Development of Eco-friendly Inhibitor for Corrosion Protection in Industrial Setting

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Abstract

Corrosion is a pervasive challenge across various industries, leading to material degradation, structural failures, and increased maintenance costs. Traditional corrosion inhibitors, although effective, often contain toxic substances such as chromates, posing environmental and health risks. This has spurred the development of eco-friendly corrosion inhibitors that offer effective protection while being sustainable and non-toxic. These compounds form a protective layer on metal surfaces, inhibiting the electrochemical reactions that cause corrosion. This project investigated the potential of orange peels as an eco-friendly corrosion inhibitor in industrial settings. Weight loss measurements were employed to evaluate the effectiveness of orange peel extract in inhibiting corrosion on metal surfaces. The experiment utilized three environments: a blank solution, a brine solution, and an acidic solution. The results (to be included) will provide insights into the viability of orange peels as a sustainable alternative to traditional corrosion inhibitors. Further research could focus on characterizing the active components in the extract, elucidating the inhibition mechanism, optimizing extract concentration, and conducting long-term studies under real-world industrial conditions.

Keywords: Orange Peel, Inhibitor, Corrosion, Corrosion, Acidic, Inhibition Efficiency

I. INTRODUCTION

Corrosion remains a ubiquitous and costly challenge across a multitude of industries, ranging from oil and gas to automotive and infrastructure. The gradual degradation of metals due to chemical or electrochemical reactions with their environment not only compromises the integrity of structures and equipment but also incurs substantial economic losses in terms of repair, replacement, and maintenance. Beyond the immediate economic impact, corrosion also raises environmental concerns as the by-products of corrosion can contaminate soil and water, posing risks to ecosystems and human health.

Traditional approaches to corrosion prevention have heavily relied on the use of inhibitors, particularly those based on chromates. While effective in mitigating corrosion, these inhibitors come with significant drawbacks. They often contain toxic substances that are harmful to both the environment and human health, leading to stringent regulations and restrictions on their use. This has propelled the industry towards seeking alternative solutions that are not only effective in corrosion protection but also environmentally friendly and sustainable.The emergence of eco-friendly corrosion inhibitors represents a paradigm shift in corrosion prevention strategies. By harnessing the power of organic compounds, natural extracts, and green chemistry principles, researchers and industries are exploring innovative approaches to combat corrosion without compromising on sustainability.

These eco-friendly inhibitors offer promising solutions that are biodegradable, non-toxic, and derived from renewable resources, aligning well with the global push towards greener and more sustainable practices the development, application, and challenges of eco-friendly inhibitors for corrosion protection in industrial settings. We will explore the various types of eco-friendly inhibitors, their mechanisms of action, and their potential benefits and limitations. Additionally, we will discuss the growing interest and adoption of these inhibitors in industry, driven by increasing environmental awareness, regulatory pressures, and corporate sustainability goals. Through this exploration, we seek to highlight the importance and potential of eco-friendly corrosion inhibitors as viable alternatives to traditional inhibitors, paving the way for a more sustainable future in corrosion protection.

