WCEJ

WORLD CHEMICAL ENGINEERING JOURNAL

Journal homepage: http://jurnal.untirta.ac.id/index.php/WCEJ

Rice Husk Extract and Damar Resin as Corrosion Preventing Bio Coating Materials for Mild Steel in NaOH Solution

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ARTICLE HISTORY

Received 14 June 2022
Received in revised form 18 June 2022
Accepted 20 June 2022
Available online 25 June 2022

ABSTRACT

Corrosion is damage due to chemical reactions between metals or metal alloys with their environment. The use of coatings can reduce the rate of corrosion, but it is constrained by stability for a long time, so it is necessary to try other protections against mild steel that can cover the metal with a coating material. This research focuses on mild steel's bio coating expertise using 1M NaOH corrosive media using natural ingredients of rice husk extract and dammar resin. Rice husk and resin are plants that can be used as bio coating materials. Rice husk extract contains several compounds that can be used to inhibit the corrosion rate, one of which is silica. In contrast, dammar resin is a natural polymer with flexible and stable properties that can prevent corrosion. This study aimed to determine the effect of the components of the bio coating material (rice husk extract and dammar resin) on the ability to protect mild steel from 1M NaOH corrosive media by calculating the corrosion rate and efficiency of the bio coating material. There are five stages in the research: the sample preparation stage, the stage of making latex solutions, the stage of making bio coating products, the stage of metal coating with bio coating materials, and the inhibition efficiency testing phase. The method used is the weight loss method to determine the rate of corrosion formed. This study obtained the highest inhibition efficiency (IE%) of 83.23% at a bio coating concentration of 1500 ppm, with a temperature of 40˚C, and an immersion time of 1 hour.

Keywords: *dammar resin, rice husk extract, bio coating, corrosion, mild steel*

1. INTRODUCTION

Corrosion is damage due to chemical reactions between metals or metal alloys and their environment. This corrosion can lead to a decrease in the quality of low-carbon steel, causing the steel to deteriorate more quickly. One method to minimize corrosion is to use a coating. The coating is a process of coating a base material which aims to protect the material from corrosion and provide protection to the material. The coating can also be interpreted to slow down the corrosion rate. The coating also protects metal materials from electrochemical reactions with the surrounding environment, especially for very moist surfaces containing a lot of water vapour. (Leppaniemi et al.,2018).

According to the primary material of manufacture, corrosion coatings can be divided into two types, namely coatings made of inorganic and organic materials. Natural polymers can form a coating. Bio coating is a corrosion coating derived from raw materials available in nature. Some plants that can be used as bio-inhibitors include tea leaves, guava leaves, soybeans, coffee, rice husks, and *Terminalia catappa* leaves. In this research, the focus is on rice husks. Natural coatings have non-toxic properties, are cheap, easy to obtain and can be renewed (El-haddad et al.,2019). Bio coating is usually designed as a film formation, protecting the metal by forming a hydrophobic layer/film on the metal surface (Roberge, 2000).

Rice husk (rice husk/rice hull) is the outermost part of the rice grain and contains much silica compared to other rice processing by-products. The by-products of rice processing include straw (4.0±7.0)%, bran (0.6±1.1)%, bran (0.2±0.3)% and husk (18.0±22)% (Ola,2015). Rice husk

waste can be used to produce coatings for metal materials. Registered that the content of rice husk waste contains a lot of compounds that can be used to inhibit the corrosion rate, and silica which produces the highest compound is one of its contents (Pramudita et al.,2018). Silica is one of the organic compounds that have the potential as a corrosion coating. Silicate (SiO_2) has good adhesion, a medium for good protection. It is possible to resist the diffusion of water vapour, ions, and oxygen to the metal surface to protect the metal from corrosion (Jayakumar et al.,2019).

The use of rice husk extract (RHE) has previously been widely used as a medium for preventing the corrosion rate. It concluded that the silica with the dip-coating technique at the variable concentration of water glass was 3.6%, the concentration of the TMCS solution was 1.5 M, and the modification time was 13 hours, which resulted in hydrophobic glass with the most significant contact angle obtained at 118˚C. But behind all the advantages, silica also has brittle and unstable disadvantages (Rochmat et al 2017).

Research on bio coating of rice husk extract has previously been carried out on mild steel. It was found that the effect of silica produced by rice husk as a corrosion bio coating medium can inhibit the corrosion rate significantly (Jayakumar et al.,2019).

Resin is a natural polymer which is very flexible, stable, and easy to obtain. Resin is also a raw material widely used for coating media. The use of latex as a coating material has also been widely proven that resin can be used as a varnish coating on building wood (Fitrida et al 2015). Resin can protect against weathering (corrosion).

