Efficiency of SS400 steel corrosion bioinhibitor from Moringa leaf (Moringa oleifera L.) extract in NaCl solution medium

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Abstract. Steel was one of a metal mainly used to create things because hard, long-term, and can be generated in large amounts. It was easy getting corrosion, damage to metal material caused by environmental factors. Therefore, it was necessary to reduce the corrosion rate by corrosion inhibitor. A study had been done on the efficiency of steel corrosion SS400 inhibitor from moringa leaf extraction (Moringa oleifera L.) in NaCl 3% solution medium. The objective was to determine soaking time and concentration of corrosion inhibitor from moringa leaf extract to inhibit the corrosion of the steel plate with the highest efficient value. The corrosion examination was conducted with a weight-loss method. Results showed that moringa leaf extract could be used as a corrosion inhibitor for steel plate SS400 in NaCl 3% with soaking time was five days in concentration 2000 ppm was 43.06%.

1. Introduction

Steel is one type of metal widely used to make equipment because it is strong, durable and can be produced in large quantities. Steel has a disadvantage namely that it is easy to experience corrosion where corrosion can be defined as the damage deterioration of a metal due to an electrochemical reaction with its environment which results in reduced metal weight and is emitted from its alloy components [1].

Corrosion events cause many losses to tools that use metal materials; this is because corrosion can reduce the service life of the tool system failure shutdown. Basically, corrosion can be prevented by converting ferrous metal into stainless steel (stainless steel) but this process is considered too expensive for most iron several other ways that can be used to minimize corrosion reactions include coating metal surfaces, cathodic protection and adding corrosion inhibitors [1, 2, 3].

Corrosion inhibitors are divided into two based on the type of material, namely inorganic and organic inhibitors. Some of the inorganic compounds used as corrosion inhibitors on metals are phosphate, chromate, dichromate, silicate, borate, tungstate, molybdate, and arsenate. However, these compounds are hazardous materials, they are relatively expensive and not environmentally friendly The compounds used in organic inhibitors are heterocyclic compounds containing N, O, P, S atoms, and atoms that have lone pairs. This lone pair of electrons will bond with the metal and form complex compounds [4,5]

The compounds contained in organic inhibitors are types of antioxidant compounds namely tannins. Moringa oleifera L. plants are plants that contain antioxidants one of which is polyphenol derivatives (tannins). Moringa leaf extract contains tannins (8.22%), saponins (1.75%), alkaloids (0.42%) and phenol (0.19%) therefore Moringa leaf extract has good potential as an inhibitor. Corrosion [5]. In this study using low alloy steel one of the low alloy steels is SS400 steel with 3% NaCl as a corrosion medium. SS400 steel has a mixture of iron (98.31%), carbon (0.20%), manganese (1.40%), phosphorus (0.05%) and sulfur (0.05%) components. 3% NaCl solution was chosen as a medium in the corrosion
reaction of steel plates. NaCl 3%’s as the medium is because of its nature as a strong electrolyte, which contains a lot of sodium ions (Na+) and dissolved chloride (Cl-) ions when compared to distilled water. Chloride ion (Cl-) is very reactive to iron, so it can accelerate the corrosion rate [3, 5].

2. Materials and methods
The material used in this research is Moringa leaves taken in the city of Palu. Methanol (pa), NaCl (pa), distilled water, aluminum foil, filter paper, SS400 steel plate, Grade 80 and 120 sandpaper. The tools used are analytical balance, vacuum rotary evaporator, volumetric flasks, 60 mesh sieve, buchner funnel, micrometer screw glassware which are generally used in laboratories and blenders. Moringa leaves are dried and then crushed using a blender and sieved using a 60 mesh sieve. Extraction was carried out using methanol by weighing 500 grams of powdered Moringa leaves and placing it in a 1000 mL erlenmayer. Then 1000 mL of ethanol is added, then stored for 3 x 24 hours, after which it is vacuum filtered and concentrated with a vacuum rotary evaporator. The concentrated extract was weighed 10 grams and dissolved with 1 L ethanol and obtained an inhibitor solution with a concentration of 10000 ppm then diluted to get a concentration of 1000; 2000; 3000; 4000 ppm.

2.1 Steel plate preparation
SS400 steel plate samples with a thickness of 3 mm are cut to the size of 50 x 20 mm. the top of the steel plate was punched with a 3 mm drill so that it could be hung during the immersion process. The steel plate is cleaned using grade 80 sandpaper and followed by grade 120 sandpaper.

2.2 Corrosion testing with variations in concentration and immersion time
The immersion vessels of 20 pieces are filled with 250 mL 3% NaCl solution each. Inhibitor solutions with various concentrations of 0, 1000, 2000, 3000 and 4000 ppm were put into these containers as much as 50 mL.

