



Study On The Application Of Red Dragon Fruit Peel Extract As An Organic Corrosion Inhibitor On Carbon Steel Pipes In Corrosive Mediums Of Seawater And Rainwater With Varying Extraction Temperatures

Ikhwan Mahendra Prasajo^{1*}, Fadhilla Maharani Nuringsih²,
Muhammad Fahmi Hakim³

^{1,2}Program Studi Teknik Kimia, Fakultas Teknik, Universitas Singaperbangsa Karawang

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Abstract

Corrosion cannot be avoided, and its presence is a concern in the chemical industry as it can disrupt processes, mainly because process equipment is commonly made of steel pipes. This necessitates the control of corrosion rates using corrosion inhibitors, whether organic or inorganic. The use of organic inhibitors is more environmentally friendly as it does not produce negative impacts on the environment, requires low costs in procurement, and is simpler in its treatment processes. One potential organic inhibitor is the extract from red dragon fruit peel waste. The extract is obtained through the maceration extraction process using 96% ethanol with temperature variations of 80, 85, and 90 °C. Subsequently, sample immersion is carried out in seawater and rainwater medium. The results of this research indicate that red dragon fruit peel extract contains flavonoids and saponins that can optimally inhibit the corrosion process at an extraction temperature of 85 °C. SEM tests show that metal samples immersed in the corrosion medium with the inhibitor have a smoother surface compared to those in the corrosion medium without the addition of an inhibitor.

Keywords: carbon steel, corrosion, maceration, organic inhibitor, red dragon fruit

(* Corresponding Author: opemvbs@gmail.com)

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INTRODUCTION

Corrosion is the deterioration of the quality of metals due to its reaction with the surrounding environment, such as air, soil, and water, resulting in metal oxides or other reaction products (Sulistijono, 2000). Corrosion can also be defined as an attack that damages metal because the metal chemically or electrochemically reacts with the environment (Fontana, 1986). In the chemical industry, corrosion events frequently occur, especially in process equipment, such as in the petroleum industry, where common types of corrosion are general corrosion and localized corrosion (Fontana & Mitra, 1953). Another significant issue in pipeline operation is internal corrosion (Ghareba & Omanovic, 2010). Corrosion can lead to various losses, both economically, and in terms of safety, including reduced metal strength, metal thinning, cracking & pitting, decreased metal surface properties, fluid leakage, and environmental pollution (Sihombing et al., 2022).

In the field of engineering, corrosion is also a problem that impacts the deterioration of metals. Metal corrosion can be caused by water vapor, environments containing acids, salts, and high ambient temperatures (Krauss & Nmai, 1994). Corrosion cannot be entirely eliminated but can be controlled and prevented. One way to control corrosion in steel is by using corrosion inhibitors. In

general, an inhibitor is a chemical substance that can hinder or slow down a chemical reaction. Meanwhile, a corrosion inhibitor is a chemical substance that, when added to an environment, can reduce the corrosion rate of the metal in that environment (Dalimunthe, 2004). In general, corrosion inhibitors can be classified into two types: organic inhibitors and inorganic inhibitors. Inorganic inhibitors exhibit good corrosion rate inhibition but pose environmental issues if left accumulated. Therefore, the use of organic inhibitors becomes an alternative choice due to their environmental friendliness (Bentiss et al., 2004).

This research utilizes red dragon fruit peel, harnessing the compounds of organic corrosion inhibitors contained within, such as vitamin C, flavonoids, alkaloids, steroids, saponins, and tannins (Wu et al., 2006).

METHODS

Materials

The materials needed to carry out the research consists of: red dragon fruit peels, carbon steel pipes, seawater, rainwater, aquades, ethanol solvent (96%), FeCl₃ solution (0.1%), Zn powder, and 2N solution of HCl.

Equipments

The following equipments are needed to support the research: digital scale, analytical balance, reduction machine, filter paper, convection oven, plastic jerry can, beaker glass, magnetic stirrer, measuring cylinder, pipette, plastic container.

Procedure

The research procedure begins with preparing test samples of the steel pipes, preparing the inhibitor solution from red dragon fruit peel extract, preparing the corrosion medium, followed by immersing the test samples in the corrosion medium with and without the inhibitor solution, and analyzing the surface of the steel pipe test samples.

