The Use Of Guava Leaf Extract (Psidium Guajava) As An Organic Inhibitor For Corrosion On Low-Carbon Steel

Lubena, Restu Rahayu Ningrum, Aep Fauzan

Abstract: Corrosion is a natural phenomenon and occurs on all materials. It, thus, cannot be stopped and only be slowed down. One of the causes of this process is the surrounding environment. There are several ways to slow down corrosion, one is the use of inhibitors. Generally, there are two types of inhibitors, which are organic and inorganic inhibitors. The latter comprise of synthetic chemical compounds that can be expensive and dangerous because of the toxicity and environmentally unfriendly nature. Whereas the former are relatively inexpensive and extracted from natural sources, such as plant materials containing tannin. One of these tanning-containing plant sources is the leaves of guava. The aims of this study were to extract tannin from these leaves and use it as an inhibitor against corrosion. The procedures included extraction employing maceration in ethanol at room temperature, characterization of the resulting extract, and tests of inhibitor activity of the extract on low carbon steel. The variables tested were the amount of tannin and the length of treatment time. The corrosion rate was measured from the weight reduction. The qualitative tests showed the presence of tannin in the extracts. The treatment without the addition of inhibitor produced the highest corrosion rate after three days of treatment at the value of 16.8641 mpy. The smallest value of 5.6214 mpy was produced by treating the low carbon steel with 3% HCl and 5000 mg extract for nine days. This translated to an efficiency of 39.31624 %.

Index Terms: corrosion rate, guava leaf, inhibitor, low carbon steel, tannin

1. INTRODUCTION
Corrosion is a phenomenon in which a material is destroyed or degraded by anodized reactions with its surrounding. Based on Gibbs free energy, nearly all metals react to the surrounding and rust, therefore, corrosion is inevitable and can only be slowed down [1]. Mechanical characteristics of corroded metals are damaged by this electrochemical reaction, which is autocatalytic, with the surrounding corrosive environment [3,9]. Corrosion inhibitors are compounds that can slow down rust by forming a film layer on the surface of the materials [10]. These inhibitors can be broadly categorized as organic and inorganic inhibitors. Inorganic inhibitors are synthetic compounds that can be expensive and dangerous to the environment because of their toxicity. Meanwhile, organic inhibitors are obtained from extracting corrosion inhibitory compounds in natural resources, especially plants. They, therefore, are more affordable, renewable, and less toxic. With increased regulations to use environmentally friendly chemicals, such compounds have become more necessary [11]. In this study, extract of guava leaves was tested for its corrosion inhibitor properties because of its tannin content, which is known to inhibit rust. The phytochemistry of guava leaves has shown that they contain tannin (12 -18%), phospor (28 mg), iron (1.10 mg), proteins 0.90 mg), fats (0.30 g), calori (49 cal), carbohydrates (12.20 g), psiditanin (9%), and water (86 g) [13]. Tannin as a polyphenolic compound carries hydroxyl and other groups, such as carboxyl, that are considered non-toxic.

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It can be found in and extracted from dycotil plants, such as guava. As a polyphenolic substance, tannin can function as a corrosion inhibitor by undergoing an adsorption reaction with molecules on the surface of a metal and forming a film layer [14,17]. This study aimed to extract tannin from guava leaves, characterize its contents, and apply it as a corrosion inhibitor on low-carbon steel.

2 METHODOLOGY
2.1 Extraction of Guava Leaves
The harvested leaves were oven dried and then pulverized in a blender. The resulting guava-leaf powder was incubated in three liters of 70% ethanol for 48 hours. The sample was filtered and filtrate was placed in a rotary vacuum evaporator at 64 – 66 °C for two hours to produce a thick liquid sample. This sample was place in a glass bottle for further qualitative analyses [19].

2.2 Tannin Qualitative Analyses
Ten grams of the thick extract was added into 10 ml of distilled water and heated to boil. The solution was filtered. Two kinds of analyses were used to determine the tannin content in the extract. First, ten drops of 1% FeCl3 solution was added to the filtrate. The presence of tannin is marked by blackish green coloration on the sample. The second method used ten drops of 10 % gelatin. A positive for tannin presence resulted in a white precipitate of the sample [20].

2.3 Tannin Extraction
Tannin was further isolated from the guave leaf extract by incubating it in 95% ethyl acetate solution until precipitation was formed. The precipitate was filtered and washed with 95% acetyl acetate repeatedly until a clean sample was collected. The resulting residue was used as the substrates in the corrosion inhibition trials.

2.4 Preparation of Trial Specimens
Low-carbon steel plates at 0.1 m thickness were cut into 3x3 cm² dimension. These plates were buffed with sand paper for
iron, washed with distilled water, and dried in an oven at 110 °C for two hours.

2.5 Immersion Tests
The corrosive environment was simulated using 3% (w/v) HCl solutions. The steel specimens were first weighed to determine the initial weights and then immersed in 50 ml of 3% HCl solutions for either three, six, or nine days. There were four inhibitor treatments, which were the additions of guava-leaf extract at 1 g, 3 g, and 5 g, with no addition as a control.

