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To cite this article: R Tambun *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **420** 012059

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Banana peel utilization as the green corrosion inhibitor of Iron in NaCl medium

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Abstract. Iron is widely used as construction material in industries, but iron will be easily corrosion when used in a corrosive medium. To overcome this problem, corrosion inhibitors are used. This study aims to use Awak Banana (*Musa paradisiacal var. Awak*) peel as iron corrosion inhibitor in 3% NaCl medium. In this experiment, the unripe Awak Banana peel acts as a corrosion inhibitor. The use of Awak banana peel as iron corrosion inhibition is varied in powder of banana peel, crude extract of banana peel, and tannin of banana peel. The results obtained that tannin of Awak banana peel, extract of Awak banana peel and Awak banana peel powder could be used as iron corrosion inhibition in NaCl Medium. After 12 days the iron is immersed in NaCl medium, the lowest corrosion rate is obtained by applying a tannin of Awak banana peel inhibitor, where the corrosion rate is 0.964 mpy. The highest inhibition efficiency amount of 67.9 % is also obtained by using tannin of Awak banana peel as inhibitor.

1. Introduction

Many industries use iron (Fe) in the process, but in its use, iron is often exposed to a corrosive environment such as acidic, alkaline and salt environment [1, 2]. Corrosion is the degradation of a metal as a result of chemical reactions between metal and the surrounding environment [3]. Developed countries are known to spend 3-5% of their country's revenues for controlling corrosion [4]. This makes the corrosion is a crucial problem that greatly affect the operational, economic and safety of workers [5, 6]. To prevent this problem, the iron is protected by corrosion inhibitors. Inhibitor is one of the solution to reduce the rate of corrosion. Corrosion inhibitors can decrease corrosion rate effectively. However, most inhibitors have toxin compounds that give the side effect on the environment and human [7]. Therefore, the organic inhibitors is developed. Organic inhibitors are a safe type of inhibitor because they have very eco-friendly, biodegradable, economical, and easily found in nature [8]. The organic inhibitor works by adsorption to protect the metal surface. The active center of electrons in the organic compound forms an adsorptive bond with a Lewis acid-base reaction in which the inhibitor acts as an electron donor and metal as an acceptor [9]. Unripe "Awak" banana (*Musa paradisiacal var. Awak*) peel, a variety of banana that can be found in North Sumatra, will be used as the corrosion inhibitor. The tannin contents of unripe banana peel, almost ripe and ripe are 6.48 %, 4.97 % and 4.69%, respectively [10]. The OH⁻ group in tannin compounds able to form bonds with iron and metallic cations. The ferric tannate is formed when Fe³⁺ reacts with OH⁻ [11]. In this study, the unripe Awak banana peel is divided into three forms, namely in the form of banana peel powder, crude extract of Awak banana peel, and tannin of Awak banana peel. The division of these forms are done to determine the ability of Awak



banana peel as a corrosion inhibitor of iron, whether the Awak banana peel must be extracted into tannin, or can be used directly in powder form or in the crude extract form.

2. Methods

Materials used in this study are iron specimen (Fe), NaCl solution as medium, Awak banana peel (*Musa paradisiacal var. Awak*) from Pringgagan Market Medan, distilled water, methanol, FeCl₃, ethyl acetate. The equipment used in this research include beaker glass, rotary vacuum evaporator, Whatman no 41 filter paper, oven, blender, and analytical balance.

a. Preparation of banana peel powder and crude extract

The banana peel is dried in the air to remove the water content. The banana peel is cut into small pieces. Banana peel is blended to be powder. The banana peel is sieved by using sieve tray of 50 mesh. The powder is macerated with methanol at a ratio of 7:1 and left for 24 hours. After 24 hours, the filtrate is filtered with Whatman no 41 filter paper. The filtrate is removed with a rotary vacuum evaporator at a temperature of 65°C into a paste form. The concentrated extract is analyzed qualitatively.

b. Qualitative analysis

Crude extract of 1 g is added 10 ml water and heated to boiling. The filtrate is filtered and 1% FeCl₃ solution is added as much as 10 drops. The presence of tannin is shown by the change of color to blackish.

c. Tannin separation from crude extract

The crude extract of banana peel is dissolved with ethyl acetate, stirred until dissolved, then settled to form precipitate. The precipitate is filtered and then washed again with ethyl acetate until the filtrate is clear. The insoluble precipitate in ethyl acetate is tannin.

d. Preparation of iron specimen

An iron specimen with a size of 1 cm x 2 cm x 0.06 cm smoothed the surface with steel emery. The iron specimen is washed with detergent and distilled water, then dried in an oven with a temperature of 110°C for 2 hours.

e. Soaking iron specimen in 3% NaCl solution without the presence of inhibitor

The iron specimen is weighed in the initial mass, then immersed in 50 ml of 3% NaCl solution for 12 days, then the corrosion rate is calculated.

