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Surface Characteristics on Mild Steel Using Aqueous Extract of Cassava (*Manihot esculenta*) Leaves as a Corrosion Inhibitor

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ABSTRACT

Surface characteristics of mild steel have been studied using FT-IR, UV-Vis Spectroscopy, Spectrometer, and Scanning Electron Microscopy. The shift in the wave number at FT-IR of the aqueous extract of cassava leaves (AECL) and products on the steel surface after soaking with AECL extract. UV-Vis spectrum of the solution before and after immersion with AECL extract showed no significant difference in the form of a spectrum and does not seem to indicate a maximum absorbance iron complex formation. It shows, the weakness of interaction and adsorption between mild steel with AECL extracts called physisorption . SEM showed the formation of a thin layer on the surface of the steel on steel that has been soaked in a solution of 0.5 M H_2SO_4 to AECL extract

Keyword: Corrosion, Surface Characteristic, Cassava, physisorpsy

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INTRODUCTION

Environmentally friendly corrosion inhibitor has been developed to protect metal against corrosion, especially in acidic media. Hydrochloric acid and sulfuric acid is usually used as industrial acid cleaning and pickling acids [1]. The electron density and high alkalinity owned by heterogeneous organic compounds such as N, O, P, S and aromatic rings can be used as a corrosion inhibitor. This compound can adsorb on the metal surface by forming a thin layer of complex compounds that separates a thin layer between the metal and the acid solution so as to reduce the corrosive attack [2,3].

The natural product is used as a corrosion inhibitor is an extract from plants such as leaves, roots, stems, and seeds. Chemical content owned by plant extracts that can be used as a corrosion inhibitor is the sugar, steroids, gallic acid, tannins, flavonoids and others [4]. Research corrosion inhibitor derived from natural products has been carried out as Theobroma cacao peels [5], Artemisia pallens [6], Bamboo leaves [7], Neolamarckia cadamba [8], Moses paradisica peels [9], Orange peel [10], Citrus peel [11], Geisospermum leaves [12]have been reported as good inhibitor.

Gusti has reported corrosion inhibitor of cassava (Manihot esculenta) leaves water extract with influence of temperature and thermodynamics [13]. Now, we report the characteristics of mild steel surface by FT-IR, UV-Vis spectroscopy, SEM, spectrometer technique and the rate of corrosion and the efficiency of steel corrosion for 72 hours at room temperature.

MATERIALS AND METHODS

2.1. Mild Steel Preparation
Content of steel used are 0,195 %C, 98,5 % Fe, Si 0,22 %Si, 0,654% Mn, 0,0786 %Cr. The steel obtained from the market town of Padang Indonesia. Steel spherical shape with a diameter of ± 2.5 cm in thickness from 0.3 to 0.5 cm. Before the steel used is polished with sandpaper and then cleaned with water and acetone [13].

2.2. Aqueous Extract of Cassava Leaves (AECL)
The extraction process cassava leaves based scheme below:

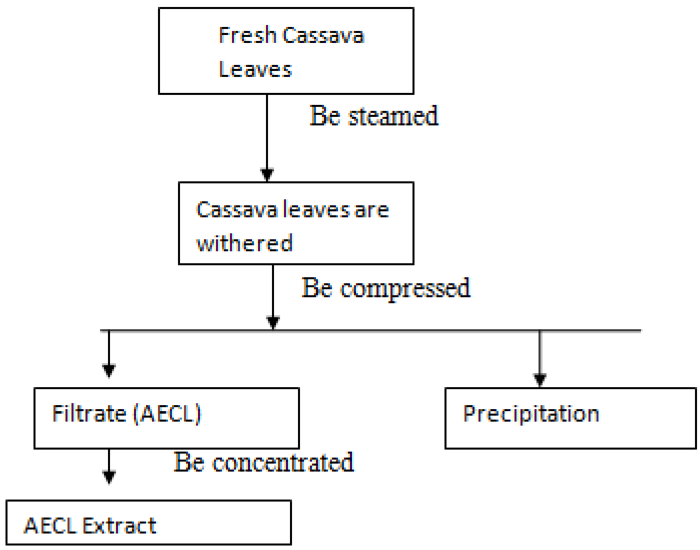


Figure 1. Scheme from aqueous extract of cassava leaves (AECL)

2.3. Solution preparation
0.5 M H_2SO_4 solution is used as the corrosive medium. AECL extract dissolved with H_2SO_4 with a concentration of 0, .1 g / L, 0.5 g / L, 1 g / L, 5 g / L, and 10 g / L .

