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The Additional of Inhibitors from Secang (caesalpinia) Leaf Extract in NaOH Solution to Minimize Aluminum Corrosion Rate

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Abstract

Corrosion is a material destruction process because of a reaction between metal and the environment. Iron is a metal that is easily corroded. But metal corrosion is not limited to iron, because there will be a lot of metal that turns out to undergo a corrosion process also one of them is aluminum. Aluminum is a soft and lightweight metal and has a dull silvery color due to the thin layer of oxidation that forms when this element is exposed to air. One corrosion prevention is to use a corrosion inhibitor that can be made using organic materials. Secang (caesalpinia) leaf flowers contain antioxidants such as anthocyanin and ascorbic acid which can be used to prevent or slow down the occurrence of corrosion. The calculation method used in this study is the method of measuring weight loss by gravimetric analysis. This inhibitor is used on aluminum metal which is immersed in 1 M NaOH solution. The concentration of inhibitor of the secang leaf flower is 20 ppm (parts per million) with time variations of 5, 15, 30, 45 and 60 minutes. Corrosion rate on aluminum before the addition of inhibitors with time variations is 0.047, 0.0598, 0.0719, 0.0786 and 0.0688 g / cm.minute. While the corrosion rate on aluminum after the addition of inhibitors namely 0.0356, 0.0465, 0.0536, 0.0757 and 0.0658 g / cm. Minutes with inhibitory power respectively 24.26%, 22.27%, 25.44%, 3.65% and 1.23%. Thus the presence of inhibitors from Secang Leaf Flowers (caesalpinia) causes the rate of corrosion of aluminum soaked in 1 M NaOH solution to be slower.

1. INTRODUCTION

Corrosion has become a very interesting study for scientists, because its existence can be said to be a great enemy that can cause so much harm to human life. The Battelle Institute has estimated the losses suffered by the United States due to corrosion reached 70 billion dollars (Avner, 1987). Another study conducted in England, estimated that 1 ton of steel turned into rust every 90 seconds (Allen, 1982). Corrosion is a process of destruction of material, especially metals because of a reaction between the metal and the environment. The process of material destruction that occurs causes a decrease in the quality of the metal material (Pattireuw, Jones, Kevin, Abdul Rauf, Fentje and Cresano, Romels, 2013). The concentration of corrosive material is related to the acidity or wetness of a metal solution which is in an acidic environment will quickly corrode while the base solution will also be exposed to corrosion as well. At present there are several ways to prevent corrosion, namely the selection of metals that are resistant to corrosion, environmental changes, anodic and cathodic protection (Callister, 1997). One of the metals that can be corroded apart from iron is aluminum. 100% pure aluminum does not have any elemental content other than aluminum itself, but pure aluminum sold on the market never contains 100% aluminum, but there is always impurity contained in it. Currently aluminum is the second metal that is often used after iron in various industries in the world (James, 2004). Aluminum alloys can be divided into two categories such as wrought alloys and cast alloys. Both have different types of symbols symbolized by ANSI H35 (James, 2004). One method that continues to be studied today is the prevention of corrosion by

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using corrosion inhibitors (Ilim and Beni, 2008). Corrosion inhibitors are chemicals that when added to an environment, can reduce the rate of corrosion that occurs in the environment of a metal in it (Akhmad Gumelar, Agung, 2011). To overcome the problem of corrosion in metals such as aluminum, corrosion inhibitor inhibitors can be made using organic materials such as plants, plants and fruits. Corrosion inhibitors with organic materials have lower prices and are environmentally friendly compared to toxic chemical inhibitors. With the addition of corrosion inhibitors, the level of corrosion that occurs with metals in a solution can be reduced. Meanwhile, the secang plant (caesalpinia) is a plant that belongs to the malvaceae family, which is a type of upright shrub that has many branches and flowers and stems that are colored and usually strikingly have dark green to red leaves. And has strong fibrous skin and stem. Secang plant has been known in Java since 1687 as kesur. Even since that year the Secang plant has been used as an ingredient for traditional drinks. A study that has been conducted shows that in 100 grams of dried secang leaf petals there are 1.9 proteins, 0.1 grams of fat, 12.3 grams of carbohydrates, 2.3 grams of fiber, and 14 milligrams of ascorbic acid, 0.04 B vitamins and original coloring components. Sumarno, 2004 also stated that rosella tea has a higher vitamin C content (ascorbic acid) than the vitamin C content in oranges. 3 times greater than black grapes and 9 times greater than the vitamin C content in citrus.

