

APPLICATION OF JENGKOL PEEL (*Pithecellobium jiringa*) AS IRON CORROSION INHIBITORS IN HYDROCHLORIC ACID MEDIUM

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ABSTRACT

The purpose of this study is to apply the Jengkol (*Pithecellobium jiringa*) peel like an iron inhibitor in a 3% hydrochloric acid medium. In this study, Jengkol peel is applied in powder form, concentrated extract form, and tannin form. The use of Jengkol peel as iron corrosion inhibitors in these three forms is made to see the ability of the three forms to act as inhibitors. The variations of inhibitor addition were 1g, 3g, 5g, 7g, and 9g for each form. Based on the results obtained, the three forms of inhibitors can act as good inhibitors for iron. Likewise, with the concentration of inhibitors used, the addition of 1g of Jengkol peel inhibitors for all forms has a good effect as an iron corrosion inhibitor. The results showed that the lowest corrosion rate on the iron plate was obtained by adding g of inhibitor and immersion time for 12 days for each form. The results achieved are not much different from the corrosion rate in the addition of inhibitors of 1g, 3g, 5g, and 7g for each form. This indicates that the addition of 1g inhibitors in each form can act to inhibit the iron corrosion rate.

Keywords: Jengkol Peel, Jiringa, Corrosion Inhibitor, Corrosion Rate, Iron

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INTRODUCTION

Corrosion is a phenomenon in which a metal deterioration by a chemical reaction when it comes into contact with air or water.¹ Corrosion is a continual process that is difficult to avoid. The corrosion of metal is most common in steel and iron materials referring to industries such as the gas and transportation sectors where a lot of funds have been spent to inhibit corrosion or replace the corroded material.² The use of the corrosion inhibitor method is the most practical and economical for the protection and prevention of metal corrosion despite the environment aggressive, particularly in the aqueous environment.³

The purpose of this study is to apply the Jengkol (*Pithecellobium jiringa*) peel like an iron inhibitor in a 3% hydrochloric acid (HCl) medium. In this study, powder of Jengkol peel, extract of Jengkol peel, and tannin of Jengkol peel was used as an iron corrosion inhibitor in HCl medium because the Jengkol peel contains tannin, and it is a waste and easy to find in Indonesia. Tannin is known as a corrosion inhibitor in the industry.⁴ Jengkol is a plant that is used as food for the people of Indonesia, and nowadays, Jengkol peel is wasted in nature. According to the research by Hidayah *et al.*, the Jengkol peel has a content of 9.56% of polyphenol, 7.82% of tannin, and 56.92% of saponin.⁵ These organic compounds can adsorb onto metal surfaces, blocking active sites on the surface and reducing corrosion rates. The content of the plant can be used as an excellent inhibitor for steel corrosion in acidic solutions.^{6,7} Corrosion is a phenomenon that results in damage to the material through chemical or electrochemical interaction with the environment.⁸ Steel corrosion in acidic media is a common phenomenon. Corrosion inhibitors are the best option to protect the metal from electrochemical attack. The plant extract is commonly used as a corrosion inhibitor. This plant extract is not toxic in nature, available in nature, inexpensive, and most importantly, environment friendly.^{1,7,9-12} Weight loss methods are widely used for corrosion rate determination. The corrosion rate (CR) and the inhibition efficiency (η_{WL}) are calculated by using eqn.-1 and eqn.-2.¹³

$$C_R = \frac{W_b - W_a}{At} \quad (1)$$

$$\eta_{WL}(\%) = \left[1 - \frac{w_i}{w_0} \right] \times 100 \quad (2)$$

Where:

w_b : Specimen weight before immersion in a solution

w_a : Specimen weight after immersion in a solution

w_0 : The rate of corrosion without an inhibitor

w_i : The rate of corrosion by using inhibitors

A: Total area of steel specimens (cm^2)

t: Immersion time (day)

EXPERIMENTAL

Materials

In this study, the inhibitor used is in 3 forms namely Jengkol peel powder form, Jengkol peel concentrated extract form, and Jengkol peel tannin form. Other chemicals used are distilled water and 3% HCl. Materials used are glass beaker, analytical balance, oven, pH meters, and iron plate size 20 mm x 10 mm x 0.6 mm.

Iron Plate Preparation

The iron plate surface with a size of 20 mm x 10 mm x 0.6 mm is smoothed, and cleaned by using detergent and distilled water before being dried in an oven for 2 hours at a temperature of 110 °C so that the iron does not contain water.

