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 inhibitory 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 ^{0}C for two hours to produce a thick liquid sample. This sample was place in a glass bottle for further qualitative analyses [19].

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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% $FeCl_3$ 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 repeteadly 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 cm^2 dimension. These plates were buffed with sand paper for iron, washed with distilled water, and dried in an oven at 110 ^{0}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 ^{0}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]

$$CR = \frac{534\ W}{D.A.t} \quad 1)$$

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)

$$\%\ IE = \frac{CR0-CRt}{CR0} \times 100\% \quad 2)$$

%IE = Inhibitor Efficiency
CR_o = 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

Amount of Inhibitor (mg)	Initial Mass (mg)	Final Mass (mg)	Weight Loss (mg)	Corrosion Rate (mg/(cm^2.day))
0	13068.6	13045.2	23.4	0.867
1000	12398.8	12379.1	19.7	0.730
3000	12719.9	12703.4	16.5	0.611
5000	13176.3	13162.1	14.2	0.526

TABLE 2

Corrosion rates of low-carbon steel specimens immersed in 3% HCl for six days

Amount of Inhibitor (mg)	Initial Mass (mg)	Final Mass (mg)	Weight Loss (mg)	Corrosion Rate (mg/(cm^2.day))
0	13068.6	13045.2	23.4	0.867
1000	12398.8	12379.1	19.7	0.730
3000	12719.9	12703.4	16.5	0.611
5000	13176.3	13162.1	14.2	0.526

TABLE 3

Corrosion rates of low-carbon steel specimens immersed in 3% HCl for nine days

Amount of Inhibitor (mg)	Initial Mass (mg)	Final Mass (mg)	Weight Loss (mg)	Corrosion Rate (mg/(cm^2.day))
0	13068.6	13045.2	23.4	0.867
1000	12398.8	12379.1	19.7	0.730
3000	12719.9	12703.4	16.5	0.611
5000	13176.3	13162.1	14.2	0.526

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

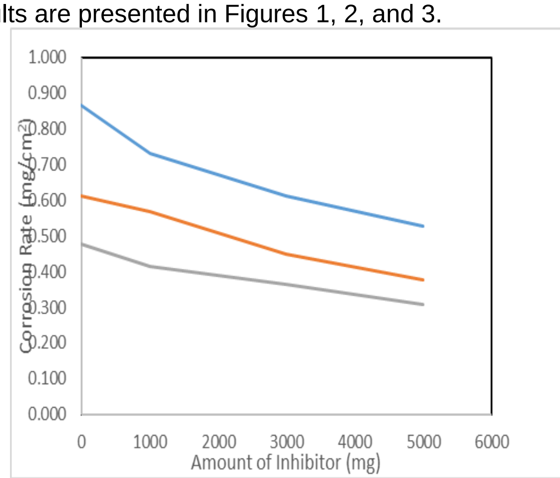

Fig 1. *The correlation between the amount of organic inhibitor added and corrosion rate*

