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Comparative study of performance of temiki (*Melastomacandidum*) and rubek (*Calotropisgigantea*) extract inhibitors for carbon steel in corrosive media

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Abstract

The use of synthetic inhibitors that negatively affect the environment is still used. Organic inhibitors are the best and most environmentally friendly solutions such as temiki plants (*Melastomacandidum*) and rubek (*Calotropisgiganteen*) which have good corrosion cell inhibitor properties and have the potential to be used as corrosion inhibitors. This study analyzed temiki and rubek extracts as corrosion inhibitors in carbon steel using the weight loss method in 3.5% NaCl solution and analyzed the efficiency of the inhibitors. Temiki and rubek's are extracted by drying the leaves, stems and flowers under the sun. Then the material is mashed together and distilled by the solid-liquid method with the Soxhlet tool. Identification of plant components using Gas Chromatography-Mass Spectrometry (GC-MS). Density and viscosity were analyzed following ASTM D 4052 and ASTM D 445 standards. Weight loss method testing was carried out at inhibitor concentrations of 200, 300, 400 and 500 ppm, with soaking time for 15 weeks and data collection was carried out every week. The results of the analysis showed the highest corrosion rate in temiki extract with a concentration of 500 ppm reaching 1,569 mpy and the lowest at a concentration of 500 ppm reaching 0.157 mpy. In rubek's extract inhibitors, the highest corrosion rate occurred in 500 ppm inhibitors reaching 1,268 mpy, while the lowest occurred at 200 ppm concentrations reaching 0.331 mpy. The highest efficiency value is the 400 ppm temiki inhibitor with efficiency reaching 82.89% and the lowest at 500 ppm reaching 19.55%. while for the efficiency of rubek's extract inhibitors, the highest value was 62.71%, at a concentration of 200 ppm. While the lowest is 28.40%, at 500 ppm inhibitors. These results show that temiki and rubek's extracts can still function well as corrosion inhibitors in low-carbon steels in NaCl solution.

Keywords:
Corrosion inhibitors, low carbon steel, temiki, rubek, weight loss, corrosion rate.

1 Introduction

Steel is a metal consisting of iron and carbon with a carbon content between 0.05% and 1.75%. Steel can undergo corrosion, which is a process of degradation or damage due to interaction with the environment containing elements that damage steel. Corrosion can reduce the durability and performance of steel as a construction materialand can provide considerable material losses, therefore it is necessary to make anticipatory efforts to prevent or reduce corrosion of steel. One way to prevent corrosion is to use inhibitors as insulators[1][2][3].

Corrosion inhibitors are chemical compounds that can reduce the rate of corrosion on metals in corrosive environments. Inhibitors are usually organic or inorganic compounds that have free electrons that can bond to metal surfaces, such as nitrites, chromates, phosphates, urea, tannins, and so on. However, some inhibitors are also toxic and negatively impact the environment. Therefore, environmentally friendly, biodegradable, inexpensive, and easily available inhibitors are preferred for corrosion applications[4][5].

In ashitaba plants (*Angelica keiskei*) which contain methanol, methanol from ashitaba contains flavonoids, saponins, and tannins play an important role as corrosion inhibitors. Other researchers also reported studies on the utilization of egg whites as corrosion inhibitors in HCl solutions analyzed using FT-IR[6][7][8][9].

Aloe vera extract (*Aloe vera*) as a corrosion inhibitor on zinc. Which can plant passive coating on the surface of zinc so that it can inhibit corrosion growth[10]. Pegaga (*Centellaasiatica*) and fern (*Chamaeropshumilis* L.) leaves have the potential as environmentally friendly corrosion inhibitorsbecausethey contain phenolic compounds and antioxidants that can protect metals from corrosion attacks [11][12].

According to Backer and Bakhuizen (1968), temiki leaves contain chemicals such as saponins, flavonoids, and hydrolyzed tannins which are also known as nobotanin B. Temiki flowers also contain various compounds such as kaempferol, anthocyanins, tannins, fatty acids, and sterols[13].