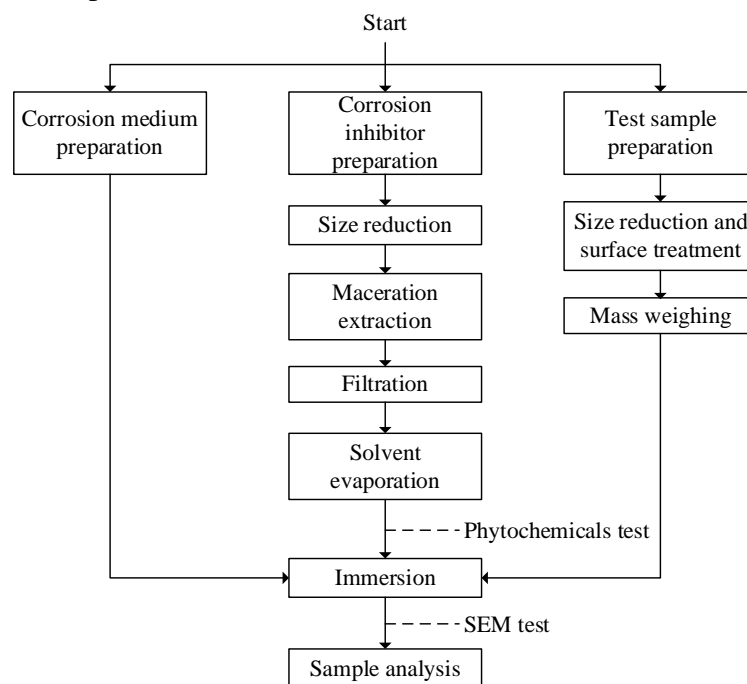


Figure 1 Research procedure flow diagram

1. Preparation of corrosion mediums

Corrosion medium consists of seawater and rainwater liquid that are prepared by dispensing the liquids into multiple beaker glasses with volume of 200 mL each.

2. Preparation of corrosion inhibitor

Corrosion inhibitor is prepared out of red dragon fruit peels, which are cleaned, sectioned into smaller pieces, and then reduced into a slurry texture. The slurry is then weighed 20 gram into each multiple beaker glass, which are then filled with 200 mL of ethanol solvent (96%). Maceration extraction is carried out using magnetic stirrer for 48 hours, and the solution is filtered using filter paper, the filtrate extract is then heated at 80 °C, 85 °C, and 90 °C variations while stirred until it's reduced into a 100 mL volume of red dragon fruit peel organic corrosion inhibitor extract.

3. Preparation of test samples

Test samples is prepared out of a carbon steel pipe that is sectioned into rectangular 2 by 1 cm pieces, which then the surface gets treated using sandpapers into a smooth finish.

4. Immersion of test samples

The test samples are placed in a set of corrosion medium containing a seawater or rainwater, and treated with the organic corrosion inhibitor extract. Furthermore, a separate set of test samples is introduced into another corrosion medium as a control. The samples is immersed for 336 hours.

5. Phytochemicals test of corrosion inhibitor

Qualitative phytochemicals test is carried out for detecting the presence of tannins, saponins, and flavonoid in the organic corrosion inhibitor. Tannins presence is tested using a drop of FeCl₃ solution (0.1%) into a 10 mL of extract solution. Saponins presence is tested using 10 mL of extract that is then shaken vigorously. Flavonoids presence is tested using a 10 mL solution treated with 2 mL of HCl with Zn powder (Kayadoe et al., 2015; Mahargyani, 2018; Maleta et al., 2018).

6. Analysis of test samples

Scanning Electron Microscope (SEM) test is carried out for the surface analysis of the test samples. SEM yields an imagery depicting the surface morphology of the analyzed metal sample. It proves effective in the analysis of surface on a scale ranging from micrometers (µm) to nanometers (nm). The generated image resolution spans from 10 to 10,000 times the magnification (Goldstein et al., 2003).

7. Determination of corrosion rate

The corrosion rate is determined using weight loss method is carried out after the immersion stage of samples. The samples which should have a reduced mass after immersed in a corrosive medium, is weighed using analytical balance. The difference in mass (W) before and after immersion can be used as the data of determining the corrosion rate using the formula $Cr = \frac{534 \cdot W}{D \cdot A \cdot T}$, with D as density of the carbon steel pipe (g/cm³), A as surface area of the carbon steel pipe (in²), and T

as the immersion time (hour), and Cr as corrosion rate (mils/year, or 0.001 inch/year) (Fontana, 1986).

RESULTS & DISCUSSION

Results

1. Phytochemicals

The presence of phytochemicals such as tannins, saponins, and flavonoid is concluded in Table 1:

Table 1 Phytochemicals presence test

Phytochemical	Results	Description
Tannins	-	No discoloration
Flavonoids	+	Discoloration into an orange shade
Saponins	+	Presence of bubbles

The qualitative phytochemicals test is carried out for detecting the presence of tannins, saponins, and flavonoid in the organic corrosion inhibitor of red dragon fruit peel extract. Tannins negative result of presence is confirmed by the non-discoloration of the extract solution into a darker shade (a). Saponins positive result is indicated by the presence of bubbles on top of the solution (c). Lastly, the discoloration of the solution into an orange shade confirms the presence of flavonoids in the extract (b) (Lumbanraja et al., 2019; Mahargyani, 2018; Yuniarsih et al., 2020).

