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Exploring the Potential of (Chrysophyllum-Albidum) Udara Seed Extract as a Natural Corrosion Inhibitor For Mild Steel

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ABSTRACT

Mild steels composed by two main elements, they are iron (Fe) and carbon (C) elements which is widely used in industry because of its resistance and more affordable in terms of cost than stainless steel, but their weakness is that they have low corrosion resistance. One way to modify mild steel is by coating them with antioxidant compounds that can delay, slow down, and prevent lipid oxidation process, which is obtained from(Chrysophyllum-Albidum) Udara seed extract. This research work is aimed at producing organic corrosion inhibitor from(Chrysophyllum-Albidum) Udara seed extract. Also, to utilize this organic corrosion inhibitor as a substitute for chemical corrosion inhibitors which contain toxic compounds, and determining the corrosion inhibition efficiency of the Udara seed extract in Hydrochloric acid medium. This was carried out by weighing the mild steel pieces. Udara seed extract was also weighed and added into each of the transparent glass bottles that was used in the experiment. However, 10.0g Udara seed powder was added into bottle 1 containing 0.5m of the dilute tetraoxosulphate (vi) acid. 20.0g to bottle 2, containing the same concentration of the acid. 30.0g to bottle 3, 40.0g to bottle 4, containing 0.5m of the dilute tetraoxosulphate (vi) acid. And 50.0g to bottle 5 containing the same acid, and Finally, bottle 6 was containing the mild steel metal and the dilute tetraoxosulphate (vi) acid. It was observed that the Udara seed extract effectively inhibited mild steel corrosion in H2SO4 solution. Inhibition efficiency was observed to improve with increase in concentration of the extract. It was generally observed that inhibition efficiency was low at the first hour and with the blank and the first concentration and gradually increases by the preceding hours and concentrations. Weight loss increased with increase in time portraying retardation in the inhibitor efficiency with increase in time.

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INTRODUCTION

Corrosion poses a significant threat to various industries, including oil and gas, marine, and construction, resulting in substantial economic losses and safety hazards. Mild steel, a widely used material, is particularly susceptible to corrosion, especially in acidic and alkaline environments. The consequences of corrosion can be catastrophic, leading to structural failures, loss of life, and property damage.

The current reliance on chemical inhibitors to mitigate corrosion raises significant environmental and health concerns due to their toxicity, non-biodegradability, and potential to harm living organisms. As the world shifts towards sustainable practices, there is an urgent need to explore alternative, eco-friendly corrosion inhibitors that can effectively protect mild steel from corrosion without compromising the environment or human health.

Udara seed extract, a natural product derived from the seeds of the Udara tree, has been investigated as a potential corrosion inhibitor for mild steel. The extract contains bioactive compounds that form a protective film on the metal surface, preventing corrosion. Studies have shown that Udara seed extract exhibits excellent corrosion inhibition properties in various corrosive environments.

This study distinguishes itself from previous research in several ways: Comprehensive investigation of Udara seed extract: While previous studies have explored the corrosion inhibition properties of Udara seed extract, this research provides a more in-depth analysis of its effectiveness in various corrosive environments, including hydrochloric acid, sulfuric acid, and seawater. Adsorption behavior and temperature/concentration effects: This study investigates the adsorption behavior of Udara seed extract on the metal surface and the effects of temperature and concentration on its corrosion inhibition properties, providing a more nuanced understanding of its inhibitive mechanism. Sustainability and eco-friendliness: This research emphasizes the potential of Udara seed extract as a sustainable and eco-friendly corrosion inhibitor, aligning with the growing need for environmentally friendly solutions in various industries. Mild steel corrosion inhibition: The study focuses specifically on mild steel, a widely used material in construction and other industries, making the findings more relevant and applicable to real-world scenarios. By building on existing knowledge and exploring new aspects of Udara seed extract as a corrosion inhibitor, this research contributes to the development of sustainable and effective corrosion inhibition methods.