Rubek's (*Calotropisgigantea*) is a wild plant that belongs to the category of sap plants and usually grows in the tropics. The Rubek's plant has been widely reported to have various beneficial properties, such as analgesic, antimicrobial, antioxidant, antipyretic, insecticide, cytotoxicity, laxative, and procoagulant[14][15][16].

This study aims to examine the effect of variations in the concentration of rubek and temiki extracts in 3.5% NaCl solution, with different concentrations, namely 0 ppm, 100 ppm, 200 ppm, 300 ppm, 400 ppm, and 500 ppm. In addition, this study also analyzed the effect of immersion duration in chloride solution on the efficiency of corrosion inhibitors.

2 Research Methods

2.1 Materials and Tools

The materials used are temiki and rubek plants that have been extracted using 96.7% ethanol and then used as inhibitors, aquades, sodium chloride and carbon steel type SAPH 620 with a carbon composition of 0.06%-0.05% with dimensions of 22×20×0.3 mm. In research with this heavy life method, the tools used are as follows: digital scales 0.001 gr, digital pH meters, multimeters, beaker glass, tissues, alcohol and soaking containers. The rubek's and temiki plants are shown in Fig. 1.

2.2 Research Procedure

This research procedure is carried out in several stages using the weight loss method. Some of these stages can be shown as follows[19][20]:the initial stage in the implementation of this research is the determination of specimens to be used in the implementation of research, in this case, the test specimen material used is carbon steel as many as 24 pieces.

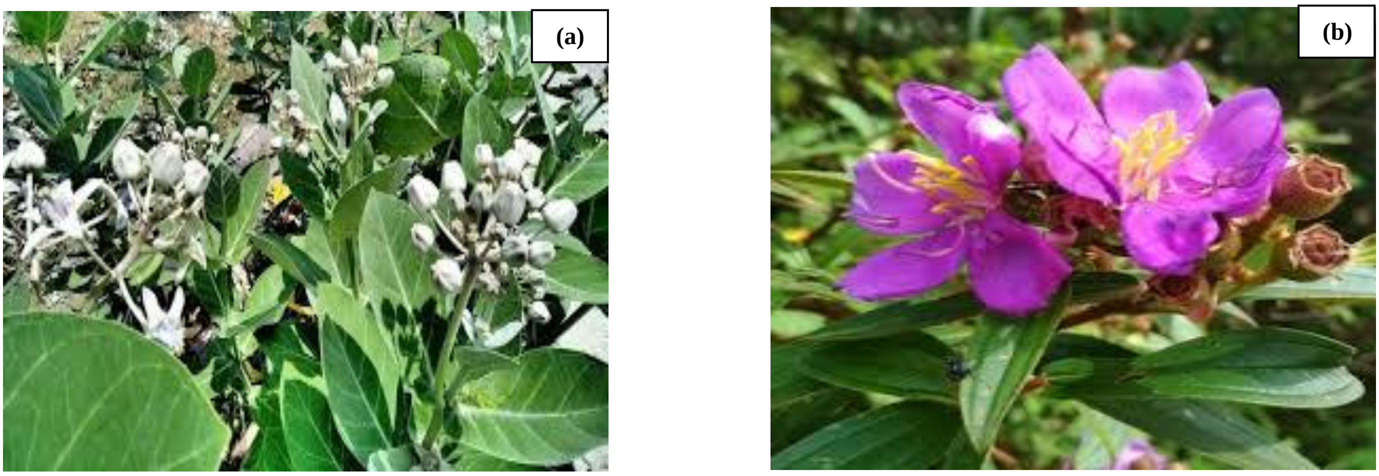


Fig. 1. (a) Rubek (*Calotropisgiganteea*) and (b) temiki(*Melastomacandidum*) as the main material of corrosion inhibitors[17][18].

2.3 Characterization of Extraction

Characterization of materials is carried out by extraction process from temiki and rubek's plants. Making temiki and rubek plant extraction begins with drying the stems, flowers, and leaves (dumped) in the sun. Then, the plant is mashed into powder using a blender. Furthermore, the extraction stage is in the form of the distillation process of rubek's plant extract into liquid form using the Soxhlet extractor 1 tool. Researchers only use the results of extracts that have been carried out in the form of extracts and can be used directly[21]. The extracts of temiki and rubek were analyzed using Gas Chromatography-Mass Spectrometry (GC-MS) QP 2010 Plus-Shimadzu series with DB-5ms column 998847. Density and viscosity are analyzed according to ASTM D 4052 and ASTM D 445[22].

