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Bio Coating Based on Damar Resin on Mild Steel in Corosive Media (Acid Effect) by Using Silica from Rice Husk Extract

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Abstract

Bio coating is a natural anti-corrosion material that can be easily degraded and renewed. Rice husk extract and damar resin are alternative natural materials that are believed to have a relatively high silica content, so they can be used as a substitute for synthetic chemicals to protect metals from corrosion. This research was conducted to determine the bio-coating ability of mild steel in H2SO4 corrosive media. The object of the experiment used rice husk waste and damar resin as the primary raw materials. The analytical method used is the weight loss method. The resin sap and silica sol obtained from the ashing of rice husks are mixed to form a homogeneous product. Metal samples coated with bio-coating material are immersed in 0.5 M sulfuric acid solution, with variations in silica concentrations of 500, 1000, 1500 ppm, 1, 2, and 3 hours, and at temperatures of 40, 60, and 80°C, which is then tested for the ability of the bio coating material. The results show that the higher the temperature and the longer the immersion time, the corrosion rate on the metal increases. The variation of the 1500 ppm silica concentration shows better efficiency results than other concentrations at a temperature of 40°C for an immersion time of 1 hour.

Keywords: bio coating, silica, damar, corrosion

INTRODUCTION

Corrosion is a form of metal degradation or damage that occurs to metals due to redox reactions between metals and several compounds that exist in the environment. The wide use of various types of metal materials, such as mild steel, and almost all industrial equipment, especially pipelines, cooling systems, refinery units, boilers, water processing, and so on, makes corrosion a significant and common problem. Corrosion cannot be stopped, but its formation can be inhibited. Various easy ways can be done to reduce the corrosion rate, one of which is by using a protective material in the form of a coating or coating.

In general, the essential ingredients for coating materials used in industry are synthetic chemical compounds, which are used in the long term and will harm the environment and the health of living things. In addition, the coating material can also enter the fluid flow and affect the characteristics of the fluid used in the industry. So, in this case, alternative materials are needed for coating materials from nature or bio coatings that can protect metals from corrosion while being friendly and safe for the environment.

Bio coating is a coating material that can be easily degraded and renewable. Rice husk extract and damar resin are alternative natural materials that can substitute synthetic chemicals to protect metals from corrosion. Damar resin is a natural polymer that can provide protection not only in the form of a thin layer that adheres and is resistant to corrosive substances but also has hydrophobic properties that can retain water(G Moodley, 2019). Silicates (in sodium silicates) with a high ratio of silica to alkali metal oxides are suitable as coating binders(Parashar et al., 2003). The utilization of rice husk extract, rich in silica content, and damar resin, which has strong adhesion and has a high potential value in coating and protecting metal materials from corrosion, is a good choice for the utilization of agricultural waste, still sufficiently abundant and little in demand (Le et al., 2021).

Research on the manufacture of bio-coating has been carried out using coffee, tea, and tobacco as bio-coating materials additives in paint. Extracts of natural ingredients like polyphenol and flavonoid compounds are efficient materials to inhibit corrosion(Septiari & Supomo, 2013).

Other research on bio-coating has also been carried out, namely using lemon seeds as a primary material for bio-coating materials to slow down the corrosion rate of mild steel in acidic media, namely HCl using electrochemical methods. Based on the results of this study, it is known that lemon seed molecules have properties that can be used as natural coating materials that are safe for the environment and are very good for corrosion protection on mild steel in HCl solution (Pal et al., 2020).

Chitosan nanocomposites can potentially be used as a bio-coating base material that can prevent the corrosion of copper using electrochemical methods. The efficiency of chitosan nano's ability to inhibit corrosion reaches 85%. This case study shows that natural materials such as chitosan can be a protective layer against copper corrosion, so it is crucial to carry out further research to develop a protective layer for the corrosion of metals (Bahari et al., 2020).

