Rice Husk Extracts Ability to Reduce the Corrosion Rate of Mild Steel

M. Pramudita, Sukirno, and M Nasikin

***Abstract*—Rice husk extracts ability to reduce the corrosion rate of mild steel in 1 M H_2SO_4 solution was studied using weight loss technique. XRD analyzed silica structure of rice husk extracts. The Inhibitor was added in various concentrations (0, 10, 15, 20 and 25 ppm) at different immersion times (2, 4 , 6 and 8 h). The results obtained indicate that rice husk extract acts as a good inhibitor for mild steel. Rice husk extract was able to reduce corrosion rate up to 4.77 mmpy with inhibition efficiency exceeded 90 in 1 M H_2SO_4 solution. X-ray Diffraction (XRD) analysis shows the silica structure present in rice husk extracts is amorphous, thus makes it more environmentally friendly.**

***Index Terms*—Rice husk extract, bio corrosion inhibitor, natural resources.**

I. Introduction

Corrosion is identified as one of the industrial problems, particularly for industries involving fluids in steel pipelines, cooling system, boiler feed water system, etc. [1]. One way to reduce corrosion effects is to use inhibitor. Application of inhibitor needs to be safe and environmentally friendly [2]

Nowadays, research regarding natural products as corrosion inhibitor has received much attention. Natural products are not only environmentally friendly but also inexpensive and renewable [3]. Silica from rice husk extracts is one of the natural resources with the ability to reduce corrosion rate. Hence, it is necessary to be studied and developed.

Silica is a compound with the ability to reduce corrosion rate, due to its muscular adhesion strength, a good barrier for diffusion water vapor, ions and oxygen on the surface of a metal and thus protects metal from corrosion. Also, silica has good thermal stability and chemical resistance [4]. Silica acts as an anodic inhibitor, which reduces corrosion rate through adsorption onto the metal surface and generates a thin protective layer [5].

Rice husk is one of the natural resources for silica. It is obtained from a by-product of paddy milling which produces 65% rice, 20% rice husk and waste [6]. However, utilization of rice husk is not commercially widespread, due to its characteristics such as rough properties, low nutrition content, low density and high content of ash [7]. According to composition data, rice husk contains 16.98% of silica [8].

Silica from plant extract exists in an amorphous structure, while silica in rocks, ashes or sands are in the crystalline structure. Amorphous silica has the random pattern and uneven atoms and molecules order. As a result, amorphous silica has complicated structure and high surface area (up to 3m2/gram [9]. Moreover, amorphous silica is not toxic and eco-friendly, whereas crystalline silica is carcinogenic [10].

Previous research on silica from rice husk extract was conducted by Azwizar *et al.* [11]. Rice husk used was from Kedah, Northern Malaysia. This study was performed using carbon steel sample in distillate water as a medium, and the results reported inhibitor efficiency of 99% in 20 ppm concentration.

In the current study, rice husk extracts ability to reduce the corrosion rate of mild steel was observed. The investigation was conducted using mild steel sample in 1 M H2SO4 solution as corroding medium, at room temperature.

II. Materials and Methods

A Silica Preparation Methods

Rice husk (Ciherang type) acquired from Cilegon, Banten, Indonesia, was used in this study. Rice husk was cleaned and burned at 973 K for two hours to isolate silica and remove any impurities. The result was white ash. Rice husk ash was passed through a 60-mesh sieve, weighed (10 gr) and extracted using reflux technique at 358 K using NaOH 1 M as a solvent for 1 hour. Rice husk extract was then filtered using filter paper to separate filtrate from residue. Afterward, to reach neutral pH (6.5 – 7), 1 M HCl was gradually added to the filtrate. Filtrate with neutral pH was held for eight hours to form a gel-like precipitate. After precipitation occurs, the remaining solution was filtered and dried in an oven at 378 K until it reached a stable weight. XRD analysis was then carried out to determine crystallinity of a sample.

B Preparation of Silica Bio-Inhibitor Solution from Rice Husk Extract

Silica powder and 1 M NaOH were prepared. Silica powder was then dissolved in 1 M NaOH solution in a beaker with various concentrations (10, 15, 20 and 25 ppm).

C Silica from Rice Husk Extract Analysis

X-ray Diffraction (XRD) was conducted to analyze amorphous properties of silica.

D Mild Steel Preparation

Mild steel with composition (%wt) 0,54Mn, 0,05Si, 0,01S, 0,01P, 0,16C and the remaining Fe was used. Mild steel

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sample (30 x 20 x 10 mm) was mechanically polished with abrasive SiC papers grade 200# - 1000#. A sample was washed with distillate water, rinsed with acetone and dried. The sample was subsequently weighed to determine initial weight.