This study aims to determine the ability of the bio coating material of rice husk extract and damar resin using the weight loss method with 1M NaOH as a corrosive medium on mild steel.

2. METHODS

2.1 Sample Preparation

The material used in this research is mild steel. The mild steel used had the following composition (wt%): 0,16C,01P, 0,01S,05Si, 0,54Mn and remaining portion was Fe. Then the mild steel is cut with a thickness of 3.09 mm and mild steel dimensions of 29.79 x 19.23 mm using a grinding machine. Then the mild steel is smoothed using abrasive paper (sandpaper). Then the mild steel was washed with acetone (Merck 70%). Next, the mild steel is dried and continued with the initial weighing.

2.2 The Process of Damar Resin Solution Preparation

In making resin solution, the resin is crushed using a mortar and then sieved using an 80-mesh sieve at the initial stage. After that, it is dissolved into a beaker and then dissolved using n-hexane solvent (SigmaAldrich 95%) in a ratio of 1: 2, where 1 is the damar resin. And 2 is the solvent. Then stirred until the resin becomes homogeneous.

2.3 Bio coating Product Manufacturing Process

In making bio coating products, the initial stage is mixed with sodium silicate. Sodium silicate was blinded by dissolving silica from RHE with NaOH solution (Pellets pure Emplura®) at 40°C. The resulting resin solution into a beaker with a ratio of 1:3, where 1 is the resin and 3 is the sodium silicate. Then stirred until a homogeneous product mixture is formed.

2.4 Metal Coating Process with Bio coating Material

In the metal coating process using silica, previously, the dried metal was given a rope as a metal binder to facilitate the immersion process, and then the metal was coated with bio coating material using a beaker with a concentration of 500, 1000, 1500 ppm, after that input metal into the glass, then removed and dried for weighing as mass data after being coated with bio coating

2.5 Inhibition Efficiency Testing Process

In testing the inhibition efficiency, metal samples that have been coated with a bio coating will be immersed for 1, 2, and 3 hours using a one molar concentration of sodium hydroxide using temperatures of 40˚C, 60˚C, and 60˚C. Then the mild steel was dried, after which the mild steel was weighed again after testing.

2.6 Weight-Loss Method

Weight loss, better known as the weight reduction method, is used to determine the magnitude of the corrosion rate (mmpy) on a material based on the reduction in initial and final weight and determine the efficiency of corrosion inhibition. The weight-loss method was used to collect data and calculate the corrosion rate. The data were obtained from weighing the initial sample of mild steel smoothed and the final sample of mild steel immersed in water. The corrosion rate can be calculated using the following equation (ASTM31):

$$\text{Cr (mmpy)} = \frac{(87500 \text{ x } \Delta W)}{\text{A.}\rho\text{.t}} \qquad (1)$$

$$I.E\ \% = \left(1 - \frac{Cr_{inh}}{Cr_{blank}}\right) x\ 100 \qquad (2)$$

Where:
Cr = Corrosion rate (mmpy)
Cr_{inh} = Corrosion rate with inhibitor (mmpy)
Cr_{blank} = Corrosion rate without inhibitor (mmpy)
ΔW = Weight loss (g)
A = Surface area (cm^2)
ρ = Density of mild steel (g/cm^3)
t = Immersion time (hr)
I.E = Inhibition efficiency (%)

3. RESULT AND DISCUSSION

3.1 The Effect of Corrosion Rate on The Addition of Silica Concentration

This study used a mild steel sample measuring 29.79 mm x 19.23 mm x 3.09 mm in a rectangular shape to test the

corrosion rate. Corrosion rate and efficiency can be calculated using the weight-loss method, where the test is carried out with a corrosive media solution in the form of 1 m NaOH. This research was conducted with various bio coating extracts of rice husks and resin of 500 ppm, 1000 ppm, and 1500 ppm with variations in temperature 40˚C, 60˚C, and 80ºC, with immersion times of 1 hour, 2 hours, and 3 hours. The results of immersion from variations in time, temperature, and concentration of bio coating extracts of rice husk and resin can reduce the weight of mild steel in the corrosion testing process. The data obtained from the research results can be seen in table 1.

Table 1. Corrosion inhibition data

Time immersion (hours)	Temperature ^{0}C	Corrosion Inhibition (mmpy) Concentration (ppm)		
		500	1000	1500
1	40	0.2728	0.2113	0.0883
2		0.3977	0.3400	0.3266
3		0.5417	0.5276	0.5187
1	60	0.3727	0.2881	0.2382
2		0.4822	0.4534	0.4418
3		0.6903	0.6570	0.6353
1	80	0.7149	0.5340	0.4649
2		0.7319	0.5879	0.5802
3		0.7902	0.7377	0.7095

The overall results show that the highest corrosion rate is 0.7902 mmpy with a concentration of 500 ppm, a temperature of 80˚C, and immersion for 3 hours, while the lowest corrosion rate is 0.0883 mmpy with a concentration of 1500 ppm, a temperature of 40˚C, and 1-hour immersion. It showed that the variation of immersion time, temperature, and concentration of bio coating would affect the value of the resulting corrosion rate.

