

The Use of Cacao Peels Extract (Theobroma Cacao) as the Corrosion Inhibitor on Steel Layers Electrodeposition



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Abstract

An electro deposition of Ni film has been carried on steel substrat using 0,5M NiSO₄.6H₂O solutions with the addition of cacao peels extract inhibitor. This study performed electro depositon variation of time and inhibitor concentration variation of cacao peels extract were performed with the tensile of 3V 2mA. There was morphology difference occurred on steel before and after being electrodeposited. The adding of extract cacao peels inhibitor influenced morphology as well and minimized the occurrence of corrosion on steel surface. Referred to characterization result in order to see morphology using optical microscope and SEM, the result was better on 1% inhibitor concentration with 25 minutes electro deposition time. Steel surface was seen more evenly and finer. Seeing it through XRD result, the constructed peaks were thinner by adding cacao peels extract inhibitor. The inhibition efficiency result of corrosion rate measurement using potentiodynamic polarization resulted 16.8% of %IE for 1% concentration, and 66.88% for 1.5% concentration. The more inhibitor concentration increased, the more and the better the compounds acted as corrosion inhibitor. The weight loss method measurement obtained an increase on corrosion rate and inhibition efficiency and more cacao peels extract inhibitor concentration.

Keywords: Steel; Electrodeposition; NiSO₄; Cacao peels extract; Inhibitor

Introduction

Steels are utilized in industry world because of its strength, easily forged and oxidized, good conductivity like iron, copper, steel, zinc, and aluminium. One of applications in using the steel is through off shore piping, bridge construction, building, framework of a vehicle. However, it is easily oxidized as it is directly interacted with its surrounding and causes corrosion. Corrosion are not only hazardous for human and environment, but also economically causes considerable costs and huge loss [1] even threatening human safety [2,3]. Corrosion is a destructive process as a result of chemical reaction between metal or alloy with its environment [4,5]. Hence, corrosion on metal is a reduction reaction process and chemical oxidation or electrochemical causing electron transfer from steel to environment, so metal oxidation number changed from zero to positively charged [3].

In order to prevent the metal from destruction and to have good performance, several techniques have been applied in minimizing the corrosion attack, by cleaning, painting or coating its surface. The more efficient and easier way to coat the steel surface is by using the electro deposition method. Electrodeposition is coating the steel surface with other metals using electrolyte solution

[2], which is NiSO₄. Another way taken for coating is by adding inhibitor solution, where this inhibitor is aimed to slow down its corrosion rate. There are many inhibitors can be perceived like organic inhibitor and inorganic one. Inorganic inhibitor is more harmful as it is included into chemical compound and relatively high-cost. Meanwhile inorganic inhibitor can be obtained from nature, relatively low-cost, and easy to use. Therefore people can make use of organic compounds found in nature as inhibitor, where the chosen natural products are those containing tannin substance, and preventing corrosion process occurred.

Moreover, several researches have been conducted using plants like pinus, gambeer and coffee extract [5], pineapple extract inhibitor [6], paniculata extract [7], red peanut extract inhibitor [8], aningeria robusta extract [9], camellia sinensis extract [10], soursop leaves extract [11], red spinach leaves extract [12].

Corrosion inhibition study and mild steel mechanical properties recovery using cacao (Theobroma cacao) peels extract in acid media [3] have been investigated. Likewise, the study on eco-friendly inhibitor corrosion behaviour of cacao peels

extract for mild steel in NaCl 1.5M [13] corrosive media has been investigated. Thus, this study concerns on making use of cacao peels extract as inhibitor which is going to be coated onto steel surface using electro deposition method by adding NiSO_4 substance.

Materials and Method

The making of electrolyte solution

The electrolyte used is NiSO_4 and made by weighting 20 grams NiSO_4 , then adding 3 grams H_3BO_3 , and dissolved in 200mL aquadest. After that, this solution is stirred using magnetic stirrer for 30 minutes at room temperature.

