



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

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ABSTRACT

Bio-coating is a natural anti-corrosion coating material that can be easily degraded and renewed. Rice husk extract and damar resin are alternative natural materials believed to have a relatively high silica content, so they can be used as a substitute for synthetic chemicals in protecting metals from corrosion. This research aims to determine the heat resistance ability of bio-coating on mild steel in a 1 M H₂SO₄ acid corrosive medium. The experimental object used rice husk waste and damar resin as raw materials. The analytical method used is the weight loss method. Damar resin and silica sol, obtained from rice husks' ashing, are mixed to form a homogeneous product. Metal samples coated with bio-coating material were immersed in 1 M sulfuric acid solution, with silica concentrations of 1500 ppm, variation times 1, 3, and 5 hours, and at temperatures of 30, 40, 60, and 80 °C. At 80 °C, the corrosion rate is very high, which proves that the temperature significantly affects the corrosion rate of mild steel immersed in an acid solution. The results showed that the best conditions were four hours of immersion time temperature of 40 °C, with an inhibition efficiency of 98%.

Keywords: *Bio-coating, Damar, Silica, Corrosion, Rice Husk*

1. INTRODUCTION

Corrosion is common in everyday life. We often encounter this phenomenon. Generally, people are more familiar with corrosion than rusting. Corrosion is a process of degradation of metal materials against environmental influences. Corrosion can occur on various metals, including copper, zinc, steel, and mild steel. The industry's common use of metal materials makes the destructive symptoms a significant problem hindering industrial equipment performance. Other impacts caused by corrosion are technical losses, reduced efficiency, reduced construction strength, poor appearance, and increased maintenance costs. The development of technology for corrosion prevention continues, with the coating being one of them coating the surface of the material as a form of protection to prevent corrosion of metal materials. The use of primary coating material often used is synthetic chemical compounds. However, using these basic materials has a negative impact if used in the long term, especially on preserving nature and living things around it. Coating materials based on synthetic chemicals can be categorized into fluid flows, affecting the characteristics of the fluids used in an industry (Susilo Wati, 2018). Therefore, natural-based or bio-coatings are necessary to protect metals from forming corrosion. In addition, the use of natural materials also has a positive impact on the environment in maintaining its sustainability.

Bio-coating is a coating material that can be easily degraded and is renewable (Pal et al., 2020). Coating materials derived from natural materials (bio-coating) can be safer than synthetic chemicals. Several studies have been conducted to determine the ability of extracts of natural materials as coating materials, including *flamboyant* resin (Pramudita et al., 2013), *Aster koroensis* (Mayakhrisnan et al., 2017), *citrus aurantium* (Hassan et al., 2016), *Pisum sativum peels* extract (Srivastava et al., 2018), *lemon seeds* (Hassannejad et al., 2018) and *Cuscuta reflexi extract* (Saxena et al., 2018). Damar resin is one of the most abundant plants in Indonesia's tropical forests and belongs to the genus of *Shorea* and *Hopea*.

Bio-coating is a breakthrough that can be applied to support and create eco-friendliness in industrial areas by changing the process of making coatings which initially used synthetic chemicals into natural or organic ingredients. There are many advantages to using bio-coating, including being environmentally friendly, materials that are easy to obtain, do not require high costs, and can minimize adverse effects on the health of living things and the environment.

Rice husk and damar resin are alternative materials for coatings derived from natural materials that can replace coating materials made from synthetic chemicals for metal protection. Rice husk extract has a relatively high silica content, ranging from 87-97%. The sol-gel method can synthesize silica in rice husks (Kuljana and Rodiah, 2019). Silica is known to have good adhesion and holding properties. On this basis,

silica makes it possible to resist the diffusion of water vapour, ions and oxygen onto the metal surface to protect against temperature and chemical substances. Damar resin is a natural material that has a very high adhesive ability. Damar resin contains terpenoid compounds. The compound is known to have a relatively high adhesive force. Therefore, the resin has the advantage of protecting the metal appropriately. Damar resin has strong adhesion, so it has excellent potential as a coating material and a successful coating on corrosion-related metals (Dahlia and Suwardi, 2004). Rice husk extract and damar resin can be the right choice because they are abundant and minimal in demand (Pramudita et al., 2022).

The corrosivity rate of mild steel material coated was determined by bio-coating, and immersion was carried out using 1 M sulfuric acid (H_2SO_4) medium with variations of 1, 2, and 3 hours at immersion temperatures of 30, 40, 60, and 80°C with silica concentration of 1500 ppm. This study aims to determine how the effect of temperature on the corrosion rate in acid-corrosive media.

2. METHODS

This research was conducted in several stages. Mild steel preparation is the stage manufacture of silica and damar resin solutions, bio-coatings material, coating mild steel with bio-coating, inhibition efficiency testing and measurement corrosion rate using the Weight Loss method.