Thus, the test results on bio-coating materials are also expected to be used as a form of utilization of waste or commonly known as waste treatment, especially in agricultural waste. Such as rice husks which are considered to be of no value but are believed to have a high enough silica content so that they have potential. To be used as a metal coating or bio coating to protect metal materials from corrosion.

This study aimed to determine the effect of adding silica from rice husk extract on damar resin-based bio-coating material on its ability to protect mild steel from 0.5M H_2SO_4 corrosive media.

METHOD

This research was carried out in several stages. The preparation of mild steel is the stage of making silica and latex solutions, bio-coating materials, coating mild steel with bio-coating, testing the inhibition efficiency and measuring the corrosion rate using the Weight Loss method.

Mild steel preparation

The initial procedure that needs to be carried out in the preparation of mild steel is to cut mild steel with dimensions of 20 x 30 x 1 mm, then sanded using a grinder, then washed with distilled water for 15 minutes and then rinse with acetone solution. Mild steel that has been washed is then dried and ready to be used for the next stage.

Preparation of Silica Solution and Damar Resin Solution

In the process of making silica solution, the thing that needs to be done is to weigh 3 g of silica powder and then dissolve it in 1000 mL of 1 M NaOH solution at a temperature of 200°C until homogeneous. This homogeneous solution is referred to as the mother liquor, which will then be diluted again with 1 M NaOH solution to obtain three silica solutions with different concentrations, namely 500, 1000 and 1500 ppm. In making a damar resin solution, 25 g of damar resin is dissolved with 100 mL hexane in a beaker at 40°C while stirring until the latex solution becomes homogeneous.

Manufacturing of Bio Coating Materials

The process of making bio-coating products is done by mixing each of the 20 mL silica solution and 80 mL damar resin solutions obtained into a beaker and then stirring until a homogeneous product mixture is formed.

Metal with Bio Coating Material

The method used to coat the surface of mild steel is dip coating. In the process of coating metal with silica sol and damar resin, the dried metal will be covered with a coating material in a beaker after being given a rope at the end of the metal to facilitate immersion for some hours and different temperature. The metal is then removed and dried for further weighing as the initial mass data for the metal as shown in **Figure 1.**

Bio-coating testing.

The testing process was carried out using a water bath with temperature variations for 303K, 323K and 343K. The concentration of silica used was 500, 1000 and 1500 ppm, while the immersion time was 1, 2 and 3 hours. In this process, mild steel that has been coated will be immersed in 0.5 M of sulfuric acid.

Weight-Loss Method

The weight reduction method is based on the difference in the weight of mild steel before being immersed in a corrosive medium (sulfuric acid) and after. This weight difference will be calculated using equation 1 to calculate the corrosion rate.

Calculation of Corrosion Rate

To calculate the corrosion rate, equation 1. Where Cr is the corrosion rate (mmpy), ΔW is the difference between the initial weight and the final weight (g), is the density of mild steel (g/cm3), and t is the difference in immersion time (h).

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

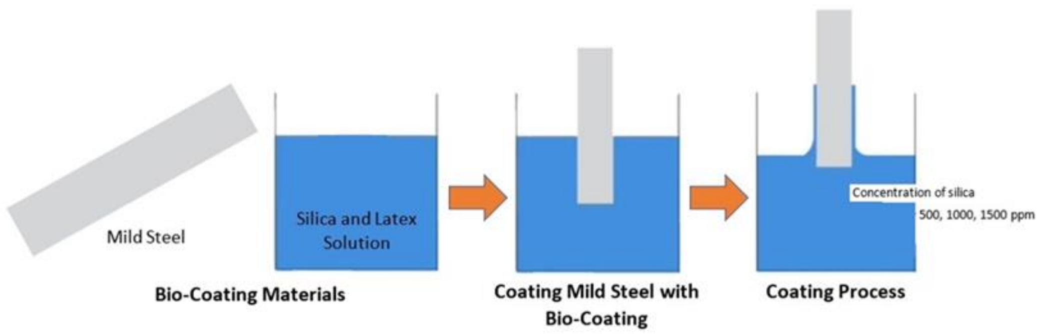

Figure 1. Dip-coating for improving corrosions resistance for mild steel in silica and Latex Solution

RESULT AND DISCUSSION

Effect of Addition of Silica Concentration and Immersion Time on Corrosion Rate.