2.4. Surface Characteristics
IR spectrum was studied using a Thermo Scientific FT-IR. Wave number of 4000 - 500 cm^{-1}. Samples tested were AECL extract samples and corrosion products after treatment on the surface of the steel. UV-Vis spectrometer Thermoinsight gauge mild steel samples after immersion in 0.5 M H2SO4 with and without AECL extract as a corrosion inhibitor. Electron Scanning Microscopy (SEM) at 500X magnification showed mild steel surface before treatment, after immersion in sulfuric acid with and without AECL extract for 72 hours.

2.5. Weight Loss Method
Mild steel immersed in H_2SO_4 solution with the concentration of extract AECL respectively are 0.1 g / L, 0.5 g / L, 1 g / L, 5 g / L, and 10 g / L for 72 hours at room temperature. After it is removed, cleaned with water and acetone and weighed. The rate of corrosion and corrosion efficiency is calculated based on the equation below[14]:

$$C_R = (W_b - W_a) / (S.t)$$

Where C_R is corrosion rate, W_b and W_a is the steel weight before and after immersion. S is the area of steel and t duration of immersion

Percentage of corrosion inhibition efficiency is calculated by the following equation [13]:

$$\% \eta = (C_{R\,(Blank)} - C_{R\,(Inh)}) / (C_{R\,(Blank)}) \times 100\%$$

Where % η is the percentage of inhibition efficiency η, $C_{R\,(Blank)}$ and $C_{R\,(Inh)}$ shows corrotion rate the absence and presence of the inhibitor in the sulfuric acid

RESULTS AND DISCUSSION

3.1. FT-IR analysis

FT-IR was used to identify the functional groups of the components in the extract. The spectrum of the AECL extract (Fig 2a) indicates a hydroxyl group (OH) in wave number 3388.48 cm-1, C-C Conjugation with C = O at 1616.80 cm-1, C-H methyl at 1412.67 cm-1, C-O aromatic ether at 1265.01 cm-1, C-O alcohol at 1080.81 cm-1. Corrosion product on the surface of the steel in 0,5 M H_2SO_4 by the addition 10 g/L AECL extract were immersed at room temperature for 72 hours (Fig 2b) showed a trend similar pattern to Figure 2a. but there has been a shift in peak frequencies and there are parts missing. Hydroxy groups shifted to 3411.60 cm-1. Conjugated C-C with C=O appeared at 1628.87 cm-1. C-H methyl shifts at 1400.44 cm-1 and C-O alcohol at 1096.84 cm-1. The peak aromatic from C-O ether is disappeared. Lost their peaks and the shift shows the interactions that occur between the steel AECL extract the sulfuric acid solution.

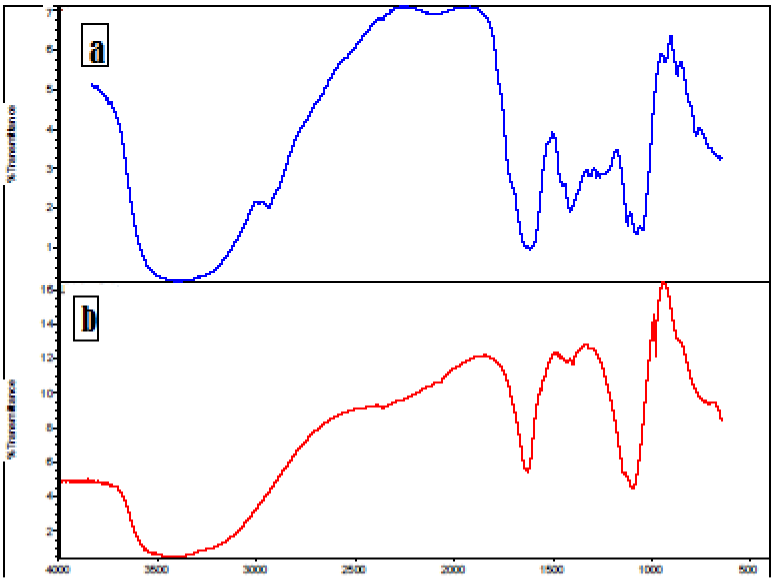


Figure 2. Figure 3.1. FT-IR spectrum (a) Extract CLesw b) Corrosion product on the surface of the steel in 0,5 M H_2SO_4 by the addition 10 g/L CLESW extract were immersed at room temperature for 72 hours

