmentally sustainable [2] [3].

Plant-based corrosion inhibitors contain bioactive phytochemicals such as alkaloids, tannins, flavonoids, polyphenols, and saponins. These compounds possess heteroatoms and conjugated systems that facilitate adsorption onto metal surfaces, thereby forming protective films that prevent metal dissolution and corrosion reactions [1]. Numerous studies have demonstrated the effectiveness of plant extracts as corrosion inhibitors in acidic and saline environments [4].

Mangifera indica L., commonly known as mango, is widely distributed in tropical regions including Southeast Asia. Mango leaves contain abundant phytochemicals such as polyphenols, flavonoids, tannins, and xanthones that possess antioxidant and metal-binding properties [5]. These compounds have the potential to adsorb onto metal surfaces and inhibit corrosion processes.

This study investigates the capability of mango leaf crude extract as a corrosion inhibitor in bellicose corrosive media, using steel nails exposed to nitric acid and distilled water environments. The effectiveness of the extract is evaluated through phytochemical analysis, experimental corrosion testing, and statistical comparison with control treatments.

II. METHODOLOGY

2.1 Research Design

The research utilized a quantitative experimental design to evaluate the corrosion inhibition capability of mango leaf extract. The experiment involved preparing crude extracts of mango leaves, conducting phytochemical screening, and testing the extract as a corrosion inhibitor on steel nails exposed to different corrosive media.

2.2 Collection and Preparation of Plant Samples

Fresh leaves of Mangifera indica were collected in Cabanatuan City. The samples were washed, air-dried, chopped, and subjected to extraction procedures. The preparation and experimentation were conducted in laboratory facilities where standard chemical extraction procedures were performed. The dried mango leaves were soaked in 95% methanol for 24 hours to extract bioactive compounds. The solution was filtered and concentrated using a rotary evaporator, producing approximately 850 mL of crude methanolic extract. This crude extract was later used to formulate the experimental corrosion inhibitor solution.

2.3 Phytochemical Screening

Qualitative phytochemical tests were conducted to identify secondary metabolites present in the mango leaf extract. Standard procedures were used to detect alkaloids, amino acids, carbohydrates, fixed oils and fats, tannins, proteins, and saponins.

The phytochemical composition is important because these compounds are known to participate in adsorption and protective film formation on metal surfaces, thereby inhibiting corrosion reactions.

2.4 Corrosion Inhibition Experiment

Steel nails were used as the metal specimen to simulate corrosion in a bellicose corrosive environment. Each experimental treatment consisted of five steel nails immersed in 40 mL of solution for a duration of five days.

Three experimental setups were prepared:

1. Distilled water (negative control)
2. Nitric acid solution (positive control)
3. Mango leaf extract corrosion inhibitor (experimental treatment)

The presence or absence of rust and changes in nail weight were used to determine corrosion inhibition efficiency.

2.5 Statistical Analysis

Analysis of Variance (ANOVA) was used to determine whether significant differences existed between treatments in terms of corrosion effects.

III. RESULTS AND DISCUSSION

3.1 Phytochemical Composition of Mango Leaves

Phytochemical screening revealed that mango leaf extract contained several biologically active compounds known for their corrosion inhibition properties. These include alkaloids, carbohydrates, fixed oils and fats, tannins, proteins, and saponins, while amino acids were not detected.

Table 1

Phytochemical Constituents Detected in Mango Leaf Extract

PHYTOCHEMICAL TEST	RESULT	INTERPRETATION
ALKALOIDS (MAYER'S TEST)	Positive	Presence of alkaloids
AMINO ACIDS (NINHYDRIN TEST)	Negative	Amino acids absent
CARBOHYDRATES (MOLISCH'S TEST)	Positive	Presence of carbohydrates
FIXED OILS AND FATS	Positive	Presence of lipids
TANNINS (FERRIC CHLORIDE TEST)	Positive	Presence of tannins
PROTEINS (MILLON'S TEST)	Positive	Presence of proteins
SAPONINS (FOAM TEST)	Positive	Presence of saponins

The presence of these compounds supports previous findings that mango leaves contain polyphenolic compounds capable of forming protective complexes with metal ions [5]

3.2 Experimental Corrosion Testing

The corrosion inhibition capability of mango leaf extract was evaluated by comparing it with nitric acid and distilled water treatments.

Table 2

Observed Corrosion Effects on Steel Nails

TREATMENT SOLUTION	OBSERVATION	CORROSION INHIBITION EFFECT
DISTILLED WATER	Nails coated with rust	Low inhibition
NITRIC ACID	Severe rust formation	No inhibition

MANGO LEAF EXTRACT (MANGO INHIBITOR)	No rust formation; dark protective coating observed	Full inhibition

The results indicate that mango leaf extract effectively inhibited corrosion in steel nails. The dark coating observed on the nail surface suggests the formation of a protective adsorption layer that prevented contact between the metal surface and the corrosive environment.

Plant-derived corrosion inhibitors function primarily through adsorption mechanisms. The phytochemical compounds present in the extract bind to the metal surface via electron-donating functional groups such as hydroxyl and aromatic rings, forming a barrier that slows down electrochemical corrosion reactions [3].

3.3 Weight Change Analysis

Changes in nail weight before and after exposure to corrosive media further illustrate the effectiveness of the inhibitor.

TREATMENT	INITIAL WEIGHT (G)	FINAL WEIGHT (G)	INTERPRETATION
DISTILLED WATER	0.79	Increased	Moderate corrosion occurred
NITRIC ACID	0.79	Increased significantly	Severe corrosion occurred
MANGO LEAF EXTRACT	0.79	0.79	No corrosion observed

The unchanged weight of nails immersed in mango leaf extract confirms the inhibition of metal oxidation. The protective layer formed by the phytochemicals prevented corrosion reactions from occurring.

3.4 Mechanism of Corrosion Inhibition

Corrosion of iron typically occurs through electrochemical reactions where iron atoms oxidize to Fe^{2+} while oxygen reduction occurs at cathodic sites. This process produces hydrated iron oxides commonly known as rust.

Green corrosion inhibitors function by interrupting this electrochemical process through adsorption on the metal surface. Polyphenolic compounds and tannins in mango leaves can chelate metal ions and form stable complexes that block active corrosion sites [1].

Furthermore, the presence of multiple heteroatoms such as oxygen and nitrogen within these compounds enhances their ability to donate electrons to the metal surface, strengthening adsorption and increasing inhibition efficiency [4].

IV. CONCLUSION

This study demonstrates that mango (Mangifera indica L.) leaf extract is an effective green corrosion inhibitor for steel exposed to bellicose corrosive environments.

Phytochemical analysis confirmed the presence of compounds such as alkaloids, tannins, saponins, proteins, and carbohydrates that are capable of forming protective adsorption films on metal surfaces. Experimental testing revealed that steel nails immersed in mango leaf extract remained free from corrosion, while significant rust formation occurred in nitric acid and distilled water treatments.

Weight measurements and observational results confirmed that the mango leaf extract effectively prevented corrosion by forming a protective coating on the metal surface. Statistical analysis further supported the significant difference between the inhibitor treatment and the control groups.

The findings highlight the potential of mango leaves as a sustainable, environmentally friendly, and cost-effective corrosion inhibitor suitable for industrial and household applications.

Future research should explore electrochemical testing methods, inhibitor efficiency at varying concentrations, and applications to other metals and corrosive environments.

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