The corrosion rate effect on the addition of silica concentration and immersion time at a temperature of 40°C is shown in Figure 1. The concentration of the ppm bio coating dam is presented on the corrosion rate in mmpy. The corrosion rate concerning the addition of silica concentration and immersion time varied 1, 2, and 3 hours at significant bio-coating concentrations of 500, 1000 and 1500 ppm. The beam image shows that the higher the concentration of silica added to the bio-coating media, the corrosion rate that occurs on the mild steel surface is lower at concentrations of 500 and 1500 ppm, while at 1000 ppm, the corrosion rate decrease is quite gentle. It shows that increasing silica content as a bio-coating medium can increase the protection of mild steel from the effects of corrosion on corrosive media in the form of 0.5 M sulfuric acid.

It is increasing the immersion time of the corrosion layer getting thicker and denser (Nabipour et al., 2020). Moreover, electrochemical measurements show that the corrosion layer and power transfer resistance increase with increasing immersion time (Febriyanti et al., 2017). In addition, with increasing immersion time, the corrosion rate tends to decrease due to passivation, namely the formation of corrosion products on the surface. It results in ions that can cause corrosion to be blocked by rust deposits on the metal surface (Gergely, 2018). However, in the process of immersing mild steel with a corrosive medium in sulfuric acid, a reaction such as equation 2.

$$H_2SO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(s)} + H_{2(g)} \quad (2)$$

The $FeSO_4$ layer will stick to the carbon steel surface and form a protective layer against further corrosion. However, the reaction for the formation of hydrogen gas which is relatively fast in the form of gas bubbles, causes the protective layer that has been formed on the metal surface to move to the bulk liquid phase (le Saché & Reina, 2022). It causes the corrosion rate in this sulfuric acid solution to continue to increase as the immersion time increases.

At a temperature of 60°C, the corrosion rate calculation for adding silica concentration and immersion time is similar to the comparison results at the previous 40°C. Increasing the silica concentration at a temperature of 60°C also shows a significant decrease in the corrosion rate (mmpy) along with adding silica concentration in the bio-coating medium. However, compared with the previous graph in Figure 2, the overall corrosion rate at 60°C is higher than at 40°C. However, the quality of the bio coating in protecting metal from corrosion is still rated "Extraordinarily Good" because it is still in the corrosion rate range of less than one mpy (Umoren et al., 2022). The effect of immersion time at concentrations of 500, 1000, and 1500 ppm also decreased the corrosion rate with increasing immersion time. It happens because of the reaction of hydrogen gas formation on the metal surface, which causes the protective layer formed on the metal surface to decrease (Songok et al., 2012). The number of hydrogen gas bubbles will be more formed along with the corrosion formation reaction.