3.2. Foundry-Master Xpert spectrometer analysis

C and Fe content analysis of steel in 0,5 M H_2SO_4 with and without AECL extracts for 72 hours can be performed using a spectrometer

Table 1. The content of surface mild steels elements on Foundry-Master Xpert spectrometer

Treatment	Element content (% by weight)	
	C	Fe
Without treatment	0,195	98,5
Immersion in 0,5 M H_2SO_4	1,47	94,5
Immersion in 0,5 M H2SO4 in CLESW extract	>1,5	89,6

The element of Fe decreased in steel immersion in 0,5 M H_2SO_4 without and with AECL extracts concentration respectively 94.5% and 89.6%. The element of Fe decreases because there are additional elements of O. element Fe on immersion in H_2SO_4 to form iron oxide. Fe in 0.5 M H_2SO_4 immersion in AECL extract 10 g / L decreased due to absorption AECL extract forms a thin layer on the surface of mild steel [14].

3.3. UV spectra analysis

The formation of the metal complex can be seen in UV-Vis spectroscopy investigation. No maximum absorbance appears to indicate that it does not appear to the formation of complexes in solution in the steel immersion in a solution of 0.5 M H_2SO_4 with AECL extract.

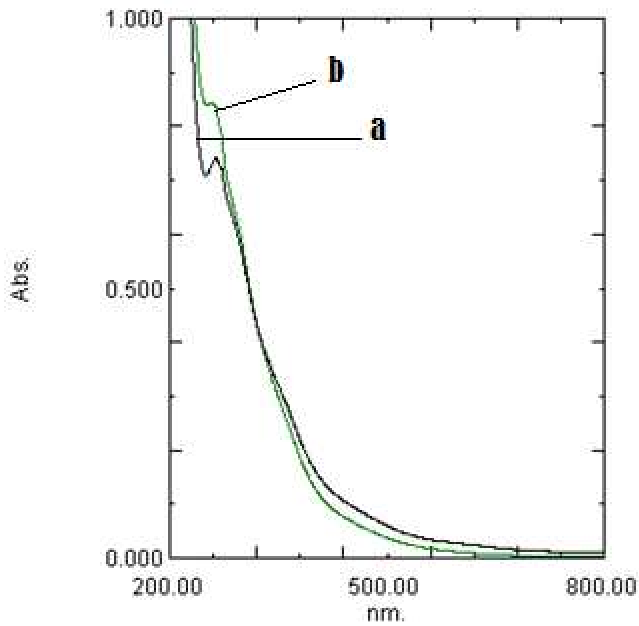
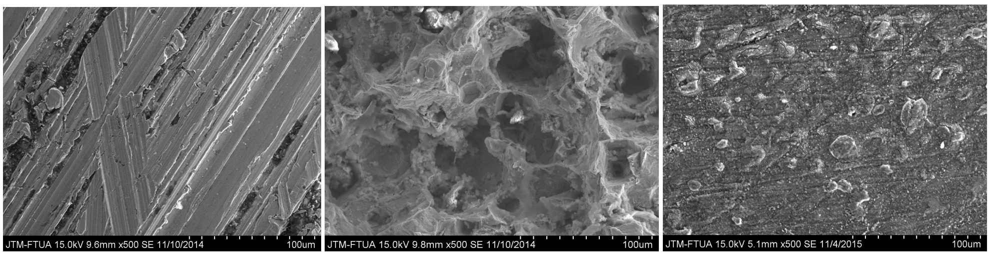


Figure 3. a) Fresh AECL extract in 0.5 M H_2SO_4. b) Solutions of steel immersion in a solution of 0.5 M H_2SO_4 with the presence of AECL extract for 3 days

Judging from the image spectrum (fig 3) before (a) and after immersing the steel in 0,5 M H_2SO_4 solution with the presence of AECL extract for 3 days (b), showed no significant difference. The spectrum (fig 3) results showed the weakness of interaction and adsorption between mild steel and AECL extract. It indicates that the dominant physical properties in the adsorption process. Gusti [13] has reported thermodynamic analysis of the inhibition of mild steel in sulfuric acid using AECL extract that kind of adsorption is physisorption

3.4. Scanning Electrone Microscopy (SEM)

Mild steel surfaces before treatment after immersion in 0,5 M H_2SO_4 with and without AECL extract seen using Scanning Elektron Microscopy (SEM) (Fig4).