f. Soaking iron specimen in 3% NaCl solution with addition of inhibitor

The iron specimen is weighed in the initial mass, then immersed in 50 ml of 3% NaCl solution, and variations of the inhibitor form are performed. The inhibitors used are powder of banana peel, crude extract of banana peel, and tannin of banana peel with each 9 g of inhibitor concentration, stored for 12 days. Then the rate of corrosion reaction and the corrosion inhibition efficiency of each inhibitor are calculated.

g. Corrosion rate calculation

After 12 days, the iron specimen is removed from the corrosion medium then washed and dried in an oven with a temperature of 110°C. The iron specimen then weighed the mass eventually. The corrosion rate, CR (mils/year or mpy) is determined by equation (1) and the corrosion inhibition efficiency is determined by equation (2) [12]:

$$CR = \frac{KW}{DA t} \quad (1)$$

Where K is constant (3.45×10^6), W is mass loss (g), D is density (g/cm^3), A is surface area (cm^2), and t is immersion time (hours).

$$\text{Corrosion Inhibition Efficiency (\%)} = \frac{C_{R0} - C_{Ri}}{C_{R0}} \times 100 \% \quad (2)$$

with C_{Ri} is corrosion rate with inhibitor (mils/year) and C_{R0} is corrosion rate without inhibitor (mils/year)

3. Results and Discussion

The Fourier Transform Infrared (FTIR) is used to analyze chemical compounds of Awak banana peel compound. Each functional group in a material will absorb a different spectrum, so that the chemical characteristics of the material can be described as at Figure 1.

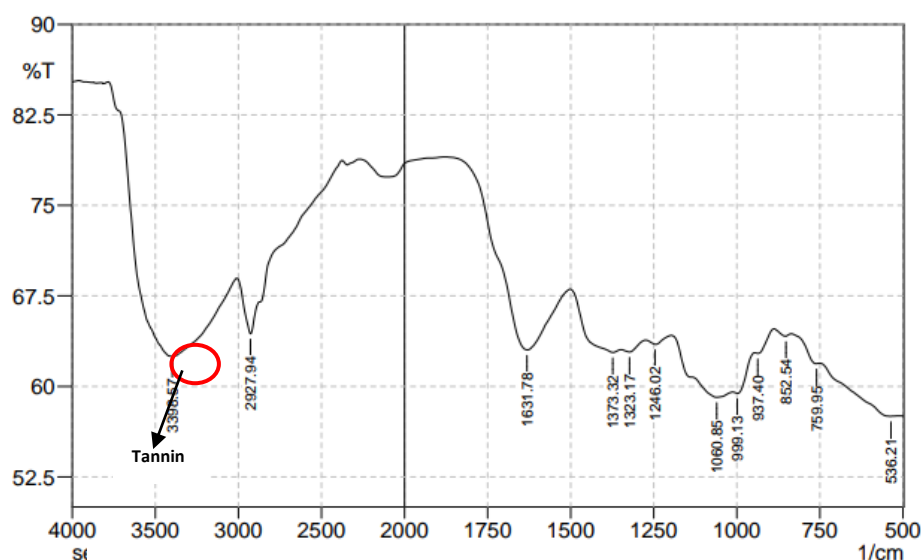


Figure 1. FTIR Analysis

From figure 1 we can be seen that the banana peel contain a phenol (OH) group characterized by peak 3398.57 cm^{-1} , where the wavelength region of the phenolic group is $3705\text{--}3125 \text{ cm}^{-1}$. Peak 2927.94 cm^{-1} indicates that Awak banana peel contains alkane (C-H) compounds which according to theory at wavelength $2863\text{--}2961 \text{ cm}^{-1}$, while peak 1631.78 cm^{-1} indicates the amide compound (C=O) which according to the theory at wavelength $1300\text{--}1655 \text{ cm}^{-1}$, peak $3132, 3544 \text{ cm}^{-1}$ for gallic acid and peak $3232, 3441 \text{ cm}^{-1}$ indicates tannic acid as specific commercial form of tannin [13]. Hence, the Awak banana peel contains tannin compounds.

The corrosion rate of iron after 12 days without inhibitor and by using inhibitor of banana peel powder, crude extract of banana peel, and tannin of banana peel are shown at Figure 2. The corrosion rate without inhibitor is very high, but decreased with the addition of inhibitors from the banana peel. The lowest corrosion rate is obtained by applying a tannin of banana peel inhibitor, where the corrosion rate is 0.964 mpy . This process occurs due to adsorption of tannin molecules in banana peel to the surface of the iron specimen. The tannin

molecules of banana peel suppresses the reaction of the iron with the medium forming a protective layer so that the iron surface is separated from the corrosion medium [14].