2.1 Mild Steel Preparation

The procedure for preparing mild steel is to cut it with 20 x 30 x 1 mm dimensions, then grind it using a grinder. After that, wash it with distilled water for 15 minutes and rinse it with acetone. Mild steel that has been dried is ready to be used for the next stage.

2.2 Silica Solution and Damar Resin Solution Preparation

The process of preparing silica solution is 1,5 g of silica powder dissolved in 1000 mL of 1 M NaOH solution at 40°C to become homogeneous. In making a damar resin solution, 75 g was dissolved with 80 mL hexane in a beaker at 40°C while stirring until the solution became homogeneous.

2.3 Preparation of Bio-coating Materials

The product was manufactured to manufacture bio-coating materials by mixing 20 mL silica solution and 80 mL damar resin solution into a chemical glass. Stir the solution at 40°C until a homogeneous mixture is formed.

2.4 Mild Steel with Bio-coating Material

The method used to coat light surfaces of mild steel is dip coating. The process of coating metal is that the

dried metal will be covered with a coating material in a beaker after being a rope to facilitate immersion for some hours at different temperatures. Then remove and dry the metal for further weighing as the initial mass data. The process can be shown in Figure 1.

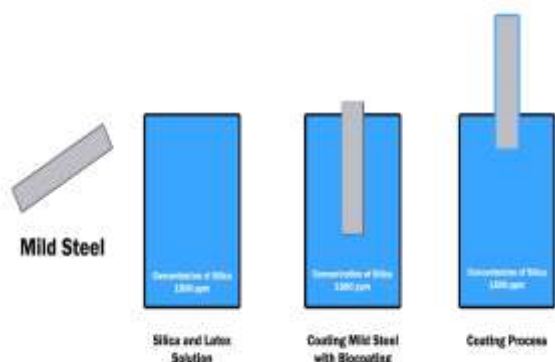


Fig. 1. Dip-coating for improving corrosions resistance for mild steel in silica and damar resin Solution

2.4 Bio-coating Test

The testing process uses a water bath with temperature variations for 30, 40, 60 and 80°C. The silica concentration used 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 1 M of sulfuric acid.

2.5 Weight-Loss Method

The Weight-Loss Method reduction 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.

2.5 Calculation of Corrosion Rate

To calculate the corrosion rate (ASTM G31-12a):

$$Cr = (87500 \cdot \Delta W) / A \rho t \quad (1)$$

Where:

Cr = corrosion rate (mmpy)

ΔW = difference between the initial weight and the final weight (g)

A = the surface area (cm²)

ρ = density of mild steel (g/cm³)

t = difference in immersion time (h)

3. RESULTS AND DISCUSSION

Effect of Temperature and Immersion Time on Corrosion Rate

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 that has been made. The efficiency value shows the bio-coating's ability to inhibit the corrosion rate of samples in corrosive media. This study used the weight loss method to determine the efficiency and corrosion rate values. This weight loss method is simple to decide on the work efficiency of bio-coating and the corrosion rate that occurs.

Bio-coating is a corrosion coating derived from natural materials available in nature. Silica is one of the compounds contained in rice husk extract to be used as a bio-coating. Meanwhile, damar resin is a natural polymer with flexible and stable properties. This bio-coating combines relaxed and durable damar resin and silica derived from rice husk extract.

To determine the effect of immersion temperature on the corrosion rate of mild steel over a particular time, conducted by varying the temperature immersion of 30°C, 40°C, 60°C, and 80°C. Then, it will be reviewed from the value of the corrosion rate in Figure 2.

Figure 2 shows that the higher the temperature at the same immersion time, the corrosion rate tends to increase. The longer a metal is in its corrosive medium (sulfuric acid) will accelerate corrosion. The bio-coating layer will be damaged over time, along with the length of immersion time.

The results show that the corrosion rate at a temperature of 30°C is lower than other temperature variations. While at a temperature of 80°C, the corrosion rate is higher. Temperature is one of the factors that can trigger the corrosion process. It occurs because an increase in temperature will cause an increase in the kinetic energy of the particles, exceeding the magnitude of activation energy.

The longer the immersion time and the higher the temperature in the sulfuric acid, the greater the corrosion rate because the surface of the mild steel will interact longer with the corrosive medium, resulting in a reaction between the mild steel and the sulfuric acid and producing high corrosion. The low corrosion rate value indicates that the mild steel tested takes a long time to corrode due to the protection from the corrosion bio-coating of rice husk extract and damar resin solution.

The corrosion rate is highly dependent on the k value. When the temperature changes, the k value will also change; when the k value changes, the corrosion rate will change. According to the Arrhenius equation, a higher temperature will result in a higher corrosion rate. Meanwhile, based on the collision theory, the high temperature will increase the collision so that the hat corrosion rate will increase.

In addition, high temperatures can cause resin sap chains cut off the bio-coating ability to reduce corrosion rate. Therefore, the lowest corrosion rate is obtained at 30°C, where the damar resin can resist low temperatures.