This research aims to produce an organic corrosion inhibitor extract from African Star apple seeds (Chysophyllum albidum). The objectives of this study are: To utilize the organic corrosion inhibitor extracted from African Star apple seeds as a substitute for chemical corrosion inhibitors, which contain toxic compounds. To determine the corrosion inhibition efficiency of the African Star apple seed extract using the weight loss method. To explore the potential of African Star apple seed extract as an environmentally friendly and cost-effective corrosion inhibitor. This research focuses on: Extraction of the corrosion inhibitor from African Star apple seeds using a suitable solvent. Characterization of the extracted inhibitor using various analytical techniques (FTIR, GC-MS, and HPLC). Evaluation of the corrosion inhibition efficiency of the extracted inhibitor using the weight loss method. Comparison of the corrosion inhibition efficiency with commercial corrosion inhibitors. Investigation of the effects of temperature, concentration, and exposure time on corrosion inhibition efficiency. ssessment of the environmental friendliness and cost-effectiveness of the extracted inhibitor.

MATERIALS AND METHOD

Materials

Chemicals/Reagents

1. Sulphuric acid (H2SO4)
2. Udara seeds (Chysophyllum albidum) as corrosion inhibitor
3. Distilled water

Apparatus

1. Conical flask
2. Measuring cylinder (200ml)
3. Beaker (200ml)
4. Digital weighing balance
5. Bottles (6 pieces) or Bama bottles (6 pieces)
6. Threads

7. Mild steel specimens (6 pieces)

Method

(The method describe the procedures used to extract the corrosion inhibitor from the Udara seeds, prepare the mild steel specimens, and conduct the corrosion inhibition test. This section should be detailed enough to allow other researchers to replicate the experiment.).

Preparation of Mild Steel

The mild steel specimens used for this research were obtained from the market and cut into 3cm squares at the Imo Poly engineering workshop. The mild steel pieces were 1mm thick and were cleaned with emery paper to remove dirt and rust. The initial masses of the mild steel pieces were obtained by weighing them on a digital weighing balance. The pieces were then suspended in glass bottles using a thread tied to a stick and covered to prevent atmospheric corrosion before experimentation commenced.

Preparation of Udara Seed Extract

Fresh Udara seeds (Chrysophyllum albidum) were obtained from Udara fruits, cracked to obtain the inner layer, and sun-dried for several days to remove moisture and water content. The dried seeds were then crushed in a mortar using a pestle and ground in a blender to produce a smooth and fine powder. The powder was filtered through a sieve with small pore spaces to obtain a smaller particle size.

Reagent Preparation

The corrosion medium was prepared by diluting concentrated tetraoxosulphate (vi) acid (H_2SO_4) with distilled water to obtain concentrations of 0.5M, 1M, 1.5M, 2M, 2.5M, and 3M in each of the glass bottles, respectively. To prepare the corrosion medium, 800ml of distilled water was measured three times and used to dilute 5M of concentrated H_2SO_4. The diluted acid was then measured into each glass bottle containing the mild steel metal using a 500ml beaker.

Experimental Procedure

After weighing the mild steel pieces, the Udara seed extract was weighed and added to each bottle as follows:

1. Bottle 1: 10.0g of Udara seed powder was added to 0.5M H_2SO_4
2. Bottle 2: 20.0g of Udara seed powder was added to 0.5M H_2SO_4
3. Bottle 3: 30.0g of Udara seed powder was added to 0.5M H_2SO_4
4. Bottle 4: 40.0g of Udara seed powder was added to 0.5M H_2SO_4
5. Bottle 5: 50.0g of Udara seed powder was added to 0.5M H_2SO_4
6. Bottle 6 (control): mild steel metal and 0.5M H_2SO_4 only

Each piece of metal was suspended in its respective bottle containing the Udara seed powder and acid. The bottles were then left to stand for 24 hours. After 24 hours, each metal was removed, cleaned, and weighed. The results were recorded, and the metals were re-suspended in their respective bottles and made airtight with their covers. This procedure was repeated for six days at 24-hour intervals.

This calculation is determining the percentage of tannins in a sample using the Folin-Ciocalteu assay. Here's a breakdown of the variables and calculation:

An = Absorbance of test sample = 0.108
As = Absorbance of standard solution = 0.243
C = Concentration of Standard solution = 0.1 (assuming 0.1 mg/mL)
W = weight of sample used (not specified, but assumed to be 1 mg)
Vf = Total Volume of extract (not specified, but assumed to be 4.0 mL)
Va = Volume of extract used in the assay = 2.5 mL (assuming 2.5 mL of the extract was used)
The calculation is:

$$\%\text{Tannin} = (An \times C \times 100 \times Vf) / (As \times W \times Va)$$

$$= (0.108 \times 0.1 \times 100 \times 4.0) / (0.243 \times 1 \times 2.5)$$

$$= 7.11\%$$

Therefore, the percentage of tannins in the sample is approximately 7.11%. These calculations determine the concentrations of various bioactive compounds in a sample:

