THE UTILIZATION OF BANANA PEEL AS AN ORGANIC CORROSION INHIBITOR OF ZINC IN CHLORIDE ACID MEDIUM

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ABSTRACT
Zinc is a type of metal that will be corrosive if it is in an acidic medium. One way to reduce the rate of zinc corrosion is by adding inhibitor. This research will examine the potential of banana peels as corrosion inhibitors in hydrochloric acid medium. In this study, the type of banana that will be used is Awak banana where is widely available in Indonesia. Banana peels used in this study varied in 3 forms, namely in the powder form, extract form, and tannin form. The ability of these 3 forms of inhibitors will be compared to their ability as zinc inhibitors in HCl medium. The amount of inhibitor added varied from 1 g, 3 g, 5 g, 7 g and 9 g to zinc where was immersed in 50 mL of 3% HCl solution. Corrosion rate and inhibition efficiency were analyzed on day 3, day 6, day 9 and day 12.

Keywords: corrosion inhibition, corrosion rate, Awak banana, banana peel, zinc.

1. INTRODUCTION
Zinc is widely used in industry and its often exposed to corrosive medium, such as acids. High-pressure hydrochloric acid is one of the acids used in the oil drilling industry [1]. One of ways to reduce this corrosion rate is the addition of inhibitors. Corrosion inhibitors can reduce the corrosion rate that occurs in the environment against metal in it. Organic inhibitors or green inhibitors are safe types of inhibitors because they have properties that are environmentally friendly or biodegradable, economical, and available in nature [2]. In this case, one of the sources of organic inhibitors can be used is banana peel which can be used as an environmental-friendly corrosion inhibitor. Banana is one of the important fruit commodities in Indonesia which is a center of origin for banana plants. Banana peel contains tannin compounds. Unripe banana peel has 6.48% tannin content, half-ripe banana peel 4.97% and ripe banana peel 4.69% [3]. In this study, the type of banana that will be used is Awak banana which is widely available in Indonesia. Awak banana peel has potential to become a corrosion inhibitor. Therefore, a study is conducted to develop Awak banana peel as a corrosion inhibitor applied to zinc plate in hydrochloric acid medium.

Talib et al., (2014) researched that mild steel immersion in HCl medium by adding Melaleuca cajuputi peel inhibitors. The results showed corrosion rates decreased with the addition of inhibitor concentrations while inhibition efficiency increased with a similar treatment [4]. Tambun et al., (2015) researched the effect of inhibitory purity from guava leaves on iron plate corrosion rate on the hydrochloric acid medium where the inhibitor was varied into three forms, namely powder, concentrated extract, and guava leaf tannin. In this study, inhibition efficiency increased with the addition of inhibitor concentrations and the highest inhibition efficiency was obtained by applying guava leaf tannin to iron plate [5]. The corrosion rate is the speed of declining material quality over time. In calculating the corrosion rate, the unit commonly used is mm/year (international standard) or mils/year (mpy, British standard). A material resistant to corrosion if material has corrosion rate between 1 - 200 mpy [6].

Based on the above studies, this study aimed to examine the Awak banana peel as a corrosion inhibitor which is applied to the zinc plate in hydrochloric acid medium. Awak banana peels used as inhibitors are made in 3 forms, namely in the powder form, extract form and tannin form. The three forms of inhibitors will be compared their ability as zinc inhibitors in HCl medium.

2. MATERIALS AND METHODS
In this study, the materials used were Awak banana from Pringgan Market, Medan, North Sumatra, FeCl3 1%, Ethyl Acetate, Methanol, Aquadest, 3% HCl, Zinc Plate size 2 cm x 1 cm x 0.06 cm. The materials used are glass beaker, blender, Whatman 41 filter paper, rotary vacuum evaporator, analytic balance, oven, pH meter. In this study, banana peels as inhibitors were made in the form of powder, extract and tannin. The amount of inhibitor added varied from 1 g, 3 g, 5 g, 7 g and 9 g to zinc which was immersed in 50 mL of 3% HCl solution. Corrosion rate and inhibition efficiency were analyzed on day 3, day 6, day 9, and day 12.