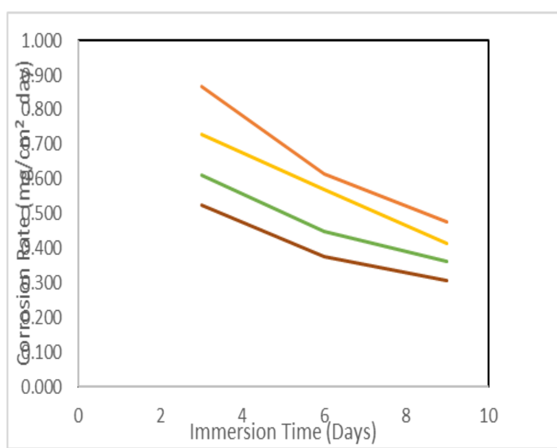

Fig 2 *The correlation between times of immersion with the corrosion rate*

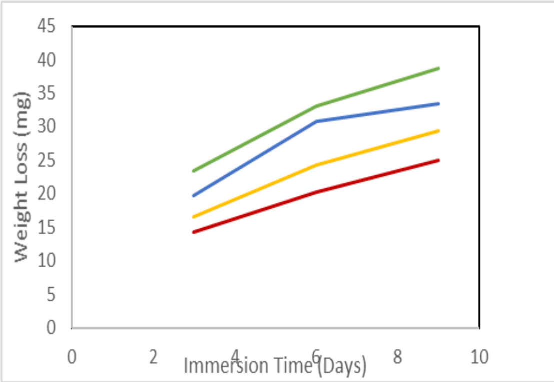

***Fig 3 The** correlation between times of immersion and weight loss*

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

Amount of Inhibitor (mg)	Initial Mass (mg)	Final Mass (mg)	Weight Loss (mg)	Corrosion Rate (mg/(cm^2.day))
0	12816.7	12778	38.7	0.478
1000	12715.5	12682	33.5	0.414
3000	12326.4	12297	29.4	0.363
5000	12529.2	12504.3	24.9	0.307

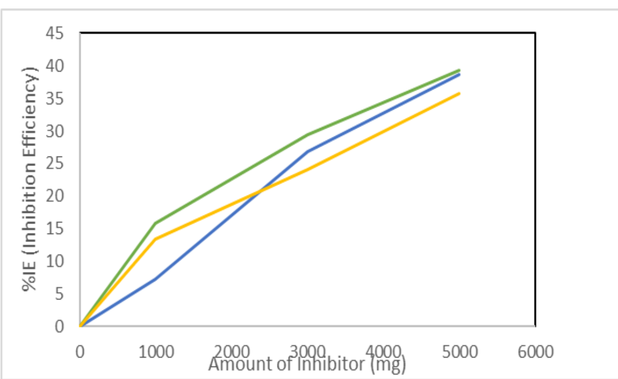

***Fig 4** The correlation between the amount of inhibitor and Inhibitor Efficiency (%IE)*

3.2. Discussion

3.2.1 Determination of tannin content in guava-leaf extract

The initial stage of this study was to determine the tannin content in guava leaves because tannin is the compound known to have corrosive inhibitory properties. Thus, the first step involved extraction of guava leaves followed by analyses of extract for tannin content to be used as the inhibitor in the corrosion rate trials. Tannin is a polyphenolic compound, which in its natural state is in the form of a glycoside and easily dissolved in alcohol. Therefore, a 70% ethanol solution was employed in the extraction process [18, 19]. Tannin in the guava-leaf extract was identified with $FeCl_3$ and gelatin. The addition of $FeCl_3$ induces a reaction that leads to a complex compound consisting of tannin-phenolytic core with Fe^{3+} ion. This reaction produces a dark green coloration in the solution. Gelatin is also an effective identifying reagent because it reacts with tannin react 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 corrotion rates across the lengths of time (days) of immersion. Moreover, corrotion 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 $Fe(OH)_2$ layer that prevented the diffusion of H_2O/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.
4. Steel carbon treated with tannin-containing guava-leaf extract exhibited lower corrosion rates than without treatment.
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) -tanin 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.
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REFERENCES

[1] Tretheway, Kr., Chamberlain J. 1991. Korosi untuk Mahasiswa dan Rekayasawan. Jakarta: PT. Gramedia Pustaka Utama.

[2] Pattireuw, Kevin Jones, Fentje Abdul Rauf, dan Romels Cresano. 2013. Analisis Laju Korosi pada Baja Karbon dengan Menggunakan Air Laut dan