Making inhibitor solutions is done by extracting temiki and rubek using a destinacy. Then, the extractsare placed in a measuring cup until the amount is bythe research plan to be carried out. It is based on the difference in concentration from the percentage of extracts used in the aquadest mixture. The test specimen is cleaned and weighed the initial weight, using a digital balance with an accuracy of up to 0.001gr, this is to obtain preliminary data from the weight of the test specimen. To make an inhibitor solution, the preparation of the container must first be carried out based on the percent concentration of the inhibitor. During the preparation of the solution, a salt meter is used to measure the salt content in the solution according to a predefined method. NaCl 3.5% solution and inhibitor are shown in Fig. 2.

Fig. 2. Preparation of solution: (a) 3.5% NaClsolution, (b) temikiextract, (c) rubek'sextract.

2.4 Weight Loss Testing Procedure

The weight loss testing procedure is carried out using the specimen weight loss method in temiki and rubek's extract solutions. The test steps are carried out after solution preparation and preliminary data collection of the test specimen weight are obtained and the inhibitor concentration solution has been prepared. The test material is then immersed in a container and the pH of the inhibitor solution is measured. The weight loss testing process is presented in Fig. 3.

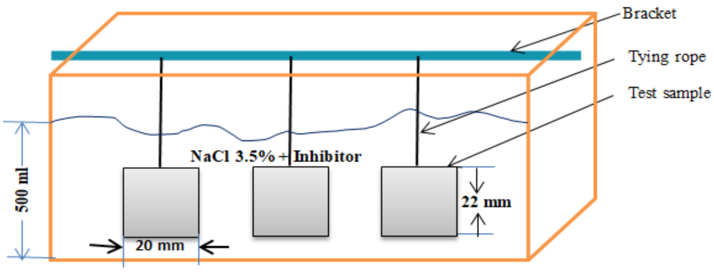


Fig. 3. Weight loss test test design in corrosion inhibitor housing.

Specimens were exposed in a 3.5% NaCl solution using temiki and rubek's inhibitors with concentration variations of 200, 300, 400, and 500 ppm for 15 weeks. Every week specimens are taken weight loss data by cleaning the development of corrosion cell growth, then weighed again to get the value of weight loss from steel due to corrosion attacks which becomes steel weight loss data every week. The cleaning and corrosion rate calculation refers to ASTM G1-03 and the Eq. 1 [19][20][23][24].

$$Corrosion\ Rate = \frac{K \times W}{D \times A \times T} \quad (1)$$

Where:
K = constant(mpy = 3.45×10^6)
W = weight loss(gram)
D = density (gram/cm^3)
A = surface area(cm^2)
T = time (hour)

2.5 Inhibitor Efficiency Calculation

Inhibitor efficiency is the ability of a chemical substance to inhibit or reduce biochemical activity or reactions in a biological or chemical system, to determine the amount of efficiency of using inhibitors in chloride solution, it is necessary to know the value of efficiency using the Eq. 2 [25].

$$E = \frac{X_a - X_b}{X_a} \times 100\% \quad (2)$$

Where:
E=inhibitor efficiency(%)
X_a = corrosion rate without inhibitors
X_b = corrosion rate with inhibitors

3 Results and Discussion

3.1 Extraction Characteristics

Some of the dominant chemical constituents in the extraction have been identified using Gas Chromatography-Mass Spectrometry (GC-MS)[26][27]. Based on the results of the examination, the dominant compound in temiki extract is 5-

Hydroxymethylfurfural with a percentage of 40.72%. This compound plays an active role in inhibiting the growth of corrosion cells[28][29]. Other compound results were obtained such as beta.-d-glucopyranoside, methyl (13.01%), 2-amino-9-(3,4-dihydroxy-5-hydro (12.05%), Hexadecanoic acid, methyl ester (6.36%), 9, 12, 15-Octadecatrienoic acid (6.20%).