2.1 The Making Banana Peel Powder
Banana peel is cut to a size of about 1 cm, then dried under the sun light for 3 days. The banana peel that has been cut is put into an oven with a temperature of 80 °C. The mass of the banana peel is weighed, then put it...
back into the oven until the mass of the banana peel is constant. After the peel is dry then peel is grinded and filtered with a sieve tray of 50 mesh. Some of the banana powder that passes through sieve tray of 50 mesh is ready to be used as an inhibitor and the rest is extracted.

2.2 The Making Banana Peel Extract
Banana peel powder of 2 kg was put in the macerator. Then the banana powder was mixed with 18 L of methanol and left for 24 hours. The pH of methanol extract was measured by a pH meter. Samples are removed from the macerator and filtered by using a filter paper. The filtrate obtained was put into a rotary vacuum evaporator at 65 °C for 2 hours. Then this concentrated extract (inhibitor) is inserted into a bottle.

2.3 Qualitative Analysis of Tannin in Concentrated Extracts
The water of 10 ml was added to concentrated extract (10 g) and heated till boiled. The filtrate was filtered and FeCl₃ solution (10%) was added. The color changed to blackish green indicated the presence of tannin.

2.4 Analysis of Tannin Level with UV-Vis Spectrophotometer
Testing of tannin content was carried out by using a UV-Vis spectrophotometer. The absorbance of methanol extract of banana peel was observed at a wavelength of 765 nm.

2.5 Separation of Tannin in Concentrated Extracts
Ethyl acetate (95%) was added to the concentrated extract, then stirred until mixed. The precipitate will be formed, then filtered. The precipitate was washed again with ethyl acetate (95%) until the filtrate is clear, then filtered to obtain the residue. The residue obtained is tannin that is ready to be used as an inhibitor.

2.6 Zinc Plate Preparation
Zinc plate with a size of 2 cm x 1 cm x 0.06 cm smoothed with sandpaper. This smooth surface was washed with detergent and distilled water, then dried in an oven at 110 °C for 2 hours.

2.7 Immersion of Zinc Plate in HCl Solution without Inhibitor
The zinc plate mass was weighed as the initial mass. The zinc plate was immersed in 50 mL of 3% HCl solution. The pH of the medium was measured by a pH meter and set as the initial pH. The immersed zinc plate was stored for 3 days, 6 days, 9 days, and 12 days and then determined the corrosion rate and inhibition efficiency with Equations (1) and (2).

2.8 The Immersion of Zinc Plate in HCl Solution with Addition of Inhibitors
The zinc plate mass was weighed as the initial mass. The zinc plate was immersed in 50 mL of 3% HCl solution. The types of inhibitors used in this study consisted of 3 forms, namely in powder form, extract form and tannin form. Each of these inhibitors was smeared with zinc plate as much as 1 g, 3 g, 5 g, 7 g, and 9 g, then immersed in HCl solution. The pH of the medium is measured by a pH meter and set as the initial pH. The zinc plate which has been immersed in HCl solution with the addition of inhibitors with a certain concentration is stored for 3 days, 6 days, 9 days, 12 days to determine the corrosion rate and inhibition efficiency by using Equations (1) and (2).

2.9 Determination of Corrosion Rate
After the corrosion processed in a certain time, the pH of the medium was measured by a pH meter and set as the final pH. Corrosion product was removed from corrosion medium, and dried in an oven at 110 °C for 2 hours, then weighed as final mass. Corrosion rate is calculated by the method of weight loss by using Equation (1) [7].

\[
K = \frac{3.45 \times 10^{-6}}{D} \\
CR = \frac{W}{D \times A \times t}
\]

where, \( K \) is the constant value (3.45 x 10⁻⁶), \( CR \) is corrosion rate (mils/year), \( W \) is the losing weight (g), \( D \) is the plate density (g/cm³), \( A \) is plate surface area (cm²), and \( t \) is the immersion time (hours).

From the corrosion rate data, the surface covered by the inhibitor because the adsorption inhibitor on the metal surface can be calculated by Equation (2) [7].

\[
\phi = \frac{\Delta A}{\Delta A_0}
\]

where, \( \Delta A \) and \( \Delta A_0 \) are corrosion rate in inhibited and in uninhibited solution (mils/year), \( \phi \) is the surface covered by inhibitors.