2. RESEARCH METHOD

The ingredients used are secang (Caesalpinia) leaf tea. Material is picked in fresh condition then dried. The inhibitors used were Secang leaf and flower extracts. Secang flowers and leaves are prepared and dried first with air-drying. Then the dried Secang is crushed to form a powder. Next Secang flower and leaf powder weighed as much as 15 grams. Secang powder which has been weighed and then extracted by extraction of soxhletation using ethanol as much as 300 ml. After that, the solution is distilled to separate ethanol with Secang flower and leaf extracts. The filtrate that has been collected is then evaporated, to separate the extract from the solvent. The crude extract obtained was weighed as much as 25 mg and dissolved with 25 ml of ethanol. And obtained an inhibitor solution with a concentration of 1000 ppm. It can be used as an inhibitor using weight loss measurement methods and gravimetric analysis.

2.1 Materials and Tools

The materials used in this study include dried Secang flowers and leaves, aluminum metal specimens, 1 M NaOH solution, aquadest and ethanol. While the tools used in this study include the oven, desiccator, distillation equipment series, series of soxhletation devices, analytical balance, separating funnel, chemical beaker, measuring cup, erlenmeyer, measuring pipette, measuring flask, stopwatch, pestle and mortar.

2.2 Corrosive Medium Preparation

The corrosive medium used was 1 M NaOH solution. The solid NaOH was weighed as much as 10 grams. Put distilled water into a measuring flask as much as 50 ml. Then 10 grams of NaOH solid was added to the measuring flask containing aquadest and rinse with the remaining solid aquadest into the measuring flask. Then homogenized until the NaOH solids are mixed. Then added aquadest to the 250 ml volumetric flask to the limit of the meniscus 250 ml volumetric flask to obtain 1 M NaOH solution.

2.3 Inhibitors of Secang Tea and leaf teas.

The inhibitors used were Secang Leaf and Flower extracts. Secang flowers and leaves are prepared and dried first with air-drying. Then the dried flowers and leaves are crushed to form a powder. Next

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Secang flower and leaf powder weighed as much as 15 grams. The weighing powder and Secang leaves that have been weighed are then extracted by soxhletation extraction using 300 ml ethanol solvent. After that, the solution is distilled to separate ethanol with Secang Leaf and Flower extracts. The filtrate that has been collected is then evaporated, to separate the extract from the solvent. The crude extract obtained was weighed as much as 25 mg and dissolved with 25 ml of ethanol. And obtained an inhibitor solution with a concentration of 1000 ppm.

2.4. Solution of Corrosive Media Mix and Inhibitor Solution

The concentration of the inhibitor solution using roselle calyx extracts used were 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm. 20 ml of 1 M NaOH solution is put into 5 100 ml volumetric flask, then 1 ml of 1 pL of inhibitor solution is added, 2 mL, 3 mL, 4 mL and 5 mL into a volumetric flask containing 20 ml NaOH solution and diluted with aquadest to the miniscus limit so as to obtain a mixture of inhibitor solution with each concentration of 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm.

2.5. Preparation of Test Objects

Test in the form of aluminum metal cut with a size of 7cm x 2.5 cm x 0.01 cm. The specimens were cleaned of impurities (grease and dust) using aquadest and acetone. After that, the initial weight of each specimen was weighed before being tested.

2.6. Corrosion Testing

Each aluminum sample that was prepared was dipped in a mixture of NaOH mixture and 60 ml inhibitor solution. The variations in the concentration of the inhibitor solution are 10 ppm, 20 ppm, 30 ppm, 40 ppm and 50 ppm. While the Soaking time (5 minutes, 15 minutes, 30 minutes, 60 minutes and 120 minutes). After soaking for a certain time, the specimens are removed, washed with a tube brush while flowing with water and acetone to remove corrosion products, then dried using hot air flow. After that the specimen is weighed again as the final weight.

2.7 Gravimetric Analysis

Analysis of the Study of Corrosion Rate of Aluminum Metal in Base Solution with the addition of Secang (Caesalpinia) Flower and Leaf Extract as an Inhibitor using Gravimetric analysis. After the corrosion process has been running for a certain time, the aluminum metal is removed from the corrosion media, then cleaned and washed carefully. Then the clean aluminum metal is allowed to dry for ± 15 minutes and weighed until a constant weight is obtained as its final weight.

Corrosion rate is calculated by the following equation:

$$\%I = \frac{ru - rp}{ru} \times 100$$

$$\theta = \frac{\%I}{100}$$

$$\text{Corrosion rate (millimeter / year)} = \frac{86{,}7\ W}{DAT}$$

Where ru is the rate of corrosion without inhibitors and rp is the rate of corrosion with inhibitors, w is the weight of the aluminum metal lost, D is the density of aluminium metal, A is the area of aluminum metal and t is the immersion time. I is the efficiency of inhibition and θ is the surface coverage.

