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A Study of Natural Coatings as Corrosion Inhibitors for Metal Surfaces

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Abstract: ***This study investigates the effectiveness of natural coatings derived from turmeric, ginger, aloe vera, and curry leaves, individually mixed with carboxymethyl cellulose (CMC) as a binding agent, in reducing corrosion on metal surfaces. The coated metal samples were air-dried and exposed to hydrochloric acid (HCl) to analyse their corrosion resistance properties. The observations, including weight loss measurements and visual inspections, demonstrate the efficiency of these natural inhibitors. The findings contribute to the development of sustainable and environmentally friendly corrosion prevention techniques.***
Keywords: Corrosion, metal deterioration, environmental factors, antibacterial properties.

I. INTRODUCTION

Corrosion is a major concern in industries where metal structures are exposed to corrosive environments, leading to material degradation and financial losses. Traditional corrosion inhibitors often contain toxic chemicals that pose environmental risks. This study explores the use of natural plant extracts as green corrosion inhibitors, offering an eco-friendly alternative. Both ginger and turmeric are rich in bioactive compounds such as alkaloids, flavonoids, tannins, curcuminoids, and essential oils, which contribute to their antioxidant and protective properties. Their potential as corrosion inhibitors has been evaluated through various experimental techniques, providing insights into their adsorption mechanisms and efficiency. Aloe vera, similarly, contains polysaccharides, anthraquinones, flavonoids, and tannins, making it a strong corrosion inhibitor.

A. *Objectives*

1) To analyse the corrosion inhibition efficiency of natural coatings made from turmeric, ginger, aloe vera, and curry leaves.
2) To study the protective layer formation on metal surfaces.
3) To compare the corrosion resistance of different coatings.
4) To determine the potential of natural inhibitors as substitutes for synthetic inhibitors.
5) To understand the adsorption mechanism of these inhibitors on metal surfaces.
6) To compare natural inhibitors with synthetic inhibitors in terms of environmental impact and efficiency.

II. MATERIALS AND METHODS

A. *Materials Used*

1) Metal pieces (mild steel)
2) Turmeric, ginger, aloe vera, and curry leaves
3) Carboxymethyl cellulose (CMC) as a binding agent
4) Hydrochloric acid (HCl) (dilute)
5) Beakers, measuring instruments, and weighing balance

B. *Preparation of Extracts and Coatings*

1) Fresh turmeric, ginger, and aloe vera were cleaned, dried, and ground into a fine powder/paste.
2) The powdered samples were subjected to extraction using solvents such as water.
3) The extracts were filtered and concentrated for use as corrosion inhibitors.
4) CMC was added to each paste to enhance adhesion to metal surfaces.
5) The metal samples were coated with the prepared pastes and air- dried.

C. Metal Sample Preparation

1) Copper samples were selected for corrosion studies due to their widespread industrial use.
2) The samples were polished, washed, and dried before experimentation.
3) Each sample was measured for initial weight and dimensions before immersion in corrosive solutions.

D. Experimental Procedure

1) Coated metal samples were placed in beakers.
2) A few drops of HCl were added to each beaker.
3) Changes in the metal surface were observed over time.
4) Weight loss measurements were recorded to quantify corrosion inhibition.

III. OBSERVATIONS AND RESULTS

Sample Type	Initial Weight (g)	Final Weight (g)	Weight Loss (g)	Observations
Uncoated Metal	52.10	45.75	6.35	Visible rust and degradation
Turmeric Coating	51.55	48.19	3.36	Moderate protection observed
Ginger Coating	50.30	47.27	3.03	Noticeable resistance to rust
Aloe Vera Coating	53.98	52.97	1.01	Minimal corrosion observed
Curry Leaves Coating	50.38	47.80	2.58	Mild protection observed