The making of cacao peels extract

Obtained cacao peels extract is thinly sliced and wind dried for 14 days. Once it is dried, grinded using the grinding machine. Then grinded cacao peels extract is macerated using 70% ethanol for 5 days, filtered and concentrated by using evaporator vacuum. The result obtained is concentrated extract of cacao peels. This concentrated extract continuing the process to be as primary solution and further dissolved into varied concentration of 0%, 0.5%, 1%, 1.5%, 2% and 2.5%.

Corrosion rate measurement

Potential-dynamic Polarization: It is a method in determining metal corrosion property based on potential connection, and anodic and cathodic current. Polarization is reaction potential deviation of its equilibrium potential. It is either in the form of anodic, if the anodic process in cathode is accelerated by changing potential in positive way, or in the form of cathodic polarization, if the cathodic process is accelerated by transferring respective potential in negative way [4].

Applied potential line (potential-greater) toward current density is commonly known as Tafel plot. The slope of Tafel, corrosion potential (E_{corr}), and corrosion current density (I_{corr}) can be indicated using extra polarization way. This Tafel Method provides information on the number of produced corrosion current (I_{corr}) on steel surface interacting with corrosive solution. Hence, further obtained current value can become performance parameter of a corrosion inhibitor. Inhibition efficiency can be identified with the equation below (1),

$$\%IE = \frac{I_{\text{unh}} - I_{\text{inh}}}{I_{\text{unh}}} \cdot 100 \quad (1)$$

where I_{unh} is current in the absence of inhibitor, and I_{inh} is solution current in the presence of inhibitor. The higher the inhibition efficiency value (%) of a solution containing particular compound, the better the compound acted as corrosion inhibitor.

Weight loss method: Weight loss method is measuring the weight loss occurred on metal before and after being immersed in corrosive solution for particular length of time. Corrosion rate on this method can be decided using the equation below (2) [14].

$$V = \frac{\Delta}{A} \quad (2)$$

where A is cross section area, Δm is weight lost and t is time. Whereas, inhibition efficiency is determined by using the equation (3) as follow:

$$\%IE = \frac{V_0 - V_1}{V_0} \cdot 100\% \quad (3)$$

Where V_0 is corrosion rate in the absence of inhibitor and V_1 is corrosion rate after receiving inhibitor treatment on corrosive media.

Result and Discussion

Surface Characterization

Initially surface characterization was recognized using optical microscope, where the whole result of time difference and cacao peels extract inhibitor concentration were visualized using this microscope. The result of this microscope can be seen in Figure 1.

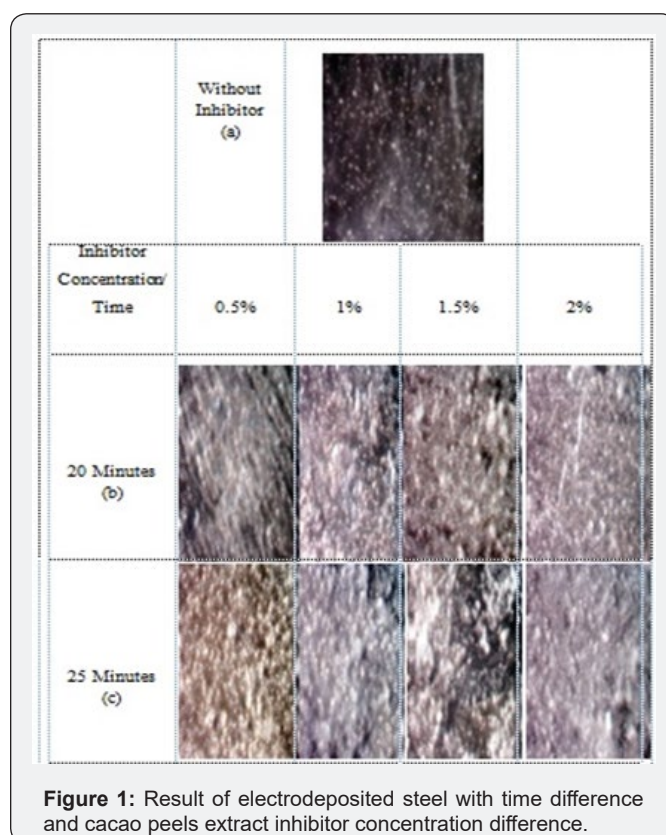


Figure 1: Result of electrodeposited steel with time difference and cacao peels extract inhibitor concentration difference.