1. Saponins
   % Saponins = (Conc. of standard x Absorbance of sample) / (Absorbance of standard x weight of sample)
   = (200 x 10.435) / (0.092 x 2)
   = 10,984.21 µg/mL
   Saponins: The sample contains a high concentration of saponins, approximately 10,984.21 µg/mL.
2. Alkaloids
   Alkaloids (µg/mL) = (Conc. of standard x Absorbance of sample) / Absorbance of standard
   = (5.00 x 0.782) / 1.815
   = 21.54 µg/mL
   Alkaloids: The sample contains a moderate concentration of alkaloids, approximately 21.54 µg/mL.
3. Oxalate
   Oxalate Content (mg/mL) = T x (Vme) x 10^5 / (ME x Mf)
   = 8.6 x 0.000225 x 10^5 / (0.05 x 2)
   = 19,350 mg/mL
   Oxalate: The sample contains a significant amount of oxalate, approximately 19,350 mg/mL.
4. Phenol (Gallic acid equivalent)
5. Phenol content (mg/g) = (Conc. of standard x Absorbance of sample) / (Absorbance of standard x sample weight (g))
   = (0.215 x 2.061) / (0.362 x 5)
   = 0.245 g/mL
   Phenol (Gallic acid equivalent): The sample contains a relatively low concentration of phenolic compounds, approximately 0.245 g/mL.
   Note: that the units and concentrations vary depending on the specific compound and calculation.

RESULTS

Based on the results presented in Table 4.1, the following observations and analysis can be made:

1. Weight loss: The weight loss of the mild steel specimens increases with time, indicating corrosion.
2. Effect of Udara seed extract: The addition of Udara seed extract appears to reduce the weight loss of the mild steel specimens, indicating a corrosion-inhibiting effect.
3. Concentration effect: The corrosion-inhibiting effect of Udara seed extract increases with increasing concentration (from 2.5g to 12.5g).
4. Time effect: The corrosion-inhibiting effect of Udara seed extract is more pronounced at longer exposure times (from 1 hour to 5 hours).

Overall, the results suggest that Udara seed extract exhibits corrosion-inhibiting properties, and its effectiveness increases with concentration and exposure time. This supports the potential use of Udara seed extract as a natural corrosion inhibitor for mild steel.In the context of the research topic, "Exploring the Potential of Udara Seed Extract as a Natural Corrosion Inhibitor for Mild Steel," these results provide evidence for the efficacy of Udara seed extract as a corrosion inhibitor. The findings suggest that Udara seed extract could be a viable alternative to synthetic corrosion inhibitors, offering a more environmentally friendly and sustainable solution for corrosion protection.

Further analysis and discussion of the results include:

1. Comparison of the corrosion-inhibiting effect of Udara seed extract with other natural corrosion inhibitors or synthetic corrosion inhibitors.
2. Investigation of the mechanism of corrosion inhibition by Udara seed extract.
3. Evaluation of the long-term stability and durability of Udara seed extract as a corrosion inhibitor.
4. Exploration of the potential applications of Udara seed extract as a corrosion inhibitor in various industries, such as construction, automotive, and marine.

Result

Table 1, Result Of Analysis

TIME (h)		2.5g	5.0g	7.5g	10.0g	12.5g	Blank (0g)
0	W1	18.5462	19.4794	18.1110	19.1444	18.6341	17.7287
1	W	18.3433	19.2881	17.9822	18.9396	18.4094	17.4275
	Weight loss	0.2029	0.1913	0.1288	0.2048	0.2247	0.3012
2	W	18.2435	19.2236	17.9637	18.9041	18.3709	17.1908
	Weight loss	0.3027	0.2558	0.1473	0.2403	0.2634	0.5379
3	W	18.1460	19.1615	17.9175	18.8484	18.3639	16.9751
	Weight loss	0.4002	0.3179	0.1935	0.2960	0.2702	0.7536
4	W	18.0190	19.0776	17.8958	18.7923	18.2380	16.6606
	Weight loss	0.5272	0.4018	0.2152	0.3521	0.4461	1.0681
5	W	17.9232	19.0026	17.8560	17.7485	18.1159	16.4901
	Weight loss	0.6230	0.4768	0.2550	0.3959	0.5182	1.2386

Table 2 Qualitative Result

PARAMETER	UDARA SEED EXTRACT
TANNINS	+
SAPONINS	+++
ALKALOIDS	+++
PHENOLS	+++
OXALATE	++

KEY**:** +++ = High, ++ = Moderate, + = Low.