Iron Plate Immersion in HCl Solution without Inhibitor

The iron plates are weighed to get the initial mass, then immerse the iron plate in 50 mL of 3% HCl medium. Using a pH meter, the pH of the HCl medium is measured and then set as the initial pH. The corrosion rate and the inhibition efficiency are determined by using equation (1) and equation (2) after the iron plates are immersed for 3 days, 6 days, 9 days, and 12 days.

Iron Plate Immersion in HCl Solution with Addition of Inhibitor

The iron plates are weighed to get the initial mass then immerse the iron plate in 50 mL of 3% HCl medium. Using a pH meter, the pH of the HCl medium is measured and then set as the initial pH. Variations in addition of Jengkol peel powder inhibitors, Jengkol peel extract inhibitors, and Jengkol peel tannin inhibitors mass were 1 g, 3 g, 5 g, 7 g, and 9 g, respectively. The corrosion rate and the inhibition efficiency are determined by using equation (1) and equation (2) after the iron plates were immersed for 3 days, 6 days, 9 days, and 12 days.

Corrosion Rate Determination

After the immersion of the iron plate is done on a given day, the corrosion medium is measured by using a pH meter, then set as the final pH. The corrosion products are taken from the medium and dried in an oven for 2 hours at a temperature of 110 °C, then weighed as the final mass.

RESULTS AND DISCUSSION

Addition Effect of Jengkol Peel Inhibitors on Iron Corrosion Rate in HCl Medium

Figure-1 shows the effect of increasing the concentration of Jengkol peel powder inhibitors (Fig.-1a), Jengkol peel extract inhibitor (Fig.-1b), and Jengkol peel tannin inhibitor (Fig.-1c) on the corrosion rate of the iron plates.

In Fig.-1a we can see that in the hydrochloric acid medium, the iron plate corrosion rate without an inhibitor is higher than the iron plate corrosion rate by adding a Jengkol peel powder inhibitor. The iron plate corrosion rate without inhibitor addition in immersion time in 3 days, 6 days, 9 days, and 12 days respectively were 0.6823 $\text{mg}/\text{cm}^2\text{day}$, 0.3521 $\text{mg}/\text{cm}^2\text{day}$, 0.2491 $\text{mg}/\text{cm}^2\text{day}$, and 0.1877 $\text{mg}/\text{cm}^2\text{day}$, while by adding Jengkol peel powder inhibitor, the corrosion rate decreases drastically. The higher concentration of Jengkol peel powder inhibitor is added, the corrosion rate will be lower. The lowest corrosion rate is 0.0339 $\text{mg}/\text{cm}^2\text{day}$ obtained by adding Jengkol peel powder in immersion time for 12 days. The effect of the addition of Jengkol peel concentrated extract inhibitor on iron plate corrosion rate can be seen in Fig.-1b. The addition of an inhibitor from Jengkol peel extract on the iron plate in the hydrochloric acid medium can reduce the iron plate corrosion rate, and the corrosion rate is lower than the corrosion rate without using an inhibitor. The lowest iron plate corrosion rate with the addition of Jengkol peel extract inhibitor obtained was 0.0226 $\text{mg}/\text{cm}^2\text{day}$ in the addition of 9% extract and 12 days immersion time.

The addition effect of Jengkol peel tannin inhibitor on iron plate corrosion rate is shown in Fig.-1c. The lowest iron plate corrosion rate with the addition of Jengkol peel tannin inhibitor obtained by the addition of 9% tannin in 12 days immersion time is 0.0189 mg/cm².day. The addition of a tannin inhibitor causes the iron plate corrosion rate to be much lower than the iron plate corrosion rate without an inhibitor.

The iron plate's corrosion rate in general decreases with the duration of immersion as shown in Fig.-1. This is a corrosion inhibitor that can cover the metal surface forming a passive layer on the cathodic side thereby affecting the cathode reduction reaction. If the reaction at the cathode is inhibited, then the iron oxidation reaction at the anode is also inhibited. The passive layer formed on the surface of this iron will block the entry of the ions to the metal surface corrosion, thereby reducing the corrosion rate of iron in hydrochloric acid solution.