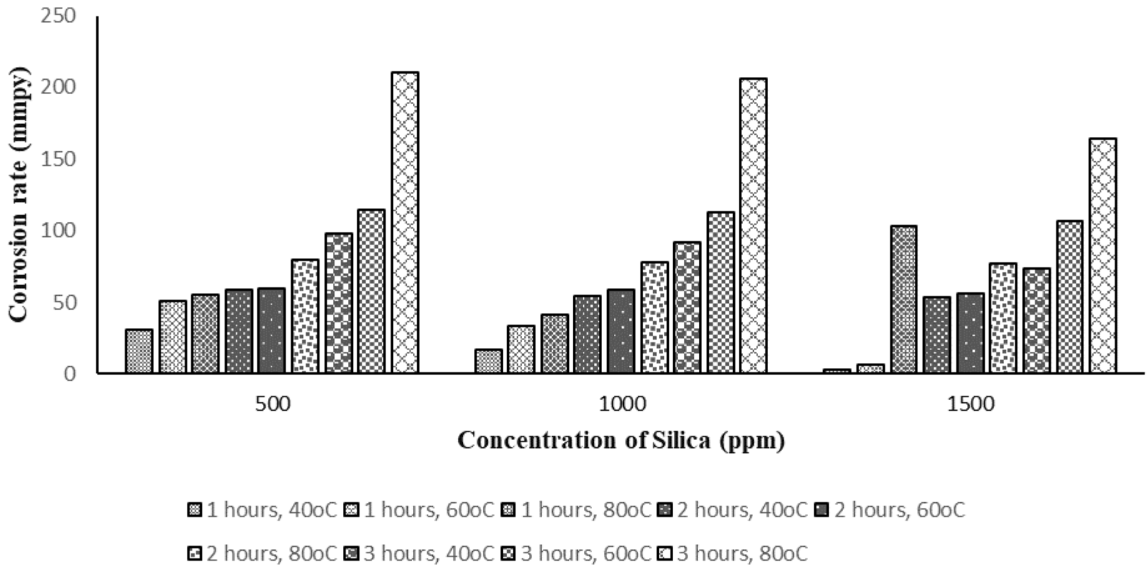

Figure 2. Effect of corrosion rate on the addition of silica concentration and immersion time at various temperatures

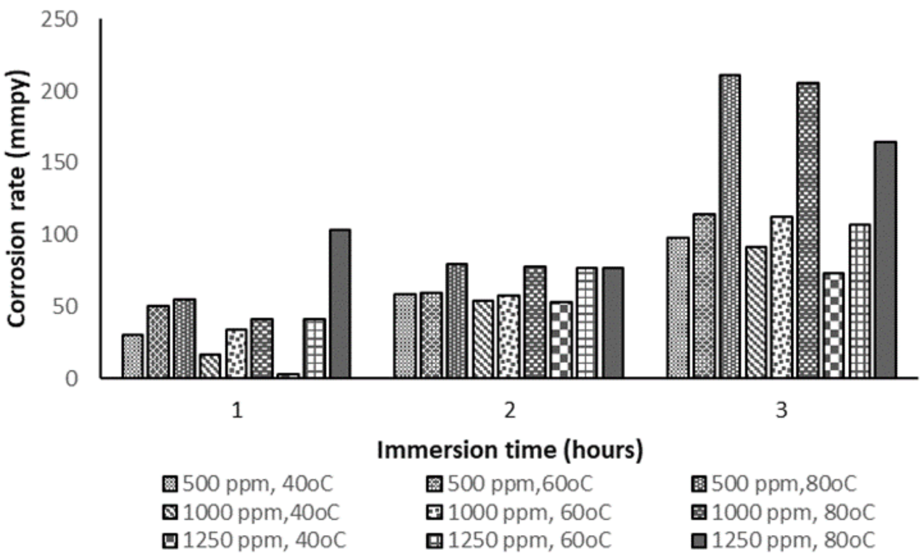

Figure 3. Effect of corrosion rate on the addition of silica concentration and immersion temperature

At a temperature of 80°C, increasing the concentration of silica in the bio-coating media can also reduce the corrosion rate of metals. In addition, the effect of immersion time on the corrosion rate also shows the same results as before.

It indicates that the bio-coating used in this study is considered capable of inhibiting the corrosion of metals in acidic media if the silica content of the bio-coating is increased. However, protection by bio-coating still needs to show better results if the metal is immersed in a corrosive medium such as sulfuric acid for a long time because this will increase the metal's corrosion rate significantly (Pu et al., 2021).

Effect of Addition of Silica Concentration and Immersion Temperature on Corrosion Rate

Determining the immersion time of temperature effect on the corrosion rate was conducted by varying the immersion temperature by 40°C, 60°C, and 80°C. Figure 3 presents a comparison graph of the corrosion rate's effect on adding silica concentration and immersion temperature.