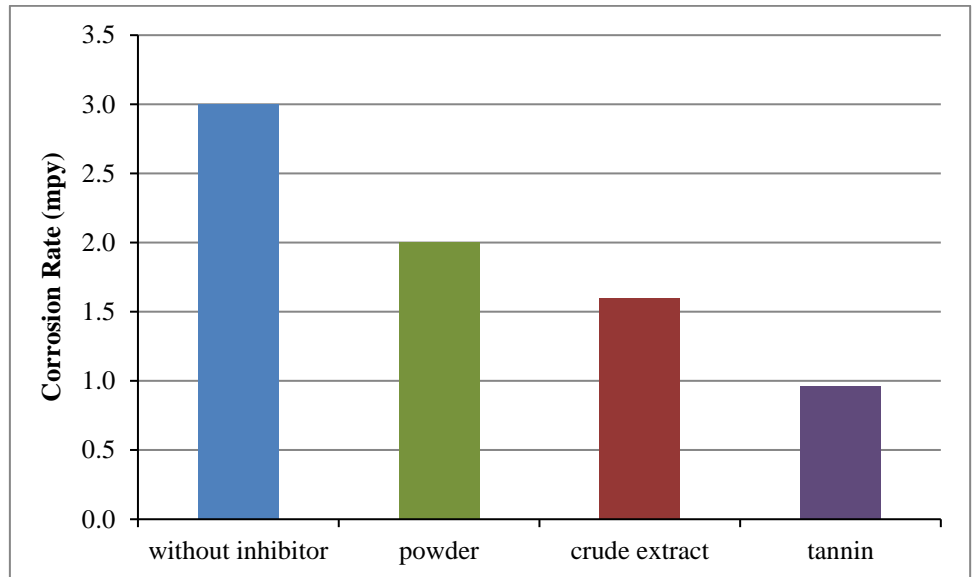


Figure 2. Influence of inhibitor type on corrosion rate

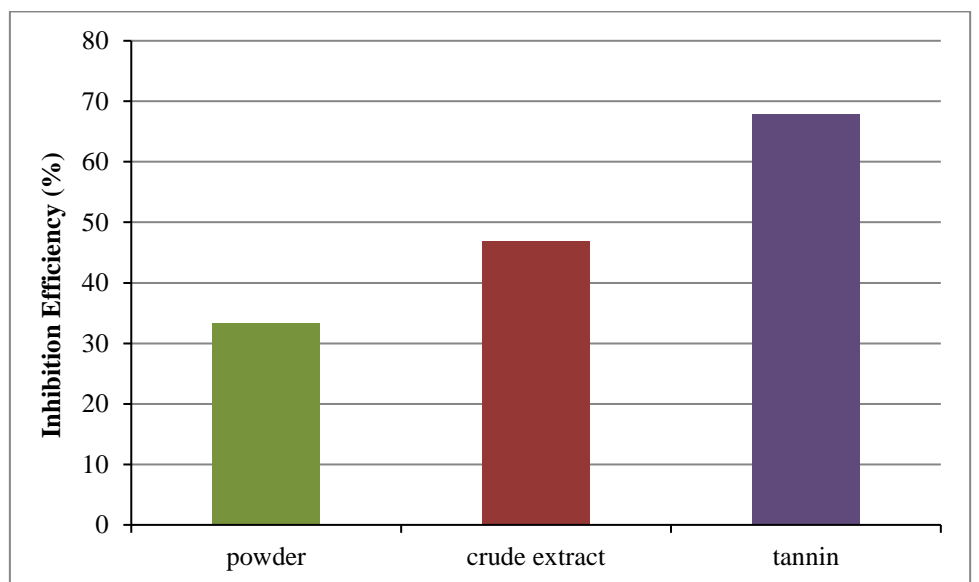


Figure 3. Influence of Inhibitor Type on Inhibition Efficiency

Figure 3 shows the corrosion inhibition efficiency by using powder of banana peel, crude extract of banana peel, and tannin of banana peel. The highest corrosion inhibition efficiency amount of 67.9 % is obtained by using tannin of Awak banana peel, followed by crude extract of banana peel, and powder of banana peel has the lowest corrosion inhibition efficiency. The mixture of some compounds in adsorption may increase the adsorption action,

but may also interfere with the adsorption action. Powder and crude extracts the banana peel compounds interfere with each other to be adsorbed on the iron specimen resulting in less effective adsorption, because besides tannin, banana peel contains carotene, phenolic, flavonoid, magnesium, calcium, etc. When the compound is not pure, each component of the compound will compete each other in order to be adsorbed to the adsorbent [15-18]. This phenomenon causes tannin inhibitors adsorbed on iron specimens better than crude extract of banana peel and powder of banana peel inhibitor.

4. Conclusion

The tannin of Awak banana peel, extract of Awak banana peel and powder of Awak banana peel could be used as iron corrosion inhibition in 3% NaCl medium. The lowest corrosion rate about is 0.964 mpy and the highest inhibition efficiency about 67.9 % are obtained by using tannin of banana peel as inhibitor.

5. Acknowledgement

The authors would like to thank Universitas Sumatera Utara for Research Grant, under TALENTA Fundamental Research Scheme 2018, No: 2590/UN5.1.R/PPM/2017, dated March 16, 2018.

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