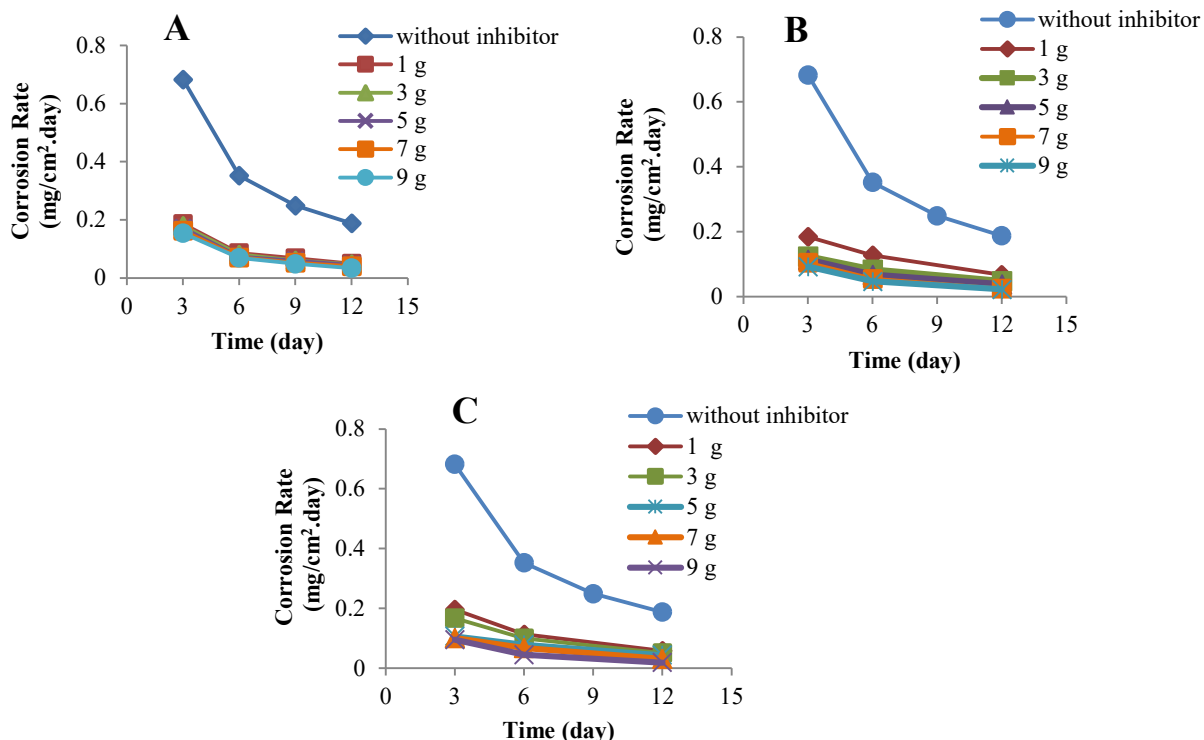


Fig.-1: The Corrosion Rate of Iron Plate without Inhibitor and with Addition of Jengkol Peel Powder Inhibitor (A), Concentrated Extract Inhibitor (B), and Tannin Inhibitor (C)

Based on research, the results obtained are comparable with the theory that the binding to metal surfaces increases with the increasing concentration of inhibitors. When the concentration increases, more of the inhibitor molecule is bound to the metal surface which results in greater surface coverage.¹⁴ The presence of electrons on the oxygen atom of the hydroxyl group inhibitor may increase the interaction between inhibitors formed on the iron surface. The hydroxyl groups present in the molecule inhibitors could create corrosion rate decreases.¹⁵

Addition Effect of Jengkol Peel Inhibitors on Iron Inhibition Efficiency in Hydrochloric Acid Medium

Inhibition efficiency is the ability to reduce corrosion of the metal. Fig.-2 shows that the inhibition efficiency increased by adding Jengkol peel inhibitor powder (Fig.-2a), concentrated extracts (Fig.-2b), and tannin (Fig.-2c). The higher concentration of inhibitor is added, the inhibition efficiency will be higher. Moreover, the longer the immersion duration of the iron plate, the higher the inhibition efficiency.

The highest iron plate inhibition efficiency on each inhibitor was obtained by adding 9% powder and the immersion time of 12 days. Under these conditions, the efficiency of 81.9262% is obtained with the addition of Jengkol peel powder inhibitor, while the addition of concentrated extract of Jengkol peel inhibitor obtained by 87.9084%, and the addition of Jengkol peel tannins inhibitor obtained by 89.9024%.