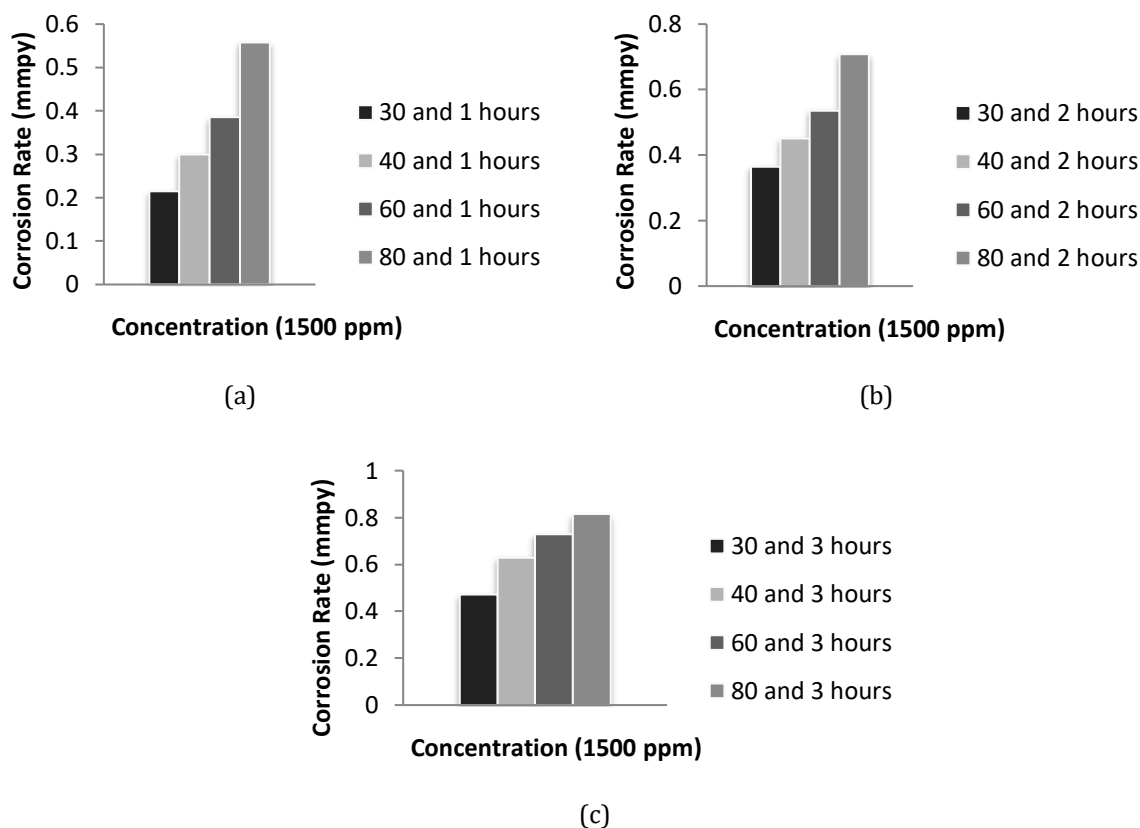


Fig. 2. Corrosion Rate vs Concentration at Constant Time 1 hour (a), 2 hours (b), and 3 hours (c)

Increasing temperature increases corrosion rate because electrochemical reactions generally occur more rapidly in higher temperatures. The increased temperature adds energy to the reaction, increasing its corrosion rate.

An increase in temperature will cause this to occur evaporation of the electrolyte. But because this is a closed system, the vapour from the corrosive medium will be trapped and increase humidity. This corrosion rate will increase due to the presence of corrosive sulfuric acid. These corrosive elements are very dominant in improving the corrosion rate. The high temperatures will cause damage to the protective coating.

Silica from rice husk has adhesive power, and the damar resin solution which is mixed has flexible properties and adheres to a homogeneous solution which reacts with the sulfuric acid, which will show the formation of a protective layer covering the surface of the mild steel electrode where the layer will form a film so that it can inhibit the corrosion process. Then, water molecules and other ions are initially adsorbed on the surface of the mild steel and then transferred to the silica and damar resin which have become a homogeneous solution.

4. CONCLUSION

Temperature significantly affects the corrosion rate of mild steel immersed in an acid solution. It follows the theory and previous research, whereas the temperature

rises in the corrosive medium will increase the corrosion rate of mild steel because high temperatures will accelerate the damage to the protective layer (coating) material so that it will accelerate and become a place electrolyte infiltration from the outside to interact directly with the specimen. When the temperature gets higher will cause damage to the protective coating, or the bio-coating material will accelerate the corrosive medium interacting directly with mild steel, thereby enhancing the corrosion rate. The results showed that the best conditions were four hours of immersion time temperature of 40 °C, with an inhibition efficiency of 98%.

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