3.2 Effect of Immersion Time vs Concentration on Corrosion Rate

Overall, the most significant corrosion rate value was at 3 hours of immersion at a temperature of 80˚C, and the lowest corrosion rate was at an immersion time of 1 hour with a temperature of 40˚C. It showed an increase in the value of the corrosion rate along with the immersion time and high temperature. The increase in the value of the corrosion rate can be seen in figure 1.

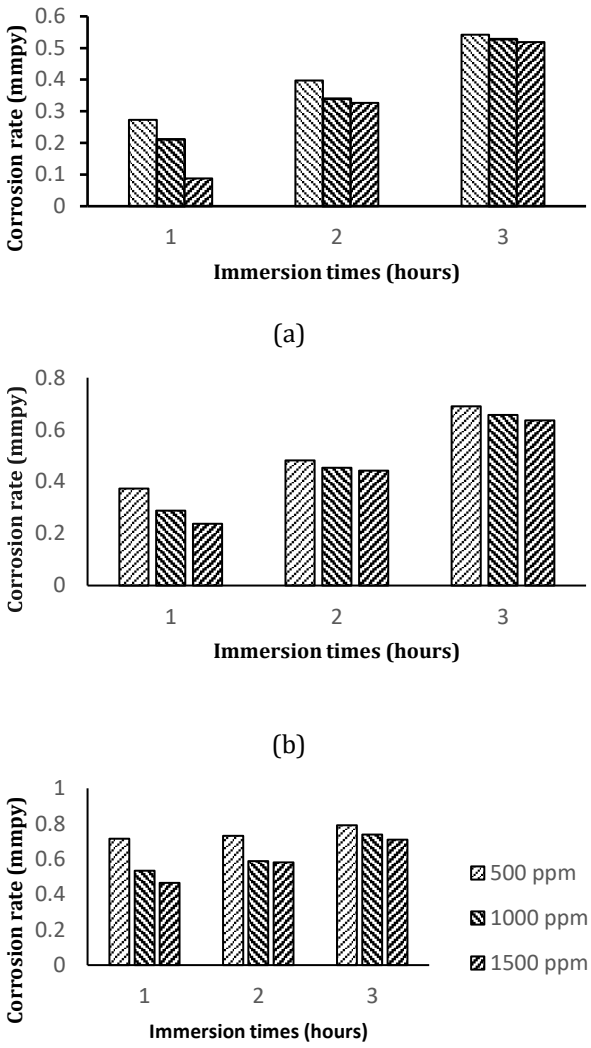

Fig.1. Effect of immersion times vs concentration on corrosion rate. (a) 40ºC (b) 60ºC (c) 80ºC

The corrosion rate increases with the length of immersion time, temperature and concentration of the bio coating used. The higher the concentration of the bio coating, the lower the temperature, and the longer the immersion time, the lower the value of the corrosion rate along with the increasing amount of silica contained, forming complex compounds with corrosive substances and covering the surface of mild steel so that the corrosion process is increasingly inhibited (Pramudita et al 2019).

The results of this study indicate a decrease in the corrosion rate when the concentration increases, the immersion time is not long, and the use of low temperatures. Following the theory, the increasing temperature, length of immersion time, and low concentration will cause the corrosion reaction speed. Due to the addition of the reacting particles' kinetic energy, the corrosive media solution's temperature exceeds the activation energy's magnitude. The corrosion rate is higher if the kinetic value exceeds the activation energy (Monticelli 2018).

The results of this study indicate that the durability of rice husk extract and damar resin solution mixed into a homogeneous solution can protect mild steel from corrosion in 1 molar NaOH solution is an immersion time of 1 hour at

a temperature of 40˚C.

The lowest value of the average corrosion rate obtained using bio coating with a concentration of 1500 Ppm, a temperature of 40˚C, and an immersion time of 1 hour was 0.0883. And the highest average corrosion rate was obtained in the sample (mild steel) with a concentration of 500 Ppm and a temperature of 80˚C. And 3 hours immersion time of 0.7095 mmpy.

3.3. Effect of Silica Concentration and Damar Resin Solution on Corrosion Rate

The effect of concentration on the corrosion rate indicates a corrosion inhibitory effect due to the concentration of bio coating of rice husk extract and resin solution. It is caused by the adsorption of the bio coating on the electrodes on the mild steel surface. The high concentration of bio coating indicates that the silica and resin content can inhibit the reduction of hydrogen ions in the cathodic part of mild steel (Dian et al.,2016).