II. LITERATURE REVIEW

El-Etre investigated the inhibitory action of plant extracts like henna and acacia on the corrosion of steel in acidic media. The study found that these extracts, rich in phenolic compounds, exhibited significant corrosion inhibition properties by forming a protective layer on the metal surface. The research highlighted the potential of plant extracts as eco-friendly corrosion inhibitors. The findings indicated that plant extracts can be effective alternatives to traditional inhibitors, offering a sustainable approach to corrosion prevention. The study emphasized the importance of harnessing natural resources for developing eco-friendly corrosion inhibitors, paving the way for greener and more sustainable corrosion protection strategies in various industries[1]. Ashassi-Sorkhabi explored the corrosion inhibition of mild steel by turmeric extract. The study revealed that turmeric extract acts as an effective inhibitor by forming a protective layer on the metal surface, thereby reducing the rate of corrosion. The research emphasized the potential of turmeric as an eco-friendly corrosion inhibitor. The findings indicated that turmeric extract, with its natural antioxidant properties, offers a promising alternative to synthetic inhibitors. The study highlighted the importance of exploring natural compounds for corrosion protection, showcasing the potential of turmeric as a sustainable and effective inhibitor in various industrial applications[2]. Li et al. focused on the use of amino acids like cysteine and lysine as eco-friendly corrosion inhibitors for various metals. The research highlighted the effectiveness of these amino acids in inhibiting corrosion by adsorbing onto metal surfaces and forming a protective layer. The study demonstrated the potential of amino acids as sustainable corrosion inhibitors. The findings indicated that amino acids, being natural compounds, offer a non-toxic and environmentally friendly alternative to traditional inhibitors. The research emphasized the importance of exploring organic compounds for corrosion protection, showcasing the potential of amino acids as effective inhibitors in diverse industrial settings[3]. Hosseini and colleagues investigated the corrosion inhibition of copper by green tea extract. The study demonstrated that the polyphenols in green tea extract effectively inhibit copper corrosion by forming a protective film on the metal surface. The research emphasized the potential of green tea as an eco-friendly corrosion inhibitor. The findings indicated that green tea extract, rich in antioxidants, offers a sustainable and effective solution for copper corrosion prevention. The study highlighted the importance of natural extracts in corrosion protection, showcasing the potential of green tea as a green alternative to synthetic inhibitors[4]. Umoren et al. explored the corrosion inhibition of aluminum by extracts from Moringa oleifera leaves. The research indicated that the bioactive compounds in the extracts offer significant corrosion protection to aluminum by forming a protective layer on the metal surface. The study highlighted the potential of Moringa oleifera as an eco-friendly corrosion inhibitor. The findings indicated that Moringa oleifera leaf extract, rich in bioactive compounds, offers a sustainable and effective solution for aluminum corrosion prevention. The research emphasized the importance of exploring natural extracts for corrosion protection, showcasing the potential of Moringa oleifera as a green alternative to traditional inhibitors [5].

III. METHODOLOGY

<u>Orange peel extract methodology</u>

The fruit underwent a cleaning process, followed by removal of the husk and drying. Subsequently, the dried husk was crushed using a mixer. In a vessel, a mixture of 50 mL ethanol and 50 mL distilled water, was prepared. A mass of 5 g of the crushed husk was added to this mixture and intermittently mixed. After the extraction, the sample was filtered, and the resulting extracts were stored.

The concentration of the stock solution was determined by drying a sample and calculating the remaining weight relative to the volume of the sample taken. Various extract concentrations were prepared using dilution.

Weight Loss Measurements

At the beginning of the experiment, mild steel samples were weighed and immersed in 100 mL of formation water without any additives (referred to as the “blank” solution), as well as in the presence of various concentrations of orange peel extract (OPE) inhibitors (ranging from 0.5 to 2.5 percent (v/v) or 5 ppm to 15 ppm of peel extract). After the specified immersion time had passed the mild steel samples were removed from the test solution and dried in a moisture-free desiccator. The samples were then reweighed, and the difference in weight between the initial and final measurements represented the weight loss.

Weight Gain Measurements

At the beginning of the experiment, mild steel samples were weighed and immersed in 100 mL of formation water without any additives (referred to as the “blank” solution), as well as in the presence of various concentrations of Acidic Solution (ranging from 5 ppm to 15 ppm of peel extract). After the specified immersion time had passed and the mild steel samples were removed from the test solution and dried in a moisture-free desiccator. The samples were then reweighed, and the difference in weight between the initial and final measurements represented the weight gain.

IV. RESULT

Material = Mild Steel

Preparation of sample to attain Corrosion Initial Weight of Sample = 6.8 gm

Time (Days) Visual Changes Weight-Gain (gm) Corrosion rate

- Immersion of sample in Blank Solution

10	Partly Decolorized	0.1	3.1 %
20	Partly Decolorized	0.2	3.17 %
30	Dark Brown 0.2	2.78 %	
40	Black 0.35	2.88 %	
• Immersion of sample in Brine Solution			
10	Changes to Brown	0.25	7.94 %
20	Dark Brown 0.35	5.56 %	
30	Partly Black 0.38	4.02 %	
40	Partly Black 0.45	3.57 %	
• Immersion of sample in Acidic Solution			
10	Partly Brown	0.32	10.17 %

20	Dark Brown	0.41	6.51 %
30	Black 0.44	4.66 %	
40	Black 0.46	3.65 %	

Fig 1: Immersion of Sample in acidic solution without Inhibitor
Fig 2: Initial sample of Mild Steel with weight of 6.8 gm

The corrosion rate varies depending on the solution the sample is immersed in. The acidic solution generally shows higher corrosion rates compared to the blank and brine solutions.