3. RESULTS AND DISCUSSIONS

3.1 The Result of Fourier Transform Infra Red (FTIR) Analysis on Banana Peel Powder
FTIR analysis is an analysis using infrared radiation absorption. Each functional group in a material absorbs a different spectrum so that the chemical characteristics of the material as a whole can be described. FTIR test results in the form of graphs, which consists of several absorption peaks that identify the compounds contained in the banana peel. Figure-1 shows the results of FTIR analysis of banana peel.
Figure-1. FTIR Analysis of banana peel.

Figure-1 shows that the banana peel contains a hydroxyl (O-H) group which is marked at the peak of absorption 3398.57 cm⁻¹ where the hydroxyl group wave number area is 3705 cm⁻¹ -3125 cm⁻¹. The FTIR test result indicates that the banana peel contains tannin compounds. The results of the FTIR analysis in this study are similar to the results of the analysis conducted by Zhao et al. (2017) [8]. Tannin in banana peels are hydrolysis tannin that are showed with blackish green in qualitative analysis with FeCl₃ 1%.

3.2 Quantitative Analysis of Tannin Content of Banana Peel Extract with UV-Vis Spectrophotometer

UV-Vis spectrophotometer is used as a quantitative analysis to determine the amount of tannin contained in banana peel. In this analysis, gallic acid is used as a comparison to make a standard curve. The spectrophotometer is operated at a maximum wavelength of 765 nm to be observed for its absorbance, then continued to measure the absorption of banana peel [8].

Figure-2. Standard curve of UV-Vis spectrophotometry of banana peel.

Figure-2 is standard curve of UV-Vis spectrophotometry of banana peel that used to calculate tannin content. Based on Figure-2, the tannin content found is 80.2931 ppm or 1.602%.

Figure-3. Comparison of zinc plate corrosion rate without inhibitors and with addition of banana peel powder inhibitors.

The corrosion rate of zinc plate without inhibitors at 3 days, 6 days, 9 days, and 12 days are 707.46 mpy, 570.49 mpy, 314.62 mpy, and 264.07 mpy respectively. The addition of banana powder as an inhibitor decreases the corrosion rate of zinc plate. The lowest corrosion rate of 23.95 mpy is achieved with the addition of 9 g of banana peel powder inhibitor and immersion time of 12 days.

The addition effect of banana peel extract as inhibitors to the corrosion rate of zinc plate can be seen in Figure-4. The lowest zinc plate corrosion rate of 17.13 mpy is achieved with the addition 9 g of banana peel extract inhibitor and immersion time of 12 days. These results indicate that the addition of banana peel extract inhibitors to the zinc plate decreases the corrosion rate of the zinc plate.

3.3 Effect of Addition of Banana Peel Inhibitors on the Corrosion Rate of Zinc Plate in Chloride Acid Medium

Figure-3 shows that the effect of adding inhibitors in the form of banana peel powder to the corrosion rate of zinc plate in hydrochloric acid medium. According to Tambun et al. (2015), the corrosion rate decreases with the addition of powder inhibitor concentration and immersion time [5]. From Figure-3 it can be seen that the corrosion rate of zinc plate without inhibitors in 3% hydrochloric acid is much higher than the corrosion rate of zinc plate with banana peel powder inhibitors in the same medium.
Figure-4. Comparison of the corrosion rate of zinc plate without inhibitors and with the addition of banana peel extract inhibitors.

Figure-5 shows that the effect of adding banana peel tannin inhibitors to the corrosion rate of zinc plate. The lowest zinc plate corrosion rate of 10.60 mpy is achieved with the addition 9 g of banana peel extract inhibitor and immersion time of 12 days. These results indicate that with the addition of tannin inhibitors, the corrosion rate of zinc plate is lower than the rate of corrosion of zinc plate without inhibitors.

Figure-5. Comparison of zinc plate corrosion rate without inhibitors and with addition of banana peel tannin inhibitors.