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3. SUCCESS AND DISCUSSION

Corrosion is a process that occurs naturally and will not be able to stop as long as the metal is still in a corrosive environment. This process will damage the metal by eroding the metal which will then reduce the mechanical properties possessed by the metal.

In this study it can be seen that the media used can cause corrosion such as 1 M NaOH solution at room temperature and atmospheric pressure. The value of material loss (corrosion rate) of aluminum metal as a function of time can be seen in Table 1.

Tabel 1. Laju Korosi, Daya Inhibisi dan Surface Coverage sebagai Fungsi Waktu

C (ppm)	t (menit)	Laju Korosi (mm/tahun)	I	θ
0	60	13,3995	0	0
20	60	13,2341	1,23%	0,012
30	60	12,0304	10,22%	0,102
40	60	10,9110	18,57%	0,185
50	60	10,6093	20,82%	0,208

In Table 1 Corrosion Rate, Inhibition Power and Surface Coverage as a Function of Time show that the corrosion rate decreases and the inhibitory power of the Secang Leaf Flower extract increases with increasing concentration of the inhibitor. Material loss (corrosion rate) of aluminum metal as a function of the concentration of Secang and Leaf extract extracts in 1 M NaOH solution with a variation of immersion time can be seen in Table 2.

Tabel 2. Laju Korosi, Daya Inhibisi dan Surface Coverage sebagai Fungsi Konsentrasi

t (menit)	r_u	r_p	I (%)	θ
5	9,1493	6,93013	24,26	0,24
15	11,654	9,05848	22,27	0,22
30	14,003	10,4406	25,44	0,25
45	15,3094	14,7514	3,65	0,03
60	13,3995	13,2340	1,23	0,01

In Table 2, Corrosion Rate, Inhibition Power and Surface Coverage as a Concentration Function show that the corrosion rate increases with the length of immersion of the aluminum metal, while the inhibitory power decreases with the immersion time. These results indicate that the Secang Leaf and Flower extract inhibitors act as corrosion inhibitors for aluminum metal in NaOH solution at a studied concentration of 20 ppm and indicate the inhibition of aluminum metal corrosion in NaOH solution. The aluminum metal which is given an inhibitor has a slower rate of corrosion than the aluminum metal which is implanted into the NaOH solution without the addition of the inhibitor. This shows that the organic sample from the rosella petal extract is adsorbed onto the aluminum surface so that the reaction site is blocked, and protects the aluminum from aggressive OH-ion attack from the alkaline solution. There are several types of organic compounds in rosella calyx extract, namely anthocyanin and ascorbic acid. In the solution, ascorbic acid is unstable and will slowly decompose to dehydroascorbic acid (DAA). However, this DAA will be unstable at pH above 6 and high temperatures because DAA will further decompose into acids, such as tatric acid and oxalate, causing a decrease in pH. The structure of tannin molecules can be seen in Figure 2.10:

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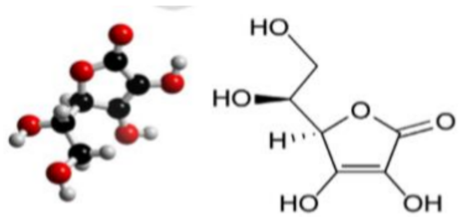

Gambar 2.10. Struktur molekul dari asam askorbat (vitamin c)[13]

Figure 2.10. Molecular structure of ascorbic acid

Ascorbic acid can inhibit corrosion because ascorbic acid can form complex compounds. Complex compounds formed by ascorbic acid will later coat the metal so that it is useful to prevent corrosion. The functional group that plays a role in the interaction between ascorbic acid molecules and the surface of aluminum forming a protective membrane is the hydroxyl group. Hydroxyl groups in ascorbic acid molecules can form covalent bonds with aluminum.

This is supported by the fact that the more ascorbic acid is adsorbed, the greater the inhibitory power, so the corrosion rate decreases. Adsorption of these compounds on aluminum surfaces reduces the surface area available for aggressive OH ion attack from an alkaline solution. As presented in Table 1. Corrosion Rate, Inhibition Power and Surface Coverage as a Function of Time, there is a significant decrease in corrosion value with the addition of inhibitors.