Silica from rice husks has adhesive power, and the mixed damar resin solution has elastic properties and adheres to a homogeneous solution that reacts with NaOH solution, will show the formation of a protective layer that covers the surface of the mild steel electrode where the coating will form a film so that it can inhibit the corrosion process. Then, water molecules and other ions are adsorbed on the surface of the mild steel and transferred to the silica and damar resin, which has become a homogeneous solution. The thickness of this protective layer increases with increasing silica concentration in rice husk extract because more silica is electrostatically adsorbed on mild steel, which decreases capacitance value. So, a barrier layer that can form on the surface of mild steel in variations of immersion time, temperature, and concentration of bio coating can prevent the mild steel from corrosion (Pramudita et al.,2019).

3.4. The Effect of Corrosion Efficiency on the Addition of Silica Concentrations in Bio coating Damar Resin and RHE

The corrosion rate of a material per unit time is the corrosion rate. This corrosion rate value can be used to calculate the efficiency value of the bio coating. The efficiency value shows the bio-coating's ability of the bio coating to inhibit the corrosion rate of the sample on the corrosive medium. In this study, the weight loss method was used to determine the value of efficiency and the corrosion rate (CR) value. The efficiency value shows the ability to inhibit the corrosion rate. The following is the data from the calculation of the inhibition efficiency in table 2 using the weight loss method.

Table 2. Efficiency Inhibition Data

Time immersion (hours)	Temperature °C	Inhibition Efficiency (%) Concentration (ppm)		
		500	1000	1500
1	40	46.81	57.15	83.23
2		29.99	40.13	42.49
3		35.40	39.78	42.42
1	60	58.47	66.57	72.30
2		51.15	54.11	55.28
3		20.93	24.75	27.25
1	80	61.80	72.63	75.87
2		44.06	56.59	57.43
3		25.92	31.01	33.32

Table 2 the value of inhibition efficiency (%IE) produced from the bio coating of rice husk extract and resin increased with increasing concentration of bio coating. The best results are a 1500 ppm concentration, an hour's immersion time, and a temperature of 40˚C, which is 83.23%, while the lowest inhibitor efficiency results are at a concentration of 500 ppm with an immersion time of 3 hours and a temperature of 80˚C by 25.92%. Similar to the corrosion rate test, the immersion time, temperature variation, and concentration of bio coating will affect the value of the resulting inhibition efficiency. However, the efficiency value is inversely proportional to the corrosion rate value. It follows the literature because when the sample uses the added concentration, the temperature and immersion time is reduced, and the greater the value of the inhibition efficiency (Sisso et al.,2020). It is because there is inhibition by the bio coating against aggressive ion attack in the corrosive media. The barrier was further increased with an increasing degree of closure by the added bio coating (Zhang et al.,2018).

In table 2, it can be seen that the efficiency of bio coating at 1 hour has the best value compared to 2 hours and 3 hours, so there will be a corrosion process and more weight reduction due to reacting with one molar NaOH solution. It is because the passivation layer formed can only last for a particular time and begins to disappear so that an active layer will be created, which causes the corrosion process to take place (Chauhan et al.,2021). The smaller the concentration added and the longer the time and temperature used, the layer formed will be eroded little by little because the oxidation event will continue to occur, even if it doesn't stop attacking mild steel. In addition, the efficiency value obtained in this study did not reach 100%. It could be because not all mild steel parts were inhibited by bio coating. It indicates that there are still parts that are affected by oxidation or the process of rusting (Fateh et al.,2020).

The coating method protects mild steel from corrosive media, namely as a barrier effect that functions as a separator or isolates the surface from water and the oxygen inhibitor effect which functions to form a passive layer. The mechanism for protecting mild steel with bio coating is that

the bio coating protects mild steel only on its surface from the corrosive medium of 1 molar NaOH. When mild steel is in contact with its corrosive medium, a bio coating layer protects the mild steel by forming a layer that can separate and hinder or isolate the metal surface with the corrosive medium (Mukherjee et al.,2019).

4. CONCLUSION

1. The lowest corrosion rate was obtained at the addition of 1500 ppm concentration, an immersion time of 1 hour and a temperature of 40˚C.
2. The durability (durability) of rice husk extract and resin solution mixed into a homogeneous solution can protect mild steel from corrosion in 1 molar NaOH solution, which is 1 hour immersion time at 40˚C.
3. The faster the corrosion rate is indicated, the higher the corrosion rate. The highest corrosion rate occurred at a temperature of 80˚C and a time of 3 hours with a corrosion rate of 0.7902 mmpy.
4. The most excellent inhibition efficiency was obtained at the addition of a 1500 ppm bio coating concentration of 83.23% with an immersion time of 1 hour and a temperature of 40˚C.

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