The addition of powder inhibitors, extracts inhibitors, and tannin inhibitors of banana peels reduced the rate of zinc plate corrosion. This process occurs as a result of binding of the banana peel inhibitor molecules to the zinc plate surface. The banana peel inhibitor molecule suppresses the reaction of the metal with the medium by forming a protective layer so that the metal surface is separated from the corrosion medium [9].

The increased concentration of banana peel inhibitors makes the corrosion rate decreases. This happens because the more banana peel inhibitors are attached to the metal surface, the greater the inhibitory ability. We can also see in Figures 3-5 that the zinc plate corrosion rate decreases with increasing zinc plate immersion time in 3% HCl medium. Corrosion rates decrease with the addition of immersion time because corrosion products accumulate on the surface resulting in blockage of ion diffusion to the metal surface. This causes a slowing of the cathodic reaction kinetics, because increasing the thickness of the corrosion product decreases the corrosion rate [9].

A material is resistant to corrosion if it has a corrosion rate value between 1 - 200 mpy [6]. The corrosion rate of zinc plate by the addition of powder inhibitors, concentrated extracts, and tannin of the banana peel in 12 days immersion time has a corrosion rate between 1 and 200 mpy, so it can be said that the zinc plate with the addition of banana peel inhibitors at that time is resistant to corrosion.

Based on this study, the results obtained are in accordance with the theory, namely the addition of inhibitor concentration decreases the rate of corrosion because the inhibitor component that is bound to the surface of the zinc plate will prevent the surface of the zinc plate from corroding in 3% HCl solution. The duration of contact between metal and corrosive medium will also affect the rate of corrosion. The longer the contact time between metal and corrosive medium, the rate of corrosion will be slower.

3.4 The Effect of Addition of Banana Peel Inhibitors on the Efficiency of Zinc Plate Inhibition in Chloride Acid Medium

Figure-6 shows the effect of addition of banana peel powder inhibitors on zinc plate inhibition efficiency. From Figure-6 it can be seen that efficiency increases with the addition of inhibitor concentrations and immersion time. The inhibition efficiency without the addition of inhibitors was 0%, while with the powder of banana peel as inhibitor; the highest inhibition efficiency of 90.93% was obtained by adding 9 g of powder, with an immersion time of 12 days.

Figure-6. Effect of addition of banana peel powder inhibitors on zinc plate inhibition efficiency.

The higher concentration of banana peel powder inhibitors used and the longer immersion time of zinc plate, the inhibition efficiency will be higher. This inhibition process occurs because the molecules of banana peel powder have a large size that can cover the active surface of the metal so that it can reduce the rate of corrosion [10].
Figure-7 shows the effect of adding banana peel extract concentrated inhibitors on inhibition efficiency. The highest inhibition efficiency of 93.79% was obtained by adding 9 g of concentrated extract with an immersion time of 12 days.

Figure-8 shows the effect of adding tannin of banana peel as inhibitors, and the highest inhibition efficiency of 90.93% was obtained by adding 9 g of tannin with a immersion time of 12 days.

The higher concentration of powder inhibitors, extracts inhibitors, and tannin inhibitors of banana peel inhibitors used and the longer immersion time of zinc plate, the inhibition efficiency will be higher. This inhibition process occurs because the molecules of banana peel have a large size that can cover the active surface of the metal so that it can reduce the rate of corrosion [11].

The addition of inhibitor concentrations improves the inhibitor coating on metals, so the inhibition efficiency increases [9]. The results obtained are in accordance with the theory, namely the value of inhibition efficiency depends on the concentration of the inhibitor and the duration of contact between the metal and corrosive medium, where the increasing the concentration of the inhibitor and the time of contact of the metal with the corrosion medium, the greater the inhibition efficiency.

CONCLUSIONS

The corrosion rate of zinc plate decreases with the addition of the Awak banana peel tannin inhibitors, Awak banana peel extract inhibitors, and the Awak banana peel powder inhibitors into 3% HCl solution. The lowest corrosion rate for each form of inhibitor was 10.23 mpy by using the Awak banana tannin inhibitor, 16.39 mpy by using the Awak banana peel extract inhibitor, and by using the Awak banana peel powder inhibitor which was 23.95 mpy. All of these rates were achieved with the addition of 9 g inhibitors and immersion time for 12 days.

REFERENCES

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