Previous research has shown that 5-Hydroxymethylfurfural is the most dominant compound among other compounds as a corrosion inhibitor. This compound can form a protective film on metal surfaces and protect them from corrosion attacks caused by corrosive environments[30][31]. The table of the structure of chemical compounds from temiki extract is presented in Table 1.

In rubek's extract, the compounds obtained include tannins (27.56%), 9, 12, 15-Octadecatrienoic acid (14.12%), Cardenalin (10.84%), and Saponins (10.81%). This plant has a sap good enough to coat metal surfaces[36]. Tannins have been investigated as good and effective corrosion inhibitors for carbon steel, aluminum, and copper in environments that are aggressive to carbon steel [30][37].The table of the structure of chemical compounds from rubek extract is presented in Table 2.

Table 1. The structure of the dominant chemical compound in temiki extract(*Melastomacandidum*)

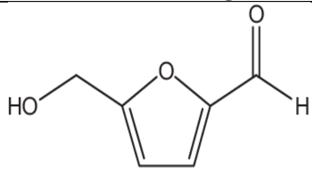
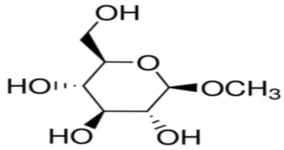
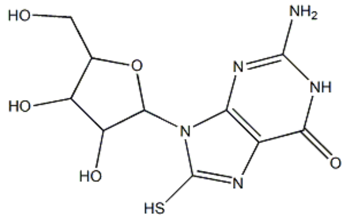
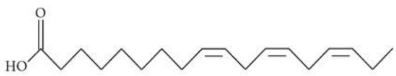
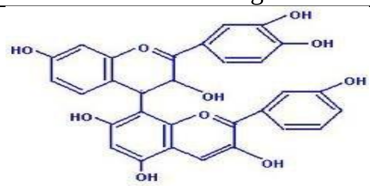
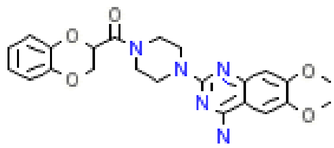
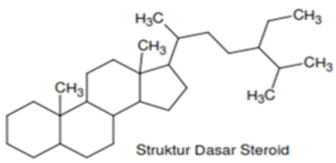
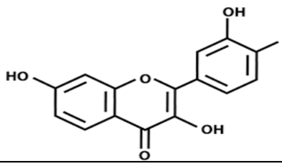
Compound	Ionic bonding
5-Hydroxymethylfurfural [32]	
beta.-D-Glucopyranoside	
Hexadecanoic acid [33]	
Hexadecanoic acid, methyl ester [34]	
9, 12, 15-Octadecatrienoic acid [35]	

Table 2. Structure of chemical compounds dominant in rubek's extract (*Calotropisgiganteea*)

Compound	Ionic bonding
Tanin[36]	
9, 12, 15-Octadecatrienoic acid [35]	
Cardenalin	
Saponin[40]	
Flavonoid[41]	

Based on the results obtained, temiki and rubek extracts can potentially be used as environmentally friendly corrosion inhibitors. This is due to the presence of several chemical elements contained in the extract so that it can form a passive layer on the surface of carbon steel and protect it from corrosion attacks caused by corrosive environments[30][38][39].

3.2 Weight Loss on Carbon Steel

Fig. 4 shows a composite graph of the results of the analysis of the rate of weight loss in steel in temiki extract solution exposed for 15 weeks. The results of the analysis showed that the highest rate of weight loss occurred in week 1 at a concentration of 500 ppm, reaching 1,569 mpy. While the lowest rate of weight loss occurred at week 15 at inhibitor concentrations of 500 ppm, reaching 0.157 mpy. Compared with a 3.5% NaCl solution without inhibitors, it was seen that the rate of weight loss was very significant. In a 3.5% NaCl solution without inhibitors, there is no protection from inhibitors against corrosion attacks on steel[42][43].