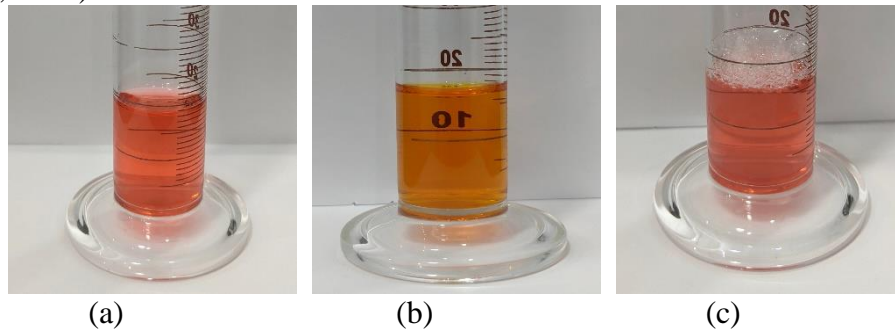


Figure 2 Qualitative phytochemicals test, (a) tannins, (b) flavonoids, (c) saponins

2. Surface analysis

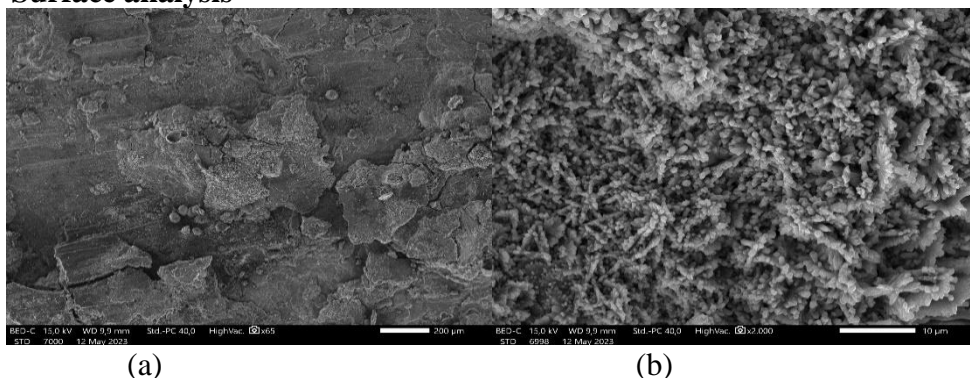
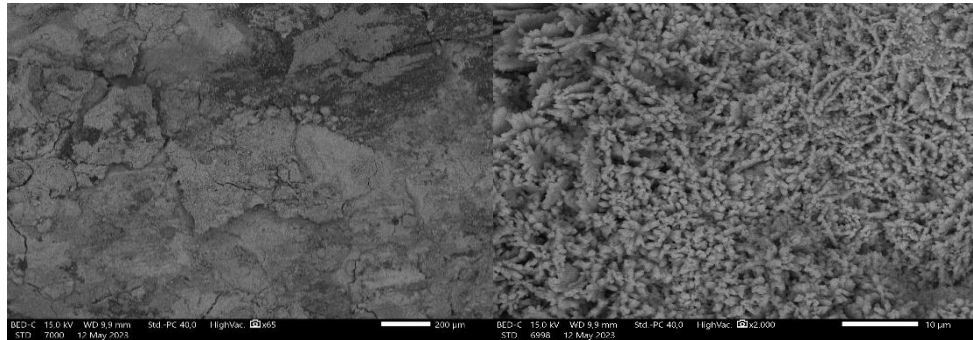


Figure 3 Sample metal surface without inhibitor (control), (a) 65x magnification, (b) 2000x magnification



(c) (d)
Figure 4 Sample metal surface with inhibitor,
 (c) 65x magnification, (d) 2000x magnification

The SEM analysis results in Figure 4 reveal that steel pipes treated with red dragon fruit peel inhibitor exhibit a smoother surface compared to those not immersed in the corrosion inhibitor in Figure 3 (Goldstein et al., 2003). This enhanced smoothness is attributed to the presence of organic compounds that acted as an inhibitor found in the red dragon fruit peel. As depicted in Figure 4, the sample with the inhibitor displays a brighter surface, suggesting minimal corrosion when exposed to seawater and rainwater. The darkened areas Figure 3 are a result of corrosion erosion induced by the oxidative-reductive reaction of carbon steel.

