J. Pijar MIPA, Vol. 18 No. 2, March 2023: 274-278 ISSN 1907-1744 (Print)
DOI: 10.29303/jpm.v18i2.4780 ISSN 2460-1500 (Online)

THE EFFECT OF SAMBILOTO LEAF (Andrographis paniculata Nees) EXTRACT INHIBITOR CONCENTRATION ON THE CORROSION RATE OF IRON IN THE CORROSIVE HCl MEDIUM AND WELL WATER

Febriyandhi Yahya, Ade Trisnawati*, and Mohammad Arfi Setiawan
Departement of Chemical Engineering, Universitas PGRI Madiun, Madiun, Indonesia
*Email:adetrisnawati@unipma.ac.id

Received: February 14, 2023. Accepted: March 25, 2023. Published: March 31, 2023

Abstract: Corrosion is a chemical reaction between metal and chemical substances in free air influenced by typographical conditions, climate, and humidity levels around the metal object. If left unchecked, it can cause damage to the metal infrastructure, material losses, and harm in terms of safety and security. Therefore, a way to inhibit corrosion is needed by creating an environmentally friendly inhibitor from natural materials. One of them is by utilizing Sambiloti leaf as a natural inhibitor. Sambiloto leaves contain tannins which can inhibit corrosion well. This study aimed to determine the efficiency of Sambiloto leaves ethanol extract in inhibiting the corrosion rate of metals in the corrosive medium of well water. HCl was soaked for seven days to determine the correlation between the corrosion rate and extract concentration in different corrosive media. Sambiloto leaves were extracted using the soxhletation method using 96% ethanol solution, then distilled to obtain a pure extract. Sambiloto leaf extract was then varied in concentration, namely 1%, 5%, 10%, and 15%. The corrosive medium is well water and HCl, and the metal material used is nails. The results showed that adding Sambiloto extract with a concentration of 15% in both corrosive mediums had the highest inhibitor efficiency values, namely 97.32% in the corrosive HCl medium and 69.3% in the corrosive well water medium. The results of the regression analysis showed that the addition of Sambiloto extract had a significant effect on the corrosion rate in well water media. In contrast, in the HCl medium, the addition of Sambiloto extract did not significantly affect the corrosion rate.

Keywords: *Corrosion, Corrosion Inhibitor, Soxhletation, Sambiloto.*

INTRODUCTION

Corrosion can be defined as a decrease in the quality of a metal caused by a chemical reaction between the metal and the surrounding environment [1]. Corrosion that occurs due to the interaction of metals with the environment is called atmospheric corrosion. Atmospheric corrosion is an event of damage to metal due to an electrochemical reaction between the metal and the environment containing various kinds of pollutants, such as gases and salts, in the air [2]. Factors that affect the occurrence of atmospheric corrosion include temperature, humidity levels of the environment around the metal, and the content of chemicals in free air. It greatly determines the corrosion rate of metal [3].

Corrosion is a problem that must be considered because if left alone, it will have a negative impact that can cause infrastructure damage and material losses. Of course, it can be detrimental regarding safety and security [4]. Various ways to overcome this problem have been widely done, one of which is the manufacture of corrosion inhibitors. A corrosion inhibitor is a compound that can work in inhibiting the corrosion rate of metal objects and can be said to be able to stop the corrosion process that will occur [5].

Corrosion inhibitors are generally derived from organic or inorganic compounds. Organic inhibitors can form complex compounds that can settle on the surface of the metal as a hydrophobic protective layer. At the same time, this property can inhibit the rate of metal corrosion caused by the interaction of metals with the environment around them [6]. In addition, according to Brycki, natural organic inhibitors are inhibitors made from plant extracts, and the characteristics of natural ingredients that can be used as natural organic inhibitors are plants that have important ingredients in the form of tannins [7].

Akbar's research utilizes guava fruit as a natural inhibitor because it is believed to have important content in the form of tannins [8]. This study aimed to determine the efficiency of guava fruit extract inhibitors in inhibiting the rate of iron corrosion in the corrosive medium of well water and seawater.