A B C

Figure 4. The surface of the mild steel with 500x magnification. (A) before treatment. (B) after immersion in a solution of sulfuric acid 0.5M. (C) after immersion in a solution of sulfuric acid in the presence of 0.5M CLESW extract 10 g / L for three days at room temperature

Steel surfaces exposed in 0,5 M H_2SO_4 to showed the shape of the rough with large holes (B) compared to mild steel which is not exposed to sulfuric acid. There has been an attack of corrosion.It is caused by the interaction of H^+ and SO_4^{-2} ions on the surface of the mild steel. In presence of the extract on the mild steel surface in fig 4c revealed a layer covering the surface and the absence of holes. Formation of a protective inhibitor layer at the mild steel surface on the mild steel surface reduces corrosion attack. [12, 16, 17].

3.5. The rate and efficiency inhibition of Corrosion

Gusti [13] has explained that the weight loss method can determine the rate of corrosion and corrosion efficiency. 3.5 From the graph indicated that the corrosion rate will be smaller with an increase in concentration and inhibition efficiency increased with increasing concentration.

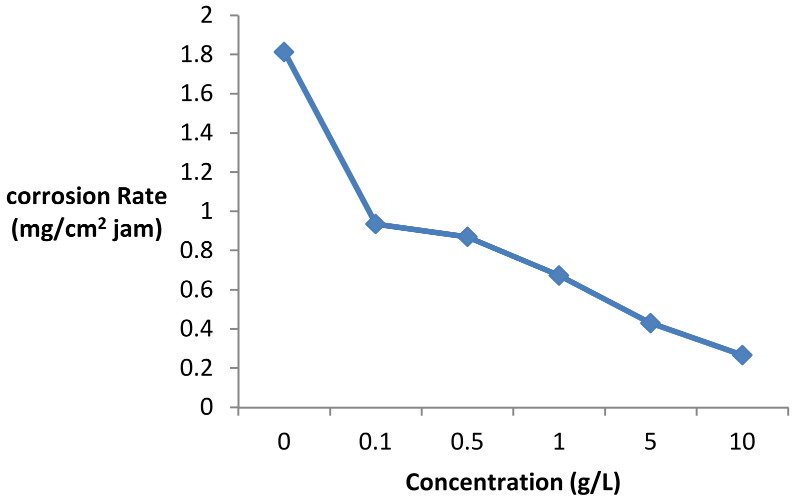


Fig. 5. The concentration of inhibitor against corrosion rate of the steel St.37 in H_2SO_4 solution in immersing for 72 hours at room temperature

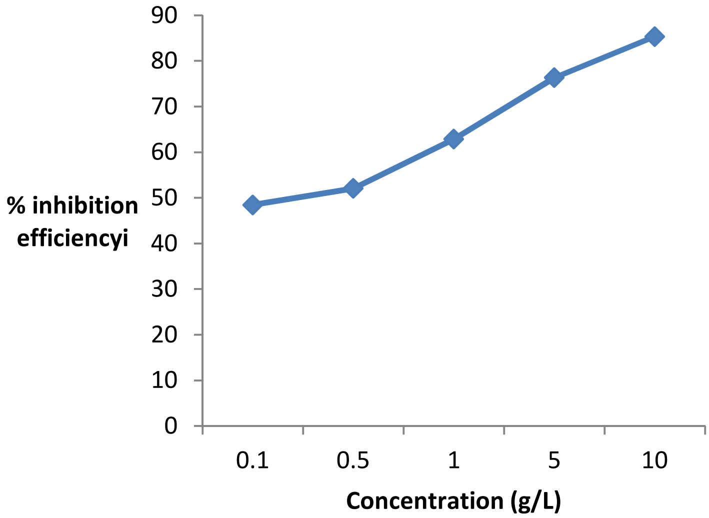


Fig. 6. The concentration of inhibitor versus the percentage inhibition efficiency St.37 steel in H_2SO_4 solution in soaking for 72 hours at room temperature

The smaller the rate of corrosion and inhibition efficiency increases with increasing concentration, this is due to the adsorption of extract CLESW forming a thin layer that protects the steel surface thereby reducing the corrosion rate and increasing the efficiency of inhibition.

CONCLUSION

The result of IR spectrum, UV-Visible spectrum, and SEM showed steel immersion in sulfuric acid in the presence of the AECL extract is physisorption. The formation of a thin layer of the AECL extract on the steel surface resulting in corrosion rate is lowered and the inhibition efficiency increases with the increase in concentration.

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