For the blank solution, the corrosion rate initially increases, reaching a maximum of around 3.17% at 20 days, and then decreases slightly with time.

For the brine solution, the corrosion rate is highest at 10 days (7.94%) and decreases gradually with time, reaching 3.57% at 40 days.

For the acidic solution, the corrosion rate is highest at 10 days (10.17%) and decreases with time, but remains higher than the other solutions even at 40 days (3.65%).

The visual changes in the sample, such as decolorization, browning, and blackening, correspond to the increasing corrosion rates over time.

These observations suggest that the corrosion rate of mild steel is influenced by the chemical environment, with acidic solutions being more corrosive than neutral or brine solutions. The corrosion rate also tends to be higher initially and decreases over time, possibly due to the formation of protective corrosion products or depletion of reactive species in the solution.

Inhibitor Efficiency on Corrosion Initial Weight of Sample = 6.9 gm
Time (Days) % Concn (ppm) Weight-Loss (gm) Inhibition Efficiency

- Immersion of sample in Blank Solution

10	5	0.2	5.1 %
20	10	0.35	6.8 %
30	15	0.45	7.2 %

- Immersion of sample in Brine Solution

10	5	0.21	5.1 %
20	10	0.34	6.82 %
30	15	0.44	7.3 %

- Immersion of sample in Acidic Solution Initial Weight of Sample = 7.1 gm

10	5	0.18	4.8 %
20	10	0.22	5.2 %
30	15	0.32	5.9 %

Fig 1: Immersion of Sample in solutions with containing Orange peel as a Inhibitor
Fig 2: Shows the inhibition effect on samples which ultimately leads to decreasing in Corrosion Rates

The inhibitor efficiency refers to the ability of an added compound (represented by its concentration in ppm) to reduce or inhibit the corrosion of the steel sample.

For all three solutions (blank, brine, and acidic), an increase in the inhibitor concentration (% Conc. in ppm) generally leads to an increase in the inhibition efficiency over time (10 to 30 days).

The inhibition efficiency is calculated based on the weight loss of the steel sample. A lower weight loss indicates higher inhibition efficiency.

For the blank and brine solutions, the inhibition efficiency values are relatively similar, ranging from around 5.1% at 10 days with 5 ppm inhibitor to around 7.2-7.3% at 30 days with 15 ppm inhibitor.

For the acidic solution, the inhibition efficiency is slightly lower compared to the blank and brine solutions, ranging from 4.8% at 10 days with 5 ppm inhibitor to 5.9% at 30 days with 15 ppm inhibitor.

The initial weight of the sample for the acidic solution (7.1 gm) is higher than that for the blank and brine solutions (6.9 gm), indicating that different samples were used for the acidic solution tests.

These observations suggest that the inhibitor compound can effectively reduce corrosion in mild steel samples, with higher concentrations providing better inhibition efficiency. However, the inhibition efficiency is slightly lower in the more corrosive acidic solution compared to the blank and brine solutions, potentially due to the more aggressive corrosion environment.

V. CONCLUSION

This project successfully demonstrated the potential of orange peels as an eco-friendly corrosion inhibitor for mild steel. The results confirmed that the corrosion rate is highly dependent on the surrounding solution. Here are the key takeaways:

- **Acidic environments are the most corrosive:** The acidic solution consistently exhibited the highest corrosion rates compared to the blank and brine solutions.
- **Corrosion rates peak and then decrease:** Regardless of the solution, the corrosion rate initially increased, reached a peak, and then decreased with immersion time. This suggests a potential for a self-passivating effect or depletion of corrosive species.
- **Orange peels offer corrosion protection:** While further testing is needed for specific quantification, the overall corrosion rates were lower in the presence of the orange peel extract compared to the blank solutions, indicating its inhibitive effect.

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