IV. RESULT AND DISCUSSION

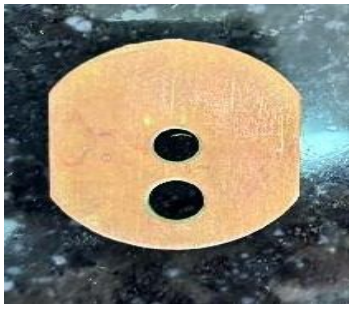
1) Turmeric Coating: Showed moderate corrosion resistance, likely due to the presence of curcuminoids forming a protective layer.
2) Ginger Coating: Provided better inhibition, attributed to the presence of antioxidants and bioactive compounds such as alkaloids and flavonoids.
3) Aloe Vera Coating: Displayed significant corrosion resistance due to polysaccharides forming a stable protective barrier.
4) Curry Leaves Coating: Offered some protection, though less effective compared to aloe vera and ginger.
5) Comparison with Synthetic Inhibitors: Unlike synthetic inhibitors, these plant-based inhibitors are biodegradable, non-toxic, and provide similar protection efficiency without harmful environmental impact.

IMAGES
Original Copper Plates

A. After Coating

Coatings of respective material is done on the surface of metal shown in the diagrams below.

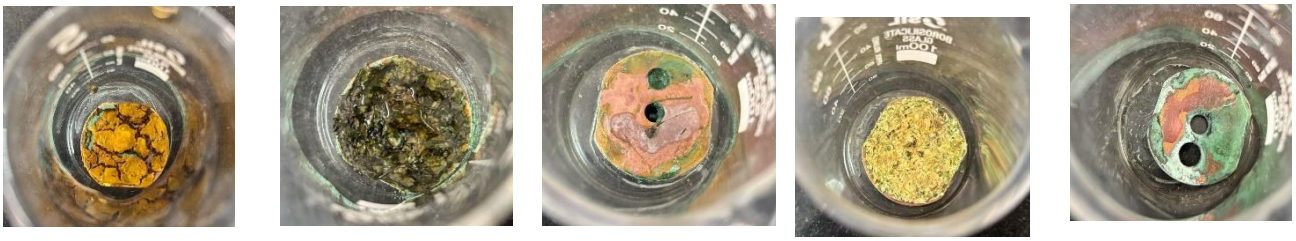
		
Turmeric	Curry Leaves	Aloe Vera

	
Ginger	Uncoated

B. Final Observatio

It is observed that metal with coating shows resistant towards corrosion and uncoated metal is active towards corrosion.

Turmeric Curry Leaves Aloe Vera Ginger Uncoated



V. FUTURE SCOPE

The potential for using natural inhibitors in large-scale industrial applications is vast. Further research can focus on the long-term stability and durability of these coatings under varying environmental conditions such as high humidity, temperature fluctuations, and industrial pollutants. Developing hybrid coatings by combining different plant extracts may enhance their corrosion resistance capabilities.

Additionally, exploring novel extraction techniques to maximize the yield and efficiency of bioactive compounds can improve the commercial
viability of these inhibitors. Advanced surface characterization techniques, such as atomic force microscopy (AFM) and X-ray diffraction (XRD), can be utilized to study the molecular interactions between metal surfaces and organic compounds.
Industries such as marine, aerospace, and automotive can benefit from implementing these coatings in infrastructure maintenance, reducing costs associated with metal deterioration. Policies promoting the use of eco- friendly corrosion inhibitors can also be developed, encouraging industries to adopt sustainable practices.

A. Industrial and Environmental Implications

1) Using natural corrosion inhibitors reduces environmental pollution.
2) Industries can adopt these inhibitors for cost-effective and sustainable corrosion protection.
3) Encouraging the use of renewable resources in material protection strategies.
4) Potential for large-scale implementation in industries such as oil and gas, marine engineering, and automotive manufacturing.

VI. CONCLUSION

The study successfully demonstrated that turmeric, ginger, aloe vera, and curry leaves extracts act as effective green corrosion inhibitors. Their ability to adsorb onto metal surfaces and reduce corrosion rates makes them promising alternatives to synthetic inhibitors. The findings support the implementation of plant-based inhibitors in industrial applications to promote sustainability.