E Weight Loss Method and Analysis

In the present work, weight loss technique was applied to evaluate the samples [10]. The sample was accurately weighed and was immersed in corroding medium 1 M H_2SO_4 and silica rice husk extract as bio inhibitor with various concentrations (0, 10, 15, 20 and 25 ppm) for 2, 4, 6, and 8 h. After immersion, the sample was removed and cleaned with brushes under running water. The sample was dried and weighed to determine final weight. From the available data, weight loss was determined, and the corrosion rate was calculated as follows [11]:

$$C_R\,(\text{mmpy}) = \frac{87500\text{x}\Delta W}{Apt} \tag{2.1}$$

where CR is corrosion rate; ΔW is weight loss (gram); A is coupon surface area (cm^2); ρ is the density of mild steel (gram/cm^3), and t is immersion time (hours).

Inhibition efficiency was determined using equation as follows:

$$I.E\% = \left(1 - \frac{C_{Rinh}}{C_{Rblank}}\right)\text{x}100 \tag{2.2}$$

III. Result and Discussion

A. X-Ray Diffraction (XRD)

Amorphous and crystalline properties can be determined by X-ray diffraction (XRD). Rice husk calcined at the temperature above 973 K generates crystalline silica [12], which can be identified by the presence of sharp peaks in XRD analysis. These sharp peaks imply regularity in the atomic structure of rice husk and structural change from amorphous to crystalline [13]. Silica with amorphous properties is depicted by broad peaks in XRD analysis.

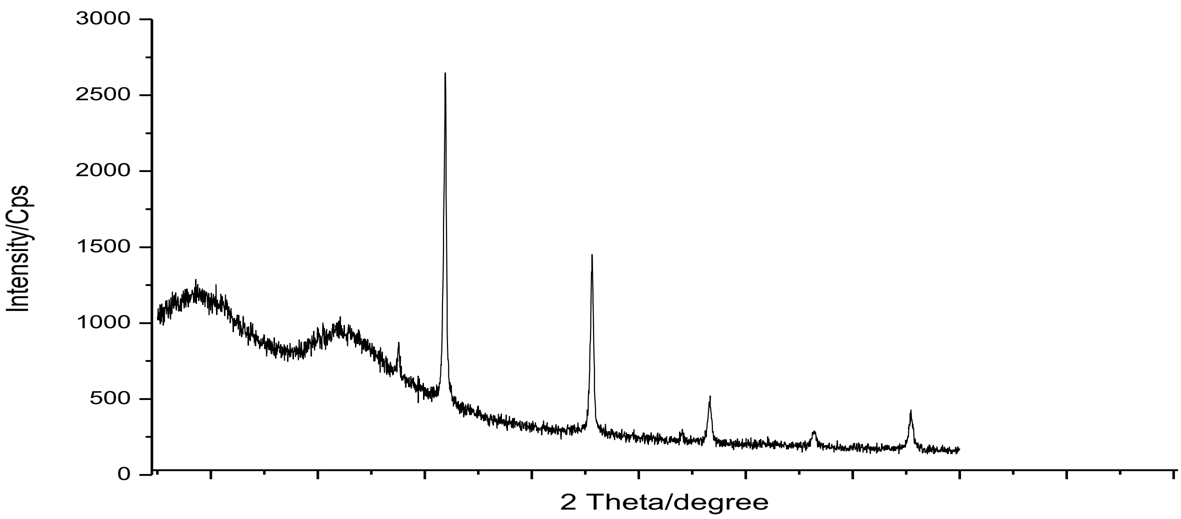

Fig. 1. XRD analysis of silica.

XRD analysis shows broad peaks (Fig. 1). Therefore, it can be concluded that silica exists in the amorphous crystal. Several high peaks may be occured from NaCl content from neutralization process with HCl. Amorphous properties of silica indicate obtained silica is safe for the environment. Silica with a crystalline structure is carcinogenic and can be harmful to the environment, mainly living organism [14].

The amorphous silica in various conditions is considered more reactive than the crystalline silica. The degree of reactivity of the amorphous silica is due to the presence of hydroxyl group is present on the surface of a silica sample which causes the formation of a reactive region [15].

B. Effect of Concentration Inhibition Efficiency of the Rice Husk Extract.

In the present work, various concentrations of rice husk extract were used (0, 10, 15, 20 and 25) ppm at room temperature. Table I presents the calculation of corrosion rate using weight loss technique.

TABLE I: Corrosion Rates for Various Concentration at Different Times Immersion

Concentration	Corrosion rate mmpy			
ppm	Time Immersion hours			
	2	4	6	8
0	140,47	184,54	206,89	253,74
10	46,13	48,48	65,81	84,84
15	45,28	46,82	58,67	55,68
20	23,41	29,09	32,90	46,82
25	4,77	25,07	31,22	34,60

From Table I and Fig. 2, it was found that the corrosion rate decreases with increasing concentration of inhibitor. Longer immersion time exhibits a decreasing in corrosion rate.