The observation result using optical microscope with 100x magnification, 3V voltage and 2mA current, showed steel surface yet being electrodeposited and the one electrodeposited by adding inhibitor concentration variation of cacao peels extract inhibitor, and by varying the time.

It could be seen that the implemented variation of time was 20 and 25 minutes with 0.5%, 1%, 1.5%, 2% on differences of cacao peels extract inhibitor concentration. The result of concentration variation and time variation of the best result was obtained on the time of 25 minutes with 1% concentration and on 20 minute with 1.5% concentration. The obtained best result from optical microscope was proceeded to characterization test by using SEM.

SEM

The next characterization was conducted using SEM, where the sample for this characterization was the best sample from obtained optical microscope result. The sample had fine surface after being electrodeposited by adding 1% and 1.5% cacao peels extract inhibitor concentration. SEM result could be seen in Figure 2.

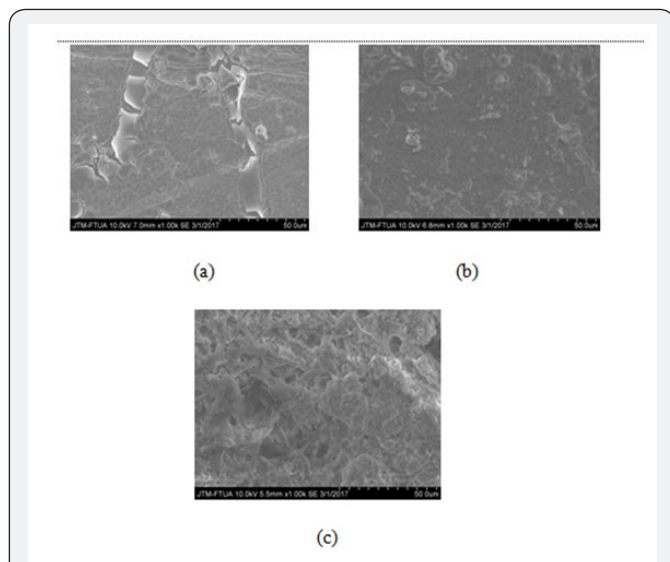


Figure 2: The result of electrodeposited steel SEM by using NiSO_4 with (a) in the absence of inhibitor (b) in the presence of 1% inhibitor concentration, (c) in the presence of 1.5% inhibitor concentration, and (d) with 60° Celsius temperature, with 1% inhibitor concentration and time for 25 minutes.

Figure 2 shows the presence of layers resulted from electro deposition which can prevent corrosion occurred. While Figure 2a shows steel SEM result in the absence of inhibitor addition, seen that steel surface is only coated by NiSO_4 solution. Figure 2b shows with the addition of 1% cacao peels extract inhibitor, seen that steel surface is more evenly and finer. Then, Figure 3c indicates that even though the surface is more even by the adding 1.5% inhibitor, it is seen rougher as the result of much inhibitor concentration given.

The addition of cacao peels extract on the electro deposition process could minimize corrosion product and holes on steel surface by constructing passive layers on the surface. These layers functioned as barrier on the corrosive ion attack on steel surface, so that the electrochemical reaction starting to slow down and eventually decreasing the corrosion rate [15].

XRD

The result of XRD on two electrodeposited samples in the absence and in the presence of cacao peels extract inhibitor can be seen in Figure 3. The three samples in Figure 3 demonstrate the two peaks; Fe and Ni peak. Figure 3a is XRD result taken from steel samples without electrodeposited in the beginning. Whereas in Figure 3b exhibits some Ni peaks resulted from electro deposition

process using NiSO_4 solution, where Fe peak covered by Ni peak. However in Figure 3c with the addition of cacao peels extract in electro deposition process, these obtained Ni peaks are forming thin layer in order to minimize the occurrence of corrosion.