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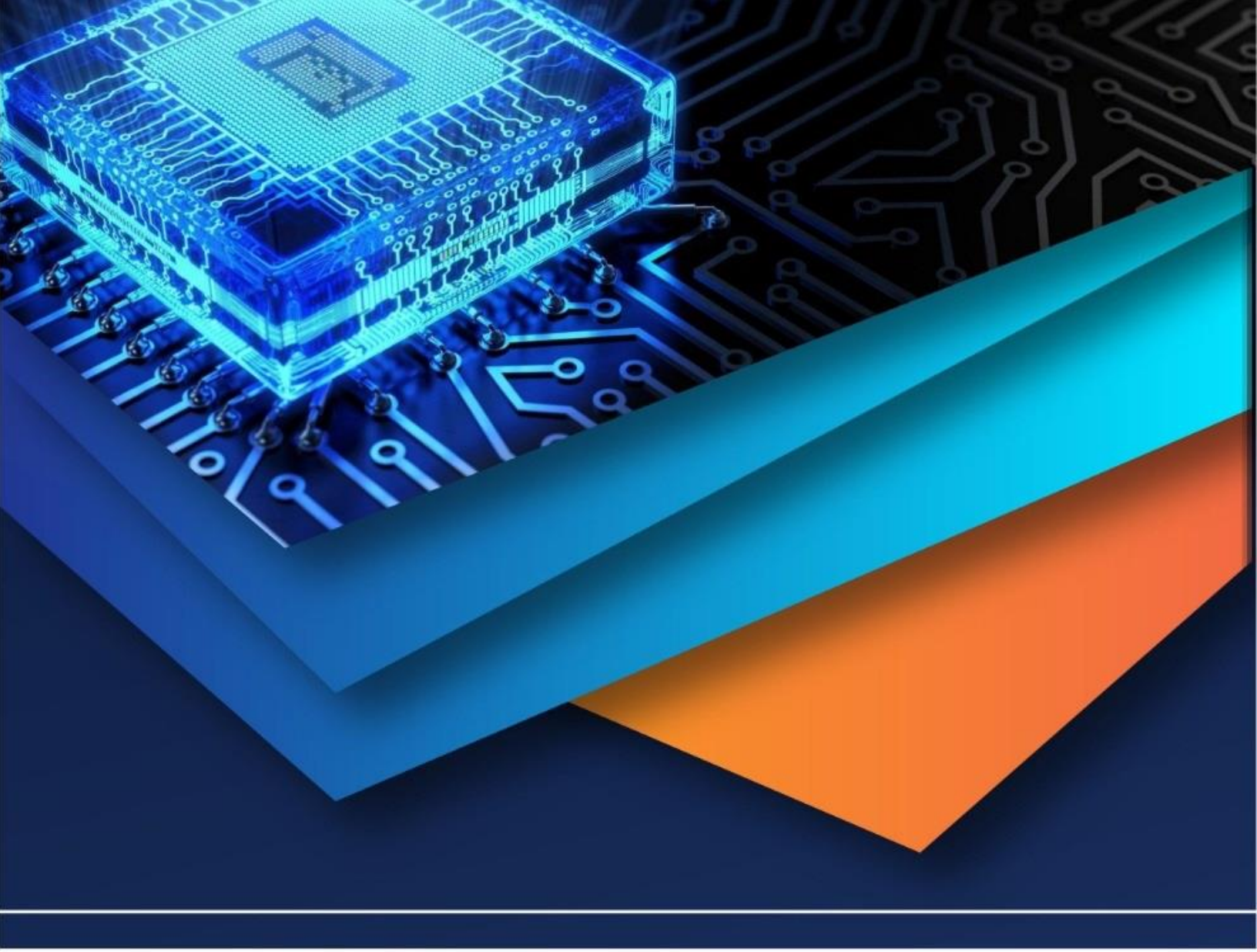

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