3. Corrosion rate

Table 2 Corrosion rate in seawater corrosive medium

Sample	Temp.	Initial mass	Final mass	Diff.	Corrosion rate
	°C				
A1	80	2.7122	2.6990	0.0132	5.0450
A2		3.2419	3.2340	0.0079	3.0194
B1	85	2.6848	2.6750	0.0098	3.7456
B2		3.4849	3.4750	0.0099	3.7838
C1	90	3.4927	3.4810	0.0117	4.4717
C2		3.4489	3.4340	0.0149	5.6948
T1	control	3.6501	3.6330	0.0171	6.5356

Table 3 Corrosion rate in rainwater corrosive medium

Sample	Temp.	Initial mass	Final mass	Diff.	Corrosion rate
	°C				
P1	80	3.5950	3.5870	0.0080	3.0576
P2		3.4542	3.4450	0.0092	3.5162
Q1	85	3.2184	3.2150	0.0034	1.2995
Q2		3.3354	3.3340	0.0014	0.5351
R1	90	3.2899	3.2870	0.0029	1.1084
R2		3.5704	3.5650	0.0054	2.0639
T2	control	2.8012	2.7890	0.0122	4.6628

The corrosion rate calculations in the two aforementioned tables utilize formula mentioned before, incorporating the density of carbon steel pipes, $D = 7.84 \text{ g/cm}^3$. Surface area $A = 0.5304 \text{ in}^2$, based on the average size of the steel pipe samples, and an immersion time $T = 336$ hours. Samples without the addition of an inhibitor (T1 and T2) under both seawater and rainwater conditions exhibit elevated

corrosion rates, measuring 6.5356 mpy in T1 and 4.6628 mpy in T2. Furthermore, the high corrosion rate is attributed to the temperature treatment, as higher temperatures result in faster corrosion rates, a phenomenon supported by previous research (Ratih et al., 2023).

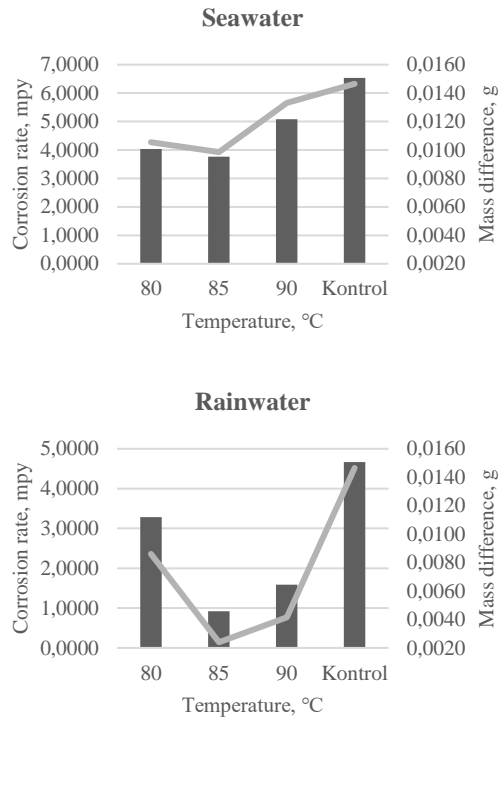


Figure 5 Corrosion rate, (a) seawater, (b) rainwater

Meanwhile, the addition of red dragon fruit inhibitor to corrosive medium with samples exposed to seawater and rainwater indicates a reduction in the corrosion rate. In the seawater medium at a temperature of 80 °C, each specimen shows a mass difference of 0.0132 and 0.0079 grams, corresponding to corrosion rates of 5.0450 and 3.0194 mpy. At 85 °C, the mass difference is 0.0098 and 0.0099 grams, with corrosion rates of 3.7456 and 3.7838 mpy. At 90 °C, the mass difference is 0.0117 and 0.0149 grams, resulting in corrosion rates of 4.4717 and 5.6948 mpy. The findings indicate that the highest temperature yields the largest mass difference after exposure for samples without inhibitor addition. This is attributed to the increased temperature causing a competitive interaction between the adsorption and desorption forces of metal molecules on the surface (Amor Nurdila et al., 2015).

CONCLUSION

Based on the findings from the conducted research, the following conclusions can be drawn:

1. The organic compounds present in the organic inhibitor derived from red dragon fruit peel extract that functions to inhibit the corrosion rate of carbon steel pipes in seawater and rainwater media are flavonoids and saponins.

2. The increase in temperature of maceration extraction influences the corrosion rate, with the highest temperature (90 °C) exhibiting the fastest corrosion rate, measuring 5.6948 mpy in seawater and 2.0639 mpy in rainwater. These values closely approach those of samples without an inhibitor. The optimum temperature for the extraction process is at 85 °C, where the corrosion rate is the lowest in both rainwater and seawater media.

CONFLICT OF INTEREST

Concerning the research, authorship, and publication of this paper, the author(s) reported no potential conflicts of interest.

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