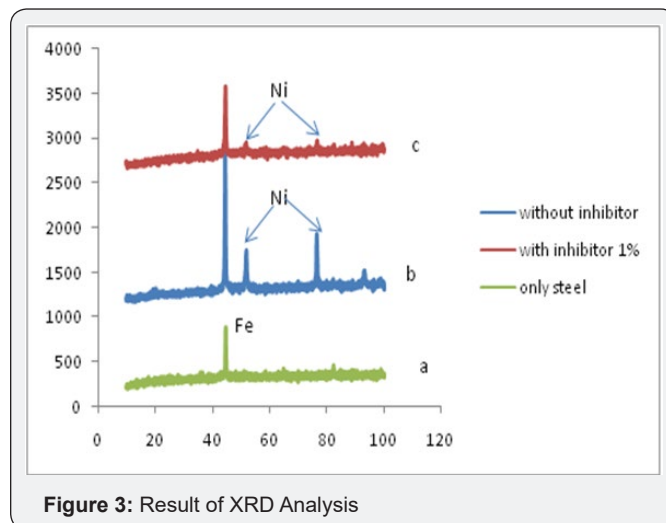


Figure 3: Result of XRD Analysis

Potential-dynamic polarization method

Steel polarization curve as the result of NiSO_4 electro deposition by adding cacao peels extract inhibitor with concentration differences; 1% and 1.5% in HCl 1N solution and been extra polarized into Tafel line can be seen in Figure 4. The result in Figure 4 indicates that the higher the inhibition efficiency value of solution containing tannin compound, the better the tannin compound acted as corrosion inhibitor. Result of %IE corrosion parameter as seen in Table 1.

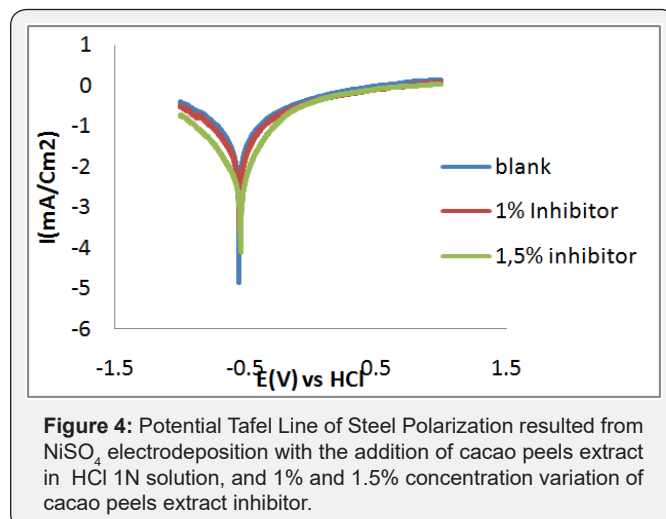


Figure 4: Potential Tafel Line of Steel Polarization resulted from NiSO_4 electro deposition with the addition of cacao peels extract in HCl 1N solution, and 1% and 1.5% concentration variation of cacao peels extract inhibitor.

Table 1: Steel corrosion parameter in HCl 1N in the absence and in the presence of cacao peels extract inhibitor obtained from polarization measurement.

Concentration % V/V	I _{corr}	E _{corr}	%IE
Blank	7,58927	0.59	-
1%	15,14258	0.69	16.82%
1.5%	26,92775	0.79	66.88%

Weight-loss method

The measurement result of corrosion rate and inhibition efficiency applying weight loss method with the formula (2) and (3) indicated that the addition of cacao peels extract into corrosion medium caused the corrosion rate decreasing, and in the contrary the inhibition efficiency increasing. It was due to the steel surface covered by molecules in cacao peels extract. The cacao peels extract molecules covering metal surface were absorbed onto the respective steel surface forming passive layer protecting steel from active ions attack which was in the acid solution. Formed passive layer derives from oxygen and functional group on cacao peels extract [15]. Figure 5 indicates that the longer the immersion time, the higher the corrosion rate as the longer the immersion takes time, the more weight loss occurred [16].