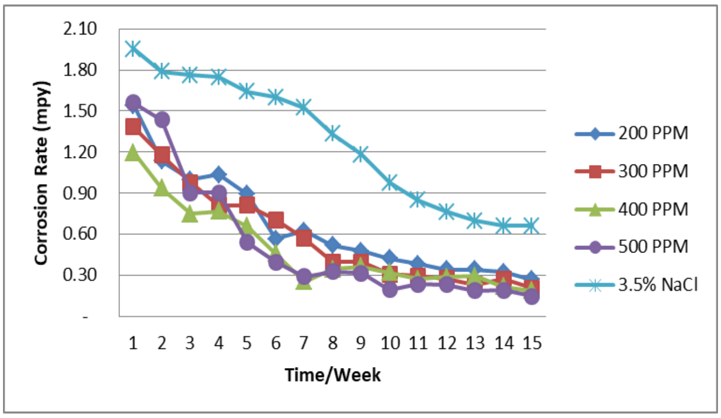


Fig. 4. Weight loss rate graph on carbon steel in solution of temiki extract inhibitor (*Melastomacandidum*).

From the graph in Fig. 4, it can be seen that the effect of concentration and duration of soaking on the difference in weight loss rates in low-carbon steel occurs. this effect leads to protection of the surface from corrosion attack in NaCl solution[36][44].

Fig. 5 is a graph of the effect of collapse corrosion inhibitors in a 500 ml solution on low-carbon steels. The results graph shows the highest rate of weight loss in steel occurred in the first week in inhibitor concentrations of 500 ppm, reaching a weight loss rate of 1,268 mpy. The lowest level of weight loss occurred at inhibitor concentrations of 200 ppm which reached 0.331 mpy. When compared to the weight loss value of steel exposed in a 500 ml solution with a NaCl concentration of 3.5% without inhibitors, it can be seen that the difference in the weight loss rate of steel reaches 1.95 mpy[45][24].

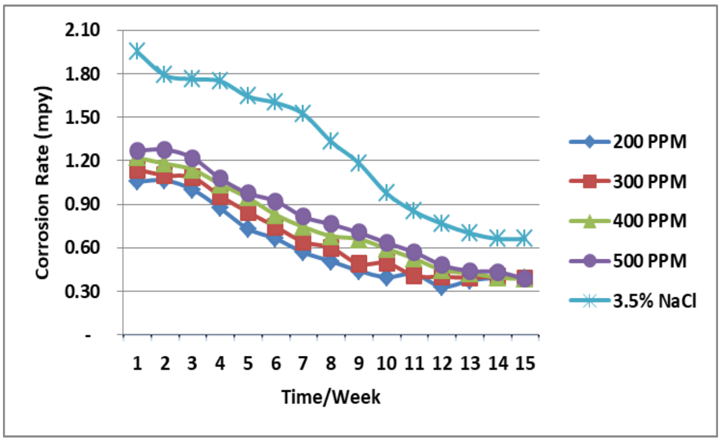


Fig. 5. Weight loss rate graph on carbon steel in solution of rubek's extract inhibitor (*Calotropisgiganteea*).

The results of the analysis show that the presence of inhibitors in the solution can protect carbon steel from corrosion attack by the growth of a passive layer on the steel surface. Inhibition of the rate of corrosion attack on steel in chloride solution is possible due to the presence of compound elements that can form a passive layer on the metal surface, such as tannin compounds[36][44][46].

3.3 Inhibitor Efficiency

In Fig. 6, it can be seen that the efficiency value of the temiki inhibitor (%) in a 500 ml solution containing 3.5% NaCl and added a temiki inhibitor of 200, 300, 400, and 500 ppm is inversely proportional to the corrosion rate. The lower the Corrosion Rate (CR), the higher the efficiency value of the inhibitor that occurs. The highest inhibitor efficiency occurred at a concentration of 400 ppm temiki inhibitor with an efficiency of 82.89%. The lowest inhibitor efficiency occurs at the concentration of 500 ppm temiki inhibitor with efficiency reaching 19.55%.