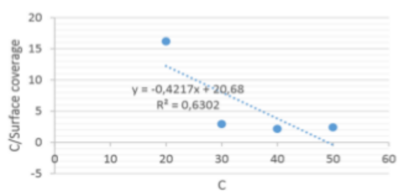

Figure 2. Langmuir Inhibitor Isotherm Adsorption Model on the surface of Aluminum Metal

As shown in Figure 2. Langmuir Ishoterm Adsorption Model Inhibitors on the surface of the Aluminum Metal shows the amount of inhibitor concentration from the extract of roselle petals to the concentration per surface coverage. The linear correlation coefficient obtained by plotting between C (inhibitor concentration) against C / Ø is 0.6302. This confirms that corrosion inhibition is caused by the process of adsorption of organic compounds on the aluminum metal surface. In the research results, the adsorption of isotherms obtained is not constant (not horizontal) but is found to increase.

The adsorption results obtained are in accordance with the Langmuir Ishoterm Adsorption theory as in the following equation:

$$\frac{c}{\emptyset} = c + \frac{1}{K}$$

The Langmuir Ishoterm Adsorption Theory is the assumption that the adsorbent has a homogeneous surface and can only adsorb one adsorbate molecule for each adsorban molecule at a constant temperature, there is no interaction between the molecules absorbed. The adsorption process is influenced by several factors including concentration, surface area and contact time.

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Tabel 3. Berat Logam Aluminium yang Hilang dalam Medium Korosif

t (menit)	Berat tanpa Inhibitor	Berat dengan Penambahan Inhibitor
5	0,0235	0,0178
15	0,0898	0,0698
30	0,2158	0,1609
45	0,3539	0,341
60	0,413	0,4079

Table 3. Weight of Missing Aluminum in Corrosive Medium

The aluminum metal corrosion kinetics model with the addition of inhibitors and without the addition of Secang (Caesalpinia) Flower and leaf extract inhibitors can be seen in Figures 3 and 4.

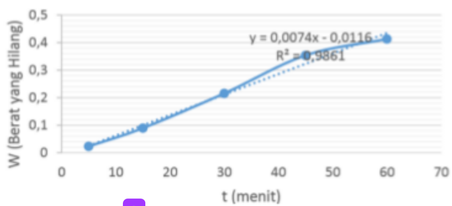

Figure 3. Kinetics Model of Order 0 for Corrosion of Aluminum Metal Without Addition of Inhibitors

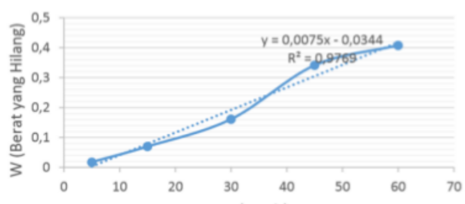

Figure 4. Kinetics Model of Order 0 for Corrosion of Aluminum Metal with Addition of Inhibitors

In Figure 3. Kinetics Model of Order 0 for Corrosion of Aluminum Metal Without Addition of Inhibitors and Figure 4. Kinetics Model of Order 0 for Corrosion of Aluminum Metal with Addition of Inhibitors shows how the influence of the length of immersion time on the weight of aluminum metal is lost. The effect of immersion time is directly proportional to the weight of the lost metal. The longer the immersion time, the greater the weight of aluminum metal lost. By plotting between time (t) and weight lost (Wt) by following the equation:

$$Wt = kt$$

By using the equation above, obtained a straight or linear equation for aluminum metal without the addition of inhibitors is 0.9861 while the addition of inhibitors is 0.9769 so that the corrosion kinetics of aluminum metal either without or with the addition of inhibitors follows the kinetics of zero order reactions (0).

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4. CONCLUSION

Based on the results of research that has been done obtained the following results:

1. With the addition of Secang Leaf and Flower extracts as corrosion inhibitors proven to be able to inhibit the rate of corrosion of aluminum metal in 1 M NaOH solution that takes place at room temperature (30 ° C) and atmospheric pressure (1 atm). In the inhibitor concentration of rosella calyx extract 20 ppm with a variation of time 5 minutes, 15 minutes, 30 minutes, 45 minutes and 60 minutes, the inhibitory power obtained were 24.26%, 22.27%, 25.44%, 3, respectively. 65% and 1.23%.

2. Linear correlation coefficient obtained is 0.6302 so it can be seen that the corrosion inhibition process is caused by the adsorption of organic compounds on the aluminum metal surface and the adsorption process in accordance with the Langmuir Ishoterm Adsorption theory.

3. Correlation kinetics of aluminum metal corrosion without or with the addition of an inhibitor follows the reaction kinetics of order 0 (zero) obtained from the measurement of aluminum weight reduction with respect to aluminum immersion time. From the straight or linear equation on aluminum metal without the addition of inhibitors obtained 0.9861 regression while the addition of inhibitors is 0.9769.

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