2.6 Corrosion Rate Determination
At the end of the determined times of immersion, the samples were removed from the corrosive media, washed, and oven dried at 110 °C. Specimens were weighed to determine the final weights. The corrosion rate and the percent efficiency of the inhibitor were calculated based on formulas (1) and (2) [4, 20,21]

\[
CR = \frac{534W}{D \cdot A \cdot t}
\]

CR = Corrosion rate (mills per year/mpy)
W = weight loss (mg)
D = Specimen Density (g/cm\(^3\))
A = sample surface area (cm\(^2\))
t = time (jam)

\[
% IE = \frac{CR_0 - CR_t \times 100%}{CR_0}
\]

%IE = Inhibitor Efficiency
CR\(_0\) = Corrosion Rate without Inhibitor (HCl 3%)
CR\(_i\) = Corrosion Rate with Inhibitor

3 RESULTS AND DISCUSSION

3.1 Results
1. Tannin extraction from guava leaves
   The assays performed on the guava-leaf extract produced white precipitates, which indicated the presence of tannins.

2. The determination of inhibitory efficacy of guava-leaf extract employing immersion tests and weight loss calculations
   The resulting tannin extract from the guava leaves to be used as an organic corrosive inhibitor had a dark brown coloration and unpleasant odor, and was in a thick liquid form. The products of calculations are presented in Table 1, Table 2, dan Table 3.

### TABLE 1
Corrosion rates of low-carbon steel specimens immersed in 3% HCl for three days

<table>
<thead>
<tr>
<th>Amount of Inhibitor (mg)</th>
<th>Initial Mass (mg)</th>
<th>Final Mass (mg)</th>
<th>Weight Loss (mg)</th>
<th>Corrosion Rate (mg/cm(^2).day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>13068.6</td>
<td>13045.2</td>
<td>23.4</td>
<td>0.867</td>
</tr>
<tr>
<td>1000</td>
<td>12398.8</td>
<td>12373.1</td>
<td>15.7</td>
<td>0.730</td>
</tr>
<tr>
<td>3000</td>
<td>12719.9</td>
<td>12703.4</td>
<td>16.5</td>
<td>0.611</td>
</tr>
<tr>
<td>5000</td>
<td>13176.3</td>
<td>13162.1</td>
<td>14.2</td>
<td>0.526</td>
</tr>
</tbody>
</table>

These data were further analyzed as correlations and the results are presented in Figures 1, 2, and 3.

![Fig 1. The correlation between the amount of organic inhibitor added and corrosion rate](image1)

![Fig 2 The correlation between times of immersion with the corrosion rate](image2)
The following table and figure show the analysis results of Inhibitor Efficiency.

**TABLE 4**
The Inhibitor Efficiency of guava-leaf extract on low-carbon steel specimens immersed in 3% HCl

<table>
<thead>
<tr>
<th>Amount of Inhibitor (mg)</th>
<th>Initial Mass (mg)</th>
<th>Final Mass (mg)</th>
<th>Weight Loss (mg)</th>
<th>Corrosion Rate (mg/cm²-day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12816.7</td>
<td>12778</td>
<td>38.7</td>
<td>0.478</td>
</tr>
<tr>
<td>1000</td>
<td>12715.5</td>
<td>12682</td>
<td>33.5</td>
<td>0.414</td>
</tr>
<tr>
<td>3000</td>
<td>12326.4</td>
<td>12297</td>
<td>29.4</td>
<td>0.363</td>
</tr>
<tr>
<td>5000</td>
<td>12529.2</td>
<td>12504.3</td>
<td>24.9</td>
<td>0.307</td>
</tr>
</tbody>
</table>

This reaction produces a dark green coloration in the solution. Gelatin is also an effective identifying reagent because it reacts with tannin to generate a copolymer that is insoluble in water and precipitates in the form of white sediment [17, 18].

### 3.2.2 Determination of Corrosion Rate

This study aimed to inhibit corrosion in steel using an organic inhibitor extracted from guava leaves. The specimen used contained iron (Fe) and carbon (C), and the corrosive environment was simulated using 3% HCl solution. The determination of corrosion rate was based on the weight loss recorded during the immersion in the acid solution. The results showed that increased amounts of inhibitor added into the solutions produced slower corrosion rates across the lengths of time (days) of immersion. Moreover, corrosion rates also decreased with the lengths of immersion time. These phenomena can be clearly observed in Figure 1. The addition of greater amount of inhibitor and increased length of immersion reduced the corrosion rate by increased production of \( \text{Fe(OH)}_3 \) layer that prevented the diffusion of \( \text{H}_2\text{O/O}_2 \) to the surface of the specimen and reduced weight loss [17, 18]. This trial demonstrated that the lowest corrosion rate occurred to the specimens treated with 5 grams of inhibitor at the value of 0.526 mg/cm².day (Table 1 and Figure 1). This amount also produced the optimal result as it generated saturated complex tannic compounds. Inhibitor Efficiency improved with addition of inhibitor, which might be caused by increased saturation and, therefore, decrease the rate of tannic compounds formation (Table 4 and Figure 4).

### 4 CONCLUSION

This study showed that:
1. Leaves of guava, *Psidium guajava*, can be used as a source of tannin.
2. Tannin can be effectively extracted from guava leaves using maceration methods.
3. Tannin extracted from guava leaves can be used as a natural inhibitor.
5. The corrosion rate of low-steel carbon immersed in 3% HCl for three days was 16.8641 mpy.
6. The decrease in corrosion rate occurs with the addition of inhibitors from extraction of guava leaves on immersion with 3% HCl solution for 9 days with a weight of 5 gram inhibitors obtained the corrosion rate of 5.6214 mpy with an efficiency of 39.31624%, this is due to tannin compounds can form iron (III) -tannin complex compounds as a layer of film attached to the surface of low carbon steel thus reducing the corrosion rate of the low carbon steel.

### 7 REFERENCES


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