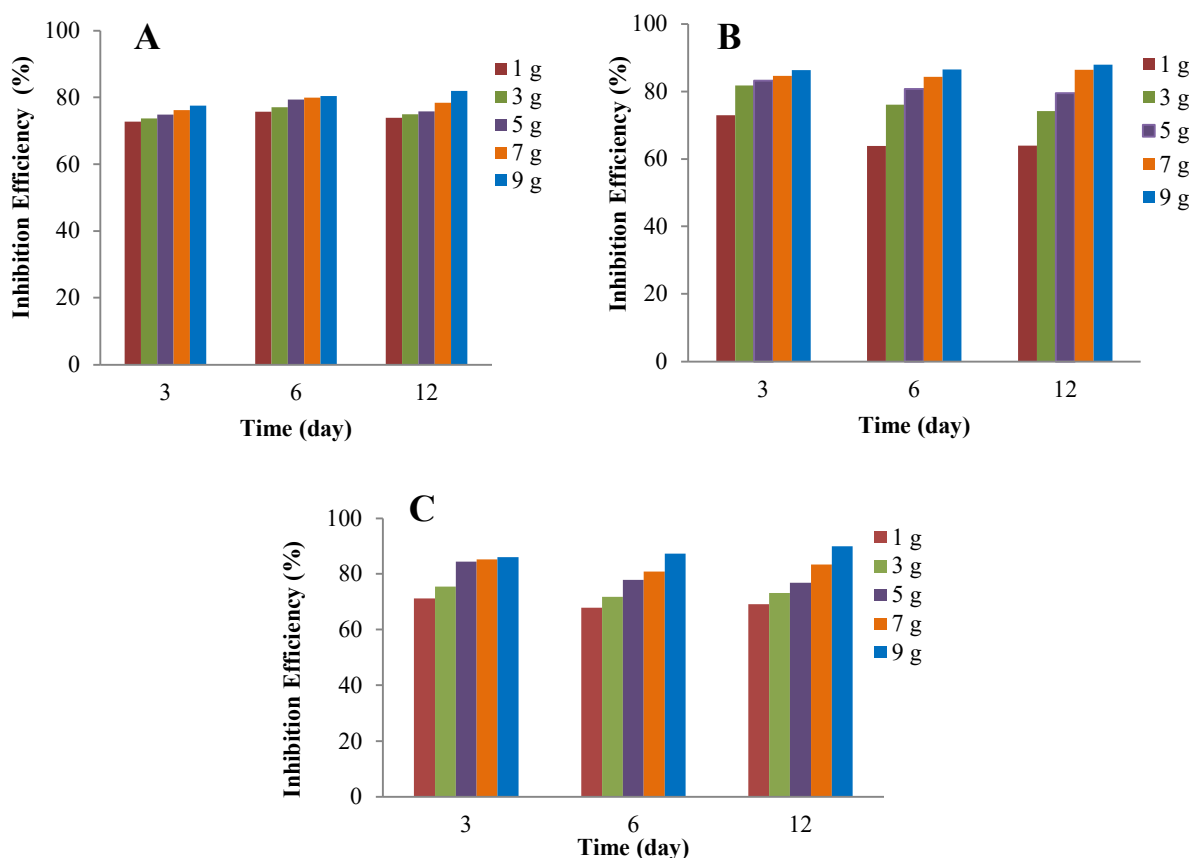


Fig.-2: Addition Effect of Jengkol Peel Powder Inhibitor (A), Concentrated Extract Inhibitor (B), and Tannin Inhibitor (C) to the Inhibition Efficiency

According to the study conducted, the obtained results are comparable to the theory that the corrosion rate decreases as the inhibitor concentration increases and the inhibition efficiency increased as the inhibitor concentration increases. This shows that the ability of inhibition depends on the amount of inhibitor powder, concentrated extract, and tannins where phytochemical components of the inhibitor are bound to the surface of the iron plate which resulted in the reaction sites blocking, thereby protecting the iron plate surface of the active iron corrosion attack.¹⁶

Surface Morphology Analysis Scanning Electron Microscope Energy Dispersive X-Ray (SEM-EDX) on Iron Plate

Testing by using SEM and EDX aims to see the depiction of the surface structure and to determine the elemental composition of the iron plate surface. Fig.-3 is an SEM test of the iron plate surface before and after immersion in HCl solution with and without the addition of tannins from the Jengkol peel inhibitor. Fig.-3a is an iron plate morphology before immersing in HCl solution. At the time before immersion, the metal surface still has a flat shape on the entire surface. Immersion in HCl solution causes morphological changes in the iron plate surface to become rougher and irregular.