H_2SO_4. Teknik Mesin. Manado: Universitas Sam Ratulangi.
[3] H.M. Uhlig, Corrosion & corrosion Control, John Wiley & Sons, Inc., N.Y., 1963. I. S. Van Delinder, Corrosion basics An Introduction, NACE, 1984. Mars. G. Fontana " Corrosion Engineering" Mc. Graw Hill
[4] Vogel, 1979, Textbook of Macro and Semimicro Qualitative Inorganik Analysis, 5th ed., p.p. 257- 337, Longman Group Limited., London
[5] Fogler, 1992, Elements of Chemical Reaction Engginering , 2nd ed, Prentice – Hall International. Inc, USA
[6] Kirk and Othmer, 1965, Encyclopedia of Chemical Technology, 2nd ed., Vol.6, p. 320, John Willey and Sons, New York
[7]] (Djaprie S ., 1995, Ilmu dan Teknologi Bahan , ed. 5, hal. 483-510. Erlangga, Jakarta.
[8] Jones, D.A., 1996, Principles and Prevention of Corrosion, 2nd Edition, Upper Saddle River, NJ: Prentice Hall. [10]
[9]] Sastri, V.S. 2011. Green Corrosion Inhibitors: Theory and Practice. Hoboken: John Wiley & Sons, Inc.
[10] Haryono, G., Sugiarto, B., Farid, H., & Tanoto, Y. (2010). Ekstrak bahan alam sebagai inhibitor korosi. Paper presented at the Prosiding Seminar Nasional Teknik Kimia "Kejuangan"
[11] Akhsan, Yudha, M.L. 2015. Pengaruh Inhibitor Ekstrak Daun Jambu Biji Merah Terhadap Laju Korosi Baja A131 Pada Air Laut. Skripsi. Jember: Teknik Mesin, Fakultas Teknik Universitas Jember.
[12] Fachry, A Rasyid, RM.Arief Sastrawan, dan Guntur Svingkoe. 2012. Kondisi Optimal Proses Ekstraksi Tanin dari Daun Jambu Biji Menggunakan Pelarut Etanol. Prosiding STNK TOPI (7): 69-73.
[13] Yatiman, P., Surdia, N.M., Purwadaria, S dan Ariwahjoedi, B., (2006), Inhibisi Korosi Baja Karbon dalam Larutan Natrium Klorida oleh Beberapa Senyawa Organik, Jurnal Teknologi Industri, Vol. X, No. 3, 231 – 240.
[14] Habibie, Lubis, A dan Palupi, A.E. 2014. "Pengaruh Daun Teh dan Daun Jambu Biji sebagai Inhibitor Organik Alami pada Baja SS 304 dalam Larutan Asam". Jurnal Teknik Mesin (JTM) 03 No.01: 9-13.
[15] Luo, H., Guan, Y.C and Han, K,N., (1998), Corrosion Inhibition of A Mild Steel by Aniline and Alkylamines in Acidic Solutions, Corrosion, 54, 721 – 731.
[16] Magnussen, O.M., (2003), Corrosion Protection by Inhibition, in Encyclopedia of Electrochemistry: Corrosion and Oxide Films, Vol. 4, Eds. Bard, A.J and Stratmann, M., Weinheim: Wiley-VCH GmbH & Co. KGaA., p 435.
[17] Tambun, R., Limbong,H.P., Nababan,P., Sitorus, N., Kemampuan Daun Jambu Biji sebagai Inhibitor Korosi Besi Pada Medium Asam Klorida., *J.Kimia Kemasan*, Vol.37 No.2, 2015
[18] Harborne, J.B, dkk. 1994. *Metode Fitokimia : Penuntun Cara Modern Menganalisis Tumbuhan*. Bandung: Penerbit ITB.
[19] Mukhriani, Nonci, F.Y., Mumamg, " Penetapan Kadar Tannin Total Ekstraksi Biji Jintan Hitam (Nigella sativa) Secara Spektrofotometri UV-VIS " Jurnal JF Fik Uinam vol. 2 No. 4 th. 2014
[20] Nugrahani, R.A.,, Hendrawati, T.Y., Susanty S. 2018 " An Analysis of Metal Surface Immersed in Based Lubricant from Mineral Oil Containing Vegetable Oil Based Bio Inhibitor" jurnal JBAT 7(X)