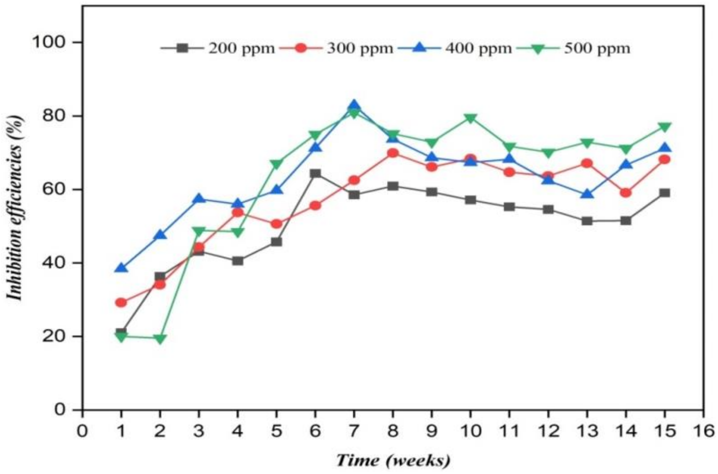


Fig. 6. The value of the efficiency of the temiki inhibitor (*Melastomacandidum*) on the corrosion rate of steel by weightloss method.

In Fig. 7, it can be seen the effect of the inhibitor efficiency value on a solution of 500 ml aquades containing 3.5% NaCl and rubek's inhibitors as much as 200, 300, 400, and 500 ppm as inhibitors of corrosive cell growth. From the results of the analysis, the highest efficiency value of 62.71% was obtained, occurring at an inhibitor concentration of 200 ppm. As for the lowest efficiency of 28.40%, it occurs at inhibitor concentrations of 500 ppm.

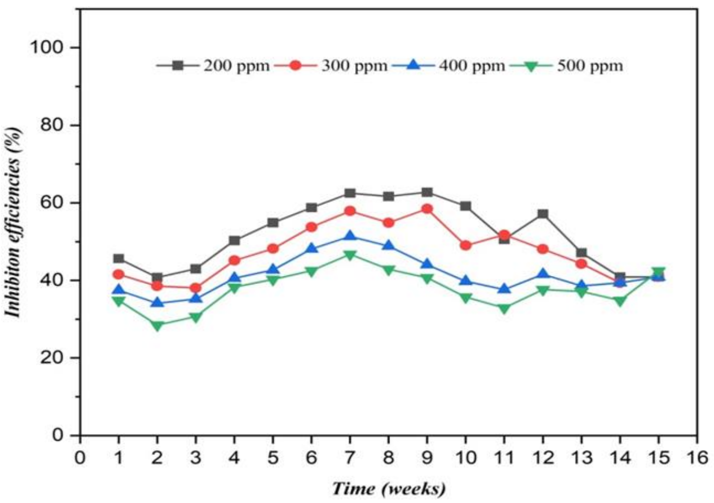


Fig. 7. The efficiency level of the rubek's inhibitor (*Calotropisgiganteea*) in solution to the corrosion rate of steel by the weight loss method.

The activeness of inhibitors in the corrosion prevention process indicates the absorption process of phytochemical active compounds in the form of flavonoids and tannins on the surface of carbon steel [47]. Furthermore, the high efficiency of inhibitor use indicates that there is an effective interaction between active molecular cells in direct contact with the carbon steel surface. This can protect metal surfaces from direct contact interaction with corrosive environments[23][48].

4 Conclusion

From the results of the analysis, it can be concluded that there is an influence of temiki and rubek's inhibitors on actively blocking the corrosion rate in the solution by forming a protective layer on the steel surface. The results of the research analysis showed that the highest corrosion rate occurred in rubek's extract inhibitors at concentrations of 500 ppm reaching 1,268 mpy, while the lowest occurred in inhibitors of 200 ppm reaching 0.331 mpy. The highest inhibitor efficiency level occurred in temiki inhibitors with a concentration of 400 ppm, achieving an efficiency of 82.89%. While the lowest inhibitor efficiency occurs at a concentration of 500 ppm, achieving an efficiency of 19.55%. As for rubek's extract, the highest value was obtained at 62.71% at a concentration of 200 ppm,The he lowest efficiency was 28.40% at a concentration of 500 ppm. These results show that temiki and rubek's extracts can function well as corrosion inhibitors in low-carbon steels in NaCl solution.

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