The prepared steel plate was put into each container that had been filled with 3% NaCl solution and the immersion inhibitor solution was carried out with variations in soaking time, namely 5, 10, 15, and 20 days. After soaking, the steel plate samples were rinsed with acetone and distilled water to remove any rust residues and rinsed again with ethanol and then dried. After that the steel plate is weighed again as the final weight. The corrosion rate of steel is calculated using the formula for determining the corrosion rate:

\[
CR = \frac{KW}{A.T.\rho}
\]

Information :
- CR = Corrosion rate (mm / year)
- K = 8.76 x 104
- W = Difference in mass before and after corrosion (W₀-W₁) (gram)
- A = Surface area (cm²)
  - = 2 (pxl + pxt + lxt) - 2πr² + 2πrt
- P = Density of steel (g / cm³)
- T = Immersion time (hours)

Next is to calculate the efficiency of the inhibitor using the equation:

\[
% E = \frac{CR₁-CR₂}{CR₁} \times 100\%
\]

Information :
- % E = inhibitor efficiency
- CR₁ = corrosion rate without inhibition
- CR₂ = rate of corrosion by inhibition
3. Results and discussion
The extraction of *Moringa oleifera* L. leaves was carried out by maceration method using methanol as solvent. Methanol was chosen as a solvent because methanol is polar, which will dissolve polar compounds in the sample. Tannins are polar compounds so that these compounds can be extracted if using methanol as a solvent. The extraction results obtained from 500 grams of moringa flour were massaged for 72 hours namely in the form of thick green liquid with a yield of 90.34 grams [5].

3.1 Corrosion test results of SS400 steel plate in 3% NaCl corrosion medium with the addition of Moringa leaf extract inhibitor
The corrosion rate is a measure that determines the amount of degradation of metals caused by interactions with their environment. The greater the value of the corrosion rate, the higher the degradation caused by corrosion. In this study using the weight loss method. The principle of this method is to calculate the amount of metal material that is lost or lost weight after immersion in the corroding medium.

3% NaCl solution was chosen as a medium in the corrosion reaction of SS400 steel plate. The choice of NaCl 3% as the medium is due to its nature as a strong electrolyte, which contains a lot of dissolved sodium (Na +) and chloride (Cl-) ions when compared to water. The chloride ion (Cl-) usually acts as an aggressive ion because it is very reactive to iron so that it can destroy the passive layer on the surface of carbon steel and accelerate the corrosion rate [5,7].

![Figure 1. SS400 steel plate in 3% NaCl medium with the addition of inhibitor and without inhibitor after immersion](image1)

The soaked steel plate was then visually observed. The results showed that there was no significant difference between the samples with the addition of the inhibitor and those without the addition of the inhibitor. This can be seen from the shape of the surface which together form a layer deposit of brown rust. Then the steel plate sample was cleaned using the pickling method.

![Figure 2. Steel plate after cleaning using the Pickling method](image2)

The difference is in the stickiness of the deposit where the layer in the system with the addition of an inhibitor is more difficult to remove or pickling than the one without the addition of the inhibitor, while the deposit layer in the system with the addition of an inhibitor is not easily separated so that it can be said that the layer deposit contained in the sample is more stable. The final sample was then weighed to see the difference before and after immersion in the corroding medium. After that the corrosion rate of the steel plate wa calculated to determine the effect of Moringa leaf extract inhibitor.

Based on Figure 3 shows that the longer the immersion time, the corrosion rate will also increase. For systems with the addition of Moringa leaf extract inhibitor, the corrosion rate decreased in 20 days of immersion. This is following the literature, where according to the longer the immersion time, the
more rust deposits are formed, the rust deposits that are formed will prevent the diffusion of O$_2$/H$_2$O into the metal surface so that the corrosion rate will decrease [8,9]

\[ \text{Corrosion rate} = \frac{\text{mass loss}}{\text{metal surface area} \times \text{time}} \]

**Figure 3.** Effect of concentration and immersion time on the corrosion rate of SS400 steel plate

The highest corrosion rate was found at 20 days of immersion without the addition of an inhibitor of Moringa leaf extract, which was 0.1665 mm/year, while the lowest was at five days of immersion with the addition of 2000 ppm of Moringa leaf extract inhibitor, which was 0.0640 mm/year.

### 3.2 Effect of immersion time and inhibitor concentration of Moringa leaf extract on efficiency of SS400 steel plate corrosion

Based on the calculation of the corrosion rate of the steel plate, then it is entered into the calculation of inhibition efficiency. This efficiency calculation is needed to determine the ability of the inhibitor to inhibit the corrosion rate.

**Figure 4.** Effect of immersion time and concentration variations on the corrosion inhibition efficiency of SS400 steel plate

Figure 4 shows that the inhibition efficiency decreased from 5 to 10 days, then increased at 15 to 20 days of immersion. The lowest efficiency was found at 10 days of immersion at a concentration of 4000 ppm, namely 3.30%, while the highest efficiency was found on the 5th day, which was 43.06% at a concentration of 2000 ppm. Based on the results obtained, the percentage of inhibition efficiency of the best Moringa leaf extract was obtained at 5 days immersion with a concentration of 2000 ppm, namely 43.06%. The results of this study are higher than those of using guava leaf extract (*Psidium guajava* L.) with an efficiency of 37.93% [9, 10]

### 4. Conclusion

Based on the research results, it can be concluded that *Moringa oleifera* L. leaf extract can be used as a corrosion inhibitor for SS400 steel plate in 3% NaCl medium with the optimum concentration of Moringa leaf extract corrosion inhibitor at a concentration of 2000 ppm and the immersion time with the highest efficiency value is at 5 days of immersion with an efficiency of 43.06%.
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