In addition, the research that Mulyaningsih has conducted uses natural inhibitors from guava leaf ingredients with important ingredients in the form of tannins [9]. This study aimed to determine the efficiency of guava leaf extract inhibitors in inhibiting the rate of metal corrosion in seawater corrosive medium.

Another study was conducted by Jufri et al., who used calliandra leaves as raw materials for making corrosion inhibitors because these leaves have a tannin content of approximately 10%, so they can be used as corrosion inhibitors in a metal [10]. This study aimed to determine the efficiency of calliandra leaf extract corrosion inhibitors in inhibiting the rate of metal corrosion in seawater corrosion medium.

Based on this research, it can be concluded that natural ingredients that can be used as natural inhibitors are natural ingredients that contain important compounds in the form of tannins. Because tannins are compounds that can form complex compounds, tannins have free pair elements that function as electron donors

to metals [11]. Until the presence of this tannin compound, the role of corrosion bioinhibitors is very influential in inhibiting the corrosion rate of metals which is quite significant [12].

Thus in this study, the selection of natural materials used as raw materials for making corrosion inhibitors is sambiloto leaves. Because according to Royani sambiloto leaves have an important content, namely tannins [13]. In addition, Nugroho et al. said that in this sambiloto plant, especially in the leaves, there are various important ingredients such as saponins, alkaloids, flavonoids, and of course, tannins [14].

The manufacture of corrosion inhibitors, in general, uses the extraction method. Extraction is one of the separation techniques between solvents and analytes in solid and liquid samples [15]. One factor affecting the quality of the extract is the selection of the extraction method used. Sokhletasi and maceration are two commonly used methods [16].

This study aimed to determine the efficiency of ethanol extract of sambiloto leaves in inhibiting the corrosion rate of metal in the corrosive medium of well water. HCl was soaked for seven days to determine the relationship between corrosion rate and extract concentration in the different corrosive mediums.

RESEARCH METHODS

Main Text Paragraph It was experimental research carried out in the laboratory. The initial stage of this research began with the preparation of tools and materials in the form of Sambiloto leaf, 95% ethanol solvent, HCl, well water, and nails. Sambiloto leaves that have been dried for 2-3 days by drying in the hot sun, then the leaves are mashed by pounding or blending, as shown in Figure 1.

Furthermore, Sambiloto leaves were extracted with 95% ethanol using the soxhletation method. Sambiloto leaf powder is wrapped in filter paper with a powder weight of 30 gr. After that, it is put into the receiver tube on the socket tool, and the ethanol solvent is placed on the bottom flask. After that, it is heated to a temperature according to the solvent's boiling point of 70 – 80 ºC. This process takes 24 hours to get the perfect extract, as shown in Figure 2.

The extract that is still mixed with the solvent is distilled at a temperature that matches the solvent's boiling point to obtain a thick extract, while the thick extract produced from this distillation process is 30 mL. Furthermore, Sambiloto leaf extract was tested against nails in a corrosive HCl medium and well water soaked for seven days. This test was carried out to determine the efficiency of the Sambiloto leaf extract inhibitor against the corrosion rate of nails by adding the Sambiloto leaf extract, which has varied concentrations of 1%, 5%, 10%, and 15% in the corrosive medium that has been provided, as shown in Figure 3.

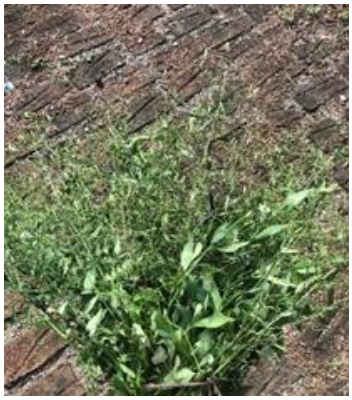


Figure 1. The process of drying Sambiloto leaves

Figure 2. The process of extracting Sambiloto leaves using the soxhletation method

The inhibitor's ability to determine the corrosion rate of nails in the corrosive medium can be determined quantitatively using the following equation [8].