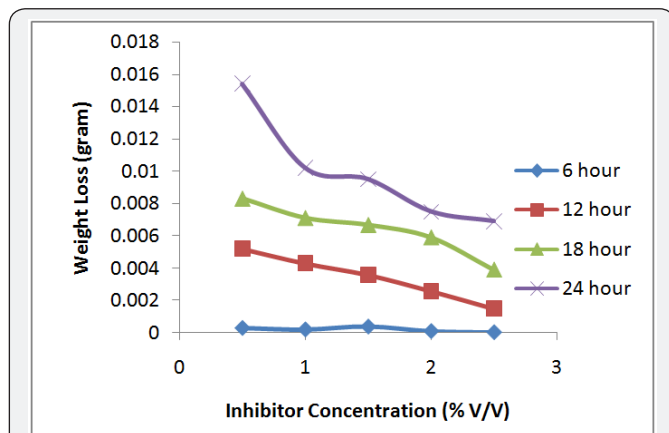


Figure 5: Cacao peels extract inhibitor concentration vs weight loss with immersion time variation.

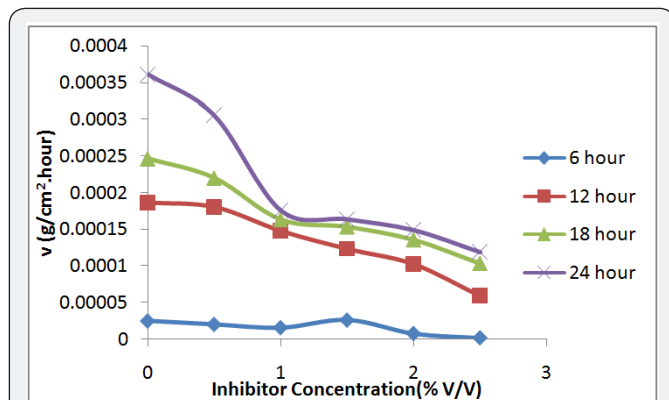


Figure 6: Cacao peels extract concentration vs steel corrosion rate in HCl 1N with immersion time variation. Immersion time vs steel corrosion rate with inhibitor concentration variation of cacao peels extract.

In Figure 6 can be seen, the effect of the addition of cacao peels extract inhibitor to the corrosion rate, the longer the immersion time causes the increase of corrosion rate and with the addition of inhibitor of cacao peels extract will decrease the corrosion rate. This is because the more inhibitors of cacao peels extract are added, the more cacao peels extract is adsorbed on the steel surface, so that the surface-formed layer can inhibit the corrosive

rate attack on the steel surface, so that the corrosion rate of steel can be inhibited [1,16,17]. On the other hand, Figure 7 shows that the increase on immersion time causes the more mass loss occurred and it stimulates desorption [16].

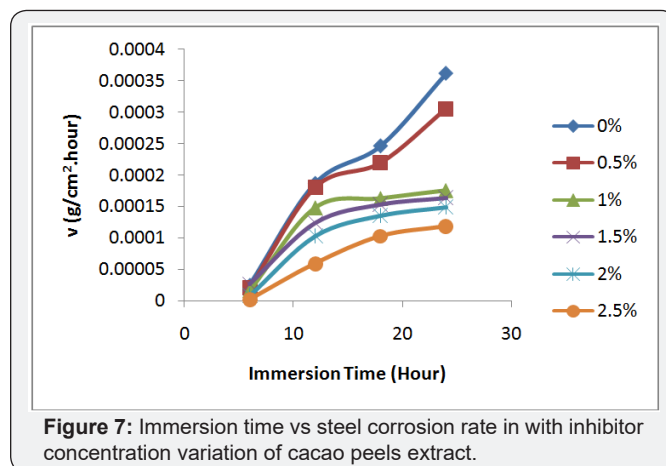


Figure 7: Immersion time vs steel corrosion rate in with inhibitor concentration variation of cacao peels extract.

Conclusion

By using 2 Volt, optimum electro deposition result is obtained through morphology on 25 minutes time and 1% cacao peels extract inhibitor concentration. Based on characterization result of electrodeposited steel surface, the morphology surface becomes more evenly and finer, and with the absence of porosity on steel sample of electro deposition by adding 1% cacao peels extract inhibitor.

The corrosion test result shows that inhibition efficiency of cacao peels extract increasing in line with the increase on concentration. Conversely, the corrosion rate decreases in line with the increasing of cacao peels extract inhibitor concentration. Based on potentiodynamic polarization method, it is known that cacao peels extract inhibitor is in the form of anodic and cathodic.

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