The surface morphology of the iron plate after immersion time for 12 days in a solution of 3% corrosive hydrochloric acid with and without the addition of Jengkol peel tannins are shown in Fig.-3b and Fig.-3c. From the two pictures, it can be seen that there are significant differences in the corrosive hydrochloric acid solution. It is seen that the iron plate surface in HCl without the addition of inhibitors forms corrosion and holes, but the presence of tannins from the jengkol peel minimizes corrosion and holes on the surface of the iron plate. This happens because the iron plate surface is formed a passive layer that prevents ions from the corrosive attack on the iron plate surface so that the electrochemical reaction is reduced and finally corrosion rate will also be reduced. The mechanism that occurs on metal surfaces with corrosion inhibitors is an organic inhibitor that forms a protective form of adsorption films. The organic compound used as an inhibitor could act as cathodic, anodic, or together as a cathodic and anodic inhibitor. This process goes

through the adsorption process on the surface and forms a continuous film. These inhibitors build a protective hydrophobic film of molecules adsorbed on the surface of the metal, forming a protection for the metal in the electrolyte. Inhibitors would be dissolved or dispersed in the media surrounding the metal.¹⁷

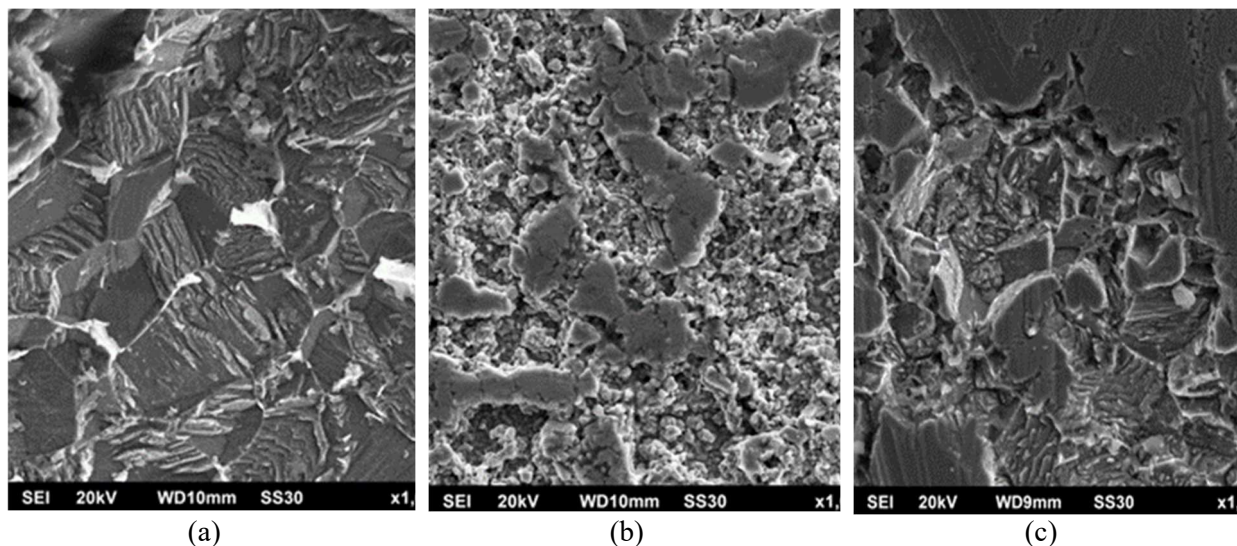


Fig-3: SEM of Iron Plate Surface before and After Immersion in HCl Solution for 12 Days Before Immersion (a), After Immersion Without Inhibitor (b), and After Immersion with Jengkol Peel Tannin Inhibitor (c)

Figure-4 showed the testing EDX Spectrometer results to iron plate sample without immersion, immersion in HCl solution without inhibitor, and immersion in the HCl solution by adding inhibitors tannins, respectively. The iron plate characterization using SEM-EDX showed that the biggest elements content of iron plates is Fe and O.