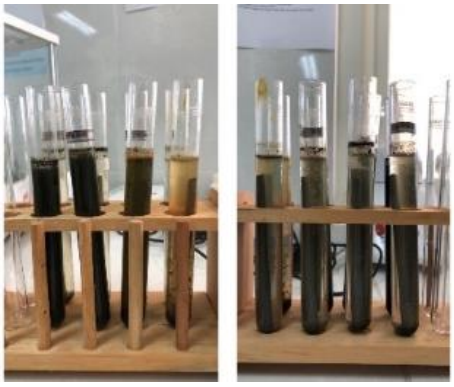
$$r = \frac{(W_0 - W_f)}{A \times t}$$

Note :
r : Corrosion rate
t : time (days)
Wo: initial weight (gr)
W_f : final weight (gr)
A : surface area (cm^2)

Furthermore, the efficiency value of the inhibitor can be determined quantitatively using the following equation [8].

$$\%E = \frac{(r_1 - r_2)}{r_1} \times 100$$

Note :
%E: Inhibition efficiency (%)
r1 : corrosion rate without inhibitor
r2 : corrosion rate with inhibitor



(a) (b)

Figure 3. (a) Soaking nails in corrosive HCl medium for seven days. (b) Soaking nails in a corrosive medium of well water for seven days.

Data analysis was conducted to determine the correlation between the concentration of Sambiloto leaf inhibitors on the corrosion rate in different media. Concentration and corrosion rate data were analyzed by data normality and regression test. The normality test was analyzed using the Kolmogorov-Smirnov test to determine whether the data were normally distributed. Linear regression test was used to determine the effect of the concentration of Sambiloto leaf extract on the corrosion rate in two different media, namely corrosive medium HCl and well water.

RESULTS AND DISCUSSION

This research utilized natural ingredients in the Sambiloto leaf, extracted using the soxhletation method. Compared to other extraction methods, such as the maceration method, the soxhletation method has an advantage in the extraction process time, the time required in the extraction process with the soxhletation method is much shorter than the time needed when extracting a sample using the maceration method [17]. In addition, the solvent used is much less than extracting using the maceration method. The results are also more perfect because the sample will be passed through the solvent in several cycles during extraction.

The selection of Sambiloto leaves as a raw material for making inhibitors is because these leaves contain tannins. Tannins can form complex compounds with iron ions to become Fe-tannate. This Fe-tannate complex compound will form a shield to coat the metal surface and become a barrier for iron against the surrounding environment [18]. It can be proven quantitatively to determine the rate of metal corrosion with the addition of Sambiloto leaf extract inhibitors with concentrations of 1%, 5%, 10%, and 15% in 1 M HCl corrosive medium and well water, as shown in Table 1 below.

Table 1 shows that adding a 1% concentration inhibitor is the fastest corrosion rate, which is 0.00004777 gr/cm^2 in the corrosive HCl medium and 0.00311306 gr/cm^2 in the corrosive HCl the corrosive well water medium. The corrosion rate was decreased by adding Sambiloto leaf extract with a concentration of 15% to 0.00003185gr/cm^2 in the corrosive HCl medium and 0.00095883gr/cm^2 in the corrosive well water medium. It is known that the higher the concentration of bitter leaf extract, the corrosion rate decreases in both corrosive media. The results follow the research of Kayaode et al., which stated that the greater the concentration of pandan leaf inhibitors tested on SS-304 steel, the corrosion rate on SS-304 steel decreased [19]. The higher the extract concentration, the more active molecular content can interact with the steel surface to coat the steel perfectly.

Table 1. Corrosion Rate Results

Concentration Inhibition corrosion %	Corrosion Rate	
	HCl	Well Water
1	0.00004777	0.00311306
5	0.00004095	0.00212352
10	0.00003298	0.00109986
15	0.00003185	0.00095883

The efficiency value of the inhibitor with a concentration of 1% is 95.98% in the corrosive HCl medium and 0.32% in the corrosive well water medium. Meanwhile, at a concentration of 15%, the efficiency value of the inhibitor increased by 97.32% in the corrosive HCl medium and 69% in the corrosive well water medium. The increase in the efficiency value of this inhibitor is closely related to the relationship between the corrosion rate and the administration of bitter leaf extract, which has been differentiated in concentration. The greater the concentration value of the inhibitor given, the inhibitor will work in inhibiting the performance of the corrosion rate.