The corrosion rate produced at a temperature of 40oC is lower than at 60°C and 80°C. The condition of the corrosion media solution at a temperature of 80°C resulted in a higher corrosion rate than at other temperatures. Temperature is one of the factors that can trigger the corrosion process. The temperature increase will increase the corrosion reaction's speed (Pramudita et al., 2022). It happens because the increase in temperature in the corrosion media solution will increase the kinetic energy of the particles so that it will exceed the activation energy. When the kinetic energy is greater than the activation energy, it will increase the corrosion rate (Al-Sawaad et al., 2016). The corrosion rate decreased with increasing temperature, indicating that the protective mechanism provided by the bio-coating is physical adsorption (Gou et al., 2021).

The corrosion rate of silica with a concentration of 1500 ppm is lower than that of silica. The silica has a range concentration from 500 to 1000 ppm. It shows that the higher concentration of the bio-coating solution will increase the ability of the silica content to protect mild steel from the effects of corrosion. However, a concentration of 1500 ppm silica at a temperature of 80°C shows a discrepancy where the corrosion rate is relatively high. The corrosion rate of mild steel that has been coated with a bio-coating material shows lower results than the corrosion rate of mild steel that has not been coated with a bio-coating material (Jayakumar et al., 2019).

Based on the graph presented in Figure 2, it can be seen that temperature has an influence that is directly proportional to the corrosion rate. The higher the temperature in the 0.5 M H_2SO_4 solution, the higher the corrosion rate. Vice versa, the lower the temperature, the lower the corrosion rate. It occurs because an increase in temperature directly leads to an increased corrosion rate. After all, electrochemical reactions generally occur faster at higher temperatures (Ibrahim et al., 2021). An increase in temperature will increase the energy for the reaction, thereby increasing the corrosion rate (Williams et al., 2019).

Figure 2 shows the effect of concentration inversely proportional to the corrosion rate, where the higher the silica concentration, the lower the corrosion rate that occurs on the mild steel surface. The lowest corrosion rate is found at a temperature of 40oC when the silica concentration is 1500 ppm, which is 53,475 mmpy. The high silica concentration will increase the bio-coating material's ability to protect the mild steel surface from corrosion due to 0.5 M sulfuric acid. The lowest corrosion rate occurs when the temperature of the corrosive media solution is 40°C, and the silica concentration is 1500 ppm. High temperatures will increase the energy for the reaction, thereby increasing the corrosion rate that occurs in mild steel (Al-Amiery et al., 2022). The higher the concentration will increase the ability of the bio coating to protect the mild steel surface from corrosion.

Under the theory and previous research, an increase in temperature in the corrosive media will increase the corrosion rate of mild steel. The high temperatures will accelerate the damage to the material's protective layer (coating). It will accelerate and become a place for electrolyte infiltration from the outside to interact directly with the material. Specimen (Fan et al., 2015). The increase in temperature will cause the evaporation process in the electrolyte. However, because this is a closed system, the vapour from the corrosive media will be trapped and increase the humidity (Syed et al., 2017). This corrosion rate will increase due to corrosive sulfuric acid elements. These corrosive elements are very dominant in increasing the corrosion rate.

CONCLUSION

Silica concentration from rice husk extract affects the corrosion rate of mild steel in 0.5 M H_2SO_4 corrosive media, where the higher the silica concentration, the lower the corrosion rate. A silica concentration of 1500 ppm resulted in a lower corrosion rate than silica concentrations of 500 and 1000 ppm in every temperature and immersion time condition. The lowest corrosion rate was obtained when the solution temperature conditions were 40°C, immersion time was 1 hour, and silica concentration was 1500 ppm. Bio coating from rice husk and damar resin has the potential to protect mild steel surfaces from corrosion. The higher the corrosive media solution temperature, the lower the corrosion rate that the protection mechanism of the bio-coating against mild steel occurs by physical adsorption.

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