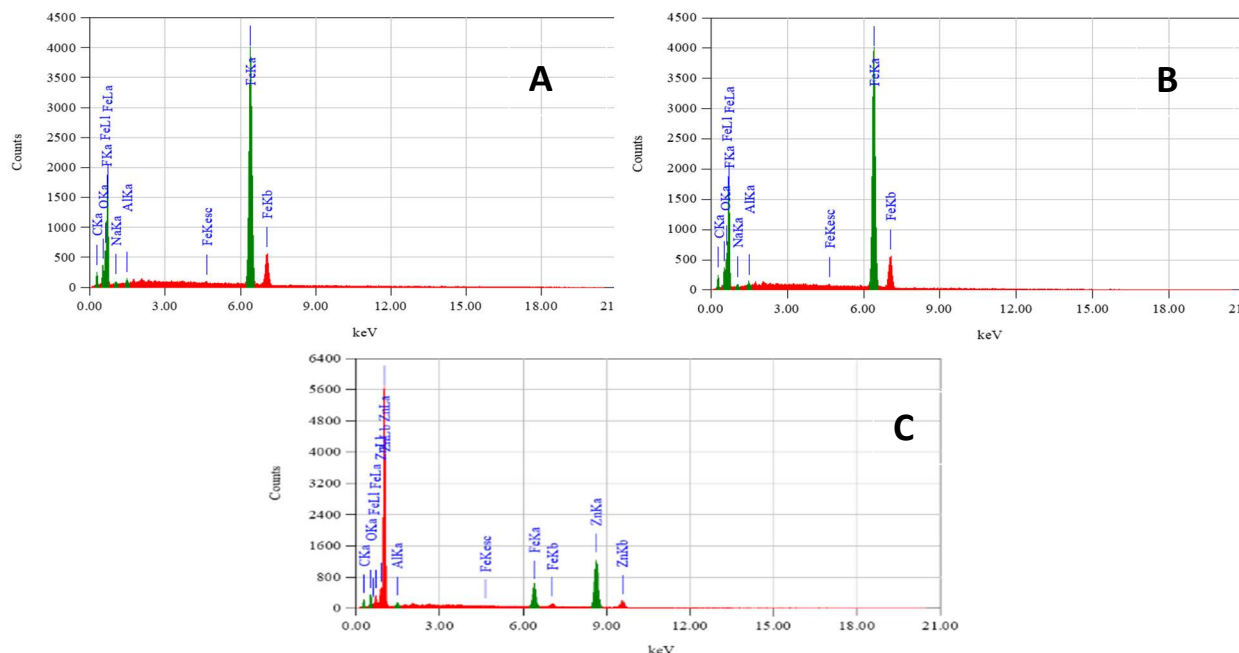


Fig-4: EDX Spectra and Chemical Composition Iron Surface Plate before Immersion (A), After Immersion for 12 Days without Inhibitor (B), and After Immersion For 12 Days With The Addition of Jengkol Peel Tannin Inhibitor of 9%

In Fig.-4(A) the element content of Fe and O respectively are 69.47% and 20.35%. In Fig.-4(B) the element content of Fe and O respectively are 10.43% and 17.31%, and in Fig.-4(C) the element content of Fe and O respectively are 67.03% and 19.70%. Meanwhile, other elements such as F, Na, and Al have a content

of less than 10%. From the comparison of the results between the iron plate immersion in the HCl solution without inhibitor and with inhibitor, the decreased elemental composition value of carbon C is from 15.6% to 7.32%. This indicates that the inhibitors are used to form a passive layer on the metal surface using an iron adsorbed on the surface. The element Fe on the iron plate in immersion without inhibitor is 10.43%, while the iron plate with the addition of tannin inhibitor is 67.03% and the iron plate without immersion was 69.47%. This shows that the Fe in the iron plate with immersion without inhibitor is much oxidized by O elements, and thus has the highest corrosion rate.

CONCLUSION

The addition of tannin Jengkol peel inhibitors, Jengkol peel concentrated extract inhibitors, and Jengkol peel powder inhibitors into a 3% HCl corrosive media solution can decrease the iron plate corrosion rate. The lowest corrosion rate on the iron plate is 0.0189 mg/cm²day by using Jengkol peel tannin inhibitors, 0.0226 mg/cm²day by using the concentrated extract of Jengkol peel inhibitor, and 0.0339 mg/cm²day using a Jengkol peel powder inhibitor. This condition is achieved with the addition of 9g of inhibitor and immersion time for 12 days. The results achieved are not much different from the corrosion rate in the addition of inhibitors of 1g, 3g, 5g, and 7g for each form. These results indicate that the addition of a 1g inhibitor in each form can act to inhibit the iron corrosion rate.

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