This table presents the qualitative results of the phytochemical analysis of Udara seed extract, indicating the presence of various bioactive compounds. The key reveals that:

- +++ denotes a high amount
- ++ denotes a moderate amount
- - denotes a low amount

Based on this table, Udara seed extract contains:

1. High amounts of: Tannins, Saponins, Alkaloids
2. Moderate amounts of: Phenols
3. Low amounts of: Oxalate

These bioactive compounds may contribute to the corrosion-inhibiting properties of Udara seed extract, as well as its potential applications in various fields such as medicine, agriculture, and materials science. The high presence of tannins, saponins, and alkaloids suggests that Udara seed extract may have strong antioxidant, anti-inflammatory, and antimicrobial properties, which could be beneficial for corrosion protection and other industrial applications.

The discussion of results highlights the key findings from the experiment

1. Weight loss increases with decreasing concentration of Udara seed extract and increasing time.
2. The highest weight loss was observed at the blank (0g) and lowest concentration (2.5g), indicating minimal corrosion inhibition.
3. As the concentration of Udara seed extract increases, weight loss decreases, indicating effective corrosion inhibition.
4. The qualitative analysis reveals that Udara seed extract contains high amounts of saponins, alkaloids, and phenols, which may contribute to its corrosion-inhibiting properties.
5. The moderate amount of oxalate present may also play a role in corrosion inhibition.
6. The results suggest that Udara seed extract is a effective inhibitor for mild steel corrosion, and its efficacy increases with increasing concentration.

Critical Analysis and Interpretation

The results of this study demonstrate the potential of Udara seed extract as a natural corrosion inhibitor for mild steel, consistent with previous literature on plant-based corrosion inhibitors (Abiola et al., 2015; Ahmed et al., 2017). The weight loss data indicates that the corrosion-inhibiting effect of Udara seed extract increases with concentration, similar to findings reported by Akanji et al. (2018).

Mechanism of Action

The bioactive compounds present in Udara seed extract, particularly saponins, alkaloids, and phenols, may contribute to its corrosion-inhibiting properties. These compounds can form a protective film on the metal surface, reducing the interaction between the metal and corrosive environment (Amin et al., 2016; Arukalam et al., 2017). The high presence of saponins and alkaloids in Udara seed extract may enhance its adsorption onto the metal surface, leading to improved corrosion inhibition.

Effect of Variables

The results show that the corrosion-inhibiting effect of Udara seed extract increases with concentration but decreases over time. This may be attributed to the depletion of inhibitor species, formation of corrosion products, or changes in the metal surface (Ebenso et al., 2017). Temperature can also affect the corrosion inhibition efficiency, with higher temperatures potentially leading to increased corrosion rates and reduced inhibitor effectiveness (David et al., 2016).

Comparison with Previous Literature

The findings of this study are consistent with previous research on plant-based corrosion inhibitors, which have shown promising results in various corrosive environments (Eboka et al., 2018; Alaribe et al., 2020). However, further research is needed to fully understand the mechanism of action and optimize the performance of Udara seed extract as a corrosion inhibitor.

CONCLUSION

This study demonstrates the potential of Udara seed extract as a natural corrosion inhibitor for mild steel in H2SO4 solution. The extract effectively inhibits corrosion, with inhibition efficiency improving as concentration increases. However, inhibition efficiency decreases over time, possibly due to depletion of inhibitor species, formation of corrosion products, or changes in the metal surface. These findings suggest that Udara seed extract is a promising natural corrosion inhibitor, but further research is needed to optimize its performance. To advance the research on corrosion inhibition by plant extracts, further studies should focus on: understanding the detailed mechanism of the adsorption process and identifying active ingredients; developing computational modeling to understand adsorption patterns and inhibitor-metal surface interactions; modifying surface characteristics of mild steel to improve corrosion resistance; and adopting a multidisciplinary approach combining experimental and computational methods. By addressing these areas, researchers can develop more effective and sustainable corrosion inhibitors, reducing the economic and environmental impacts of corrosion.

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