Table 2. Regression Analysis Results

Medium Corrosion	r	R^2	*Sig*
Well Water	0.967	0.935	0.007
HCl	0.560	0.314	0.326

Based on the results of Table 2, it is known that Sambiloto leaf extract can be used as a natural inhibitor in a corrosive well water medium, and the concentration of Sambiloto leaf extract has a significant effect on the corrosion rate of nails in a corrosive well water medium (sig < 0.05). It is indicated by the results of the regression test on the treatment of Sambiloto leaf extract on the corrosion rate in the corrosive medium of well water the r value is 0.967, meaning that the correlation of inhibitor concentration and corrosion rate has a very close relationship because it is close to number 1. The R^2 value is 0.935, meaning the effect of giving Sambiloto leaf extract in inhibiting the corrosion rate of nails in a well water medium was 93.5%. Other variables influenced the rest.

Based on the results in Table 2, it is also known that in an HCl medium, Sambiloto leaf extract can be used as a natural inhibitor in the corrosive medium of well water. Still, the concentration of Sambiloto leaf extract does not significantly affect the corrosion rate of nails (sig > 0.05). The HCl solution is a strong acid that, when ionized, will produce H^+ ions, which can accelerate corrosion. The absence of a significant effect indicates that the bitter leaf inhibitor is less effective when used as a natural inhibitor to reduce the corrosion rate of metals. In addition to the presence of H^+ ions, in the HCl solution, there are Cl^- ions which are very aggressive towards the element iron in metals. Cl^- ions will attract the Fe element to the metal so that the metal is attacked by corrosion and becomes rusty [20]. So the content of bitter leaf inhibitors is less effective in dealing with ion attack on HCl medium when compared to the results in well water.

CONCLUSION

The conclusion obtained from this study is the addition of Sambiloto extract with a concentration of 15% in both corrosive media has the highest inhibitor efficiency value, namely 97.32% in corrosive HCl medium and 69.3% in corrosive well water medium. The results of the regression analysis showed that the addition of Sambiloto extract had a significant effect on the corrosion rate in well water media. In contrast, adding Sambiloto extract did not significantly affect the corrosion rate in HCl media.

REFERENCES

[1] Widyawati, F., Hidayat, S., Bahtiar, S., & Musbihin, M. (2022). Effect of the addition of inhibitors of kirinyuh leaf (Chromolaena Odorata) in methanol extract on corrosion rate of ASTM 36 steel. *Jurnal Pijar Mipa*, *17*(6), 793-799.

[2] Desiasni, R., Mardiana, M., & Hidayat, S. (2021). Corrosion inhibition efficiency of moringa leaf extract (Moringa oleifera) against A36 steel. *Jurnal Pijar Mipa*, *16*(5), 600-607.

[3] Huzni, S., Siregar, A. M., Siregar, C. A., Nasution, A. R., Tanjung, I., & Fonna, S. (2020). Analisa Korosi Atmosferik Baja Karbon Rendah Di Kecamatan Medan Belawan. *Multitek Indonesia*, *14*(2), 80-88.

[4] Lestari, D. S. (2021). Tingkat Korosivitas Air Terhadap Infrastruktur Sumber Daya Air Berbahan Semen atau Mortar dengan fc'≤ 30 MPa pada 9 Waduk di Indonesia. *Jurnal Teknik Kimia Indonesia*, *19*(1), 20-25.

[5] Stiadi, Y., Arief, S., Aziz, H., Efdi, M., & Emriadi, E. (2019). Inhibisi Korosi Baja Ringan Menggunakan Bahan Alami Dalam Medium Asam Klorida. *Jurnal Riset Kimia*, *10*(1), 51-65.

[6] Turnip, L. B., Handani, S., & Mulyadi, S. (2015). Pengaruh penambahan inhibitor ekstrak kulit buah manggis terhadap penurunan laju korosi baja ST-37. *Jurnal Fisika Unand*, *4*(2).

[7] Brycki, B. E., Kowalczyk, I. H., Szulc, A., Kaczerewska, O., & Pakiet, M. (2018). Organic corrosion inhibitors. *Corrosion inhibitors, principles and recent applications*, *3*, 33.

[8] Hamdiani, S., Arduha, J., Purwoko, A. A., & Hadisaputra, S. (2016). Optimasi Sifat Inhibitor Korosi Senyawa Thiaamida-Pirazolindol Berdasarkan Teori Fungsional Kerapatan. *Jurnal Pijar Mipa*, *11*(1).

[9] Mulyaningsih, N., Mujiarto, S., & Ubaydillah, G. (2019). Pengaruh Daun Jambu Biji sebagai Inhibitor Korosi Alami Rantai Kapal. *Journal of Mechanical Engineering*, *3*(1), 36-42.

[10] Jufri, M., Surya, I., & Suwarsono, S. (2021, January). EFEKTIVITAS EKSTRAK DAUN KALIANDRA (CALLIANDRA CALOTHYRSUS) SEBAGAI INHIBITOR LAJU KOROSI BAJA ST-37 PADA PERENDAMAN AIR LAUT. In *Prosiding SENTRA (Seminar Teknologi dan Rekayasa)* (No. 6, pp. 97-100).

[11] Hakim, M., Mulyaningsih, N., Suharno, K., & Taufik, I. (2020). Analisis Pengaruh Penggunaan Inhibitor Minyak Biji Kapas Terhadap Laju Korosi Pipa Radiator Mobil. *Journal of Mechanical Engineering*, *4*(1), 15-21.

[12] Rochmat, A., Liantony, G., & Septiananda, Y. D. (2019). Uji kemampuan tanin daun ketapang sebagai inhibisi korosi pada baja mild steel dalam pipeline. *Jurnal Integrasi Proses*, *8*(1), 45-50.

[13] Royani, J. I., Hardianto, D., & Wahyuni, S. (2014). Analisa kandungan andrographolide pada tanaman sambiloto (Andrographis paniculata) dari 12 lokasi di Pulau Jawa. *Jurnal Bioteknologi & Biosains Indonesia (JBBI)*, *1*(1), 15-20.

[14] Nugroho, A., Rahardiningtyas, E., Putro, D., & Wianto, R. (2016). *Pengaruh Ekstrak Daun Sambiloto (Andrographis paniculata Ness.) terhadap Daya Bunuh Bakteri Leptospira sp*. National Institute of Health Research and Development, Indonesian Ministry of Health.

[15] Widodo, H., Kustiyah, E., Sari, N. W., Andhy, A., & Prastia, M. (2019). Ekstraksi Pektin Dari Kulit Pisang Dengan Proses Sokletasi. *Jurnal Siliwangi Seri Sains dan Teknologi*, *5*(1).

[16] Nurhasnawati, H., Sukarmi, S., & Handayani, F. (2017). Perbandingan metode ekstraksi maserasi dan sokletasi terhadap aktivitas antioksidan ekstrak etanol daun jambu bol (Syzygium malaccense L.). *Jurnal Ilmiah Manuntung*, *3*(1), 91-95.

[17] Leba, M. A. U. (2017). Ekstraksi Dan Real Kromatografi, Cetakan Pertama, Ed. *Deepublish, Yogyakarta*.

[18] Xu, W., Han, E. H., & Wang, Z. (2019). Effect of tannic acid on corrosion behavior of carbon steel in NaCl solution. *Journal of Materials Science & Technology*, *35*(1), 64-75.

[19] Kayadoe, V., Fadli, M., Hasim, R., & Tomasoa, M. (2015). Ekstrak daun pandan (Pandanus

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

amaryllifous Roxb) sebagai inhibitor korosi baja SS-304 dalam larutan H_2SO_4. *Molekul*, *10*(2), 88-96.

[20] Septianingsih, D., Suka, E. G., & Suprihatin, S. (2014). Pengaruh Variasi Konsentrasi Asam Klorida Terhadap Laju Korosi Baja Karbon Rendah Astm A 139 Tanpa Dan Dengan Inhibitor Kalium Kromat 0, 2%. *Jurnal Teori dan Aplikasi Fisika*, *2*(2).