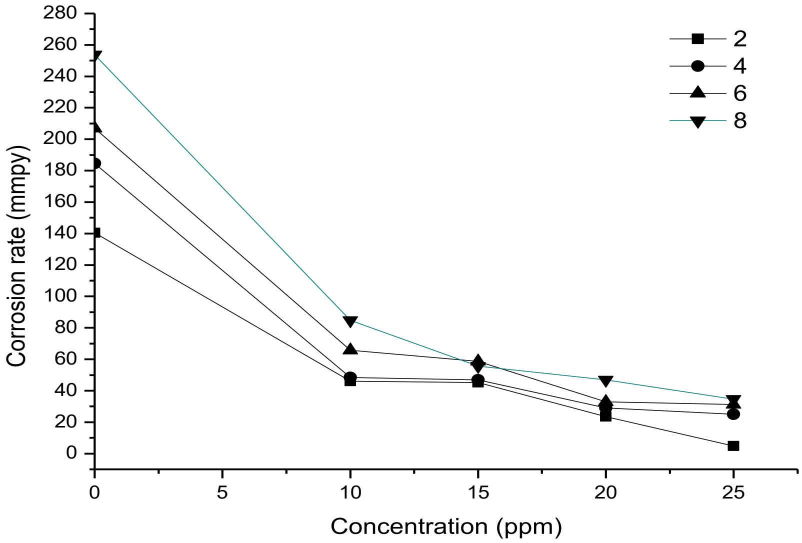

Fig. 2. Graph plotting of corrosion rate as a function of concentration for 2, 4, 6 and 8 h immersion time

Corrosion rate decreases with increasing concentration of bio-inhibitor. It may be caused by the presence of a significant amount of rice husk extract in corrosion medium (1M H_2SO_4) in the higher concentration of inhibitor. Rice husk extracts adsorb onto the surface of mild steel and form a protective layer as a result. This layer will hold oxygen on the surface of the mild steel.

An immersion time of 2 h, inhibition efficiency increased from 67.16% to 96.60% with increasing concentration from 10 ppm to 25 ppm. This result indicates that silica in rice husk extracts plays a significant role to reduce corrosion rate. It can be inferred from Fig. 3 and Table II, the addition of higher concentration led to an increase in inhibition efficiency. Inhibition efficiency is a parameter to measure the ability of inhibitor in protecting the surface of the mild steel.

TABLE II. THE INHIBITION EFFICIENCY OF VARIOUS CONCENTRATION AT DIFFERENT TIMES IMMERSION

Concentration	The inhibition efficiency %			
ppm	Time Immersion hours			
	2	4	6	8
10	67,16	73,73	68,19	66,56
15	67,77	74,63	71,64	78,06
20	83,33	84,24	84,10	81,55
25	96,60	86,41	84,91	86,36

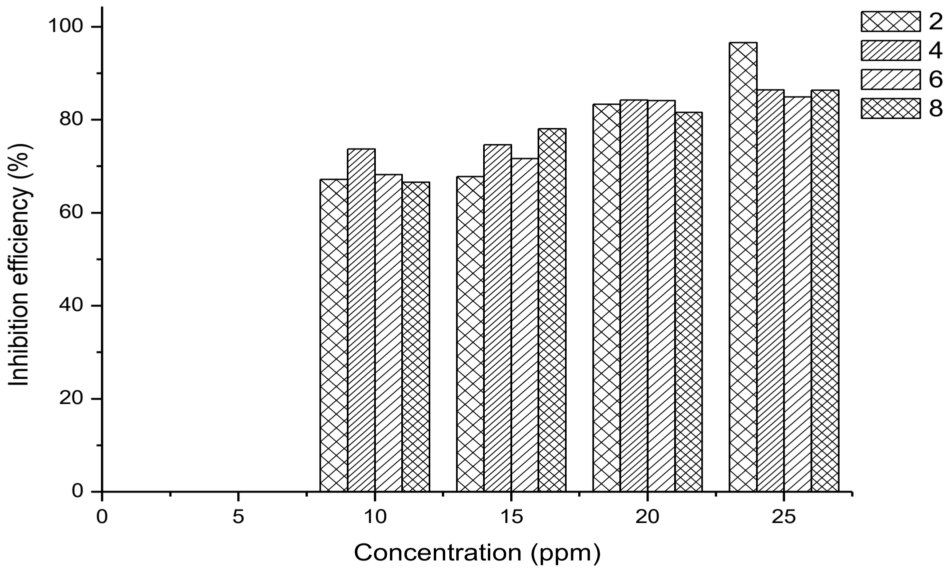

Fig. 3. Graph plotting of inhibition efficiency as a function of concentration for 2, 4, 6, and 8 h immersion time.

IV. CONCLUSION

1) Risk husk extract is an excellent corrosion inhibitor due to its ability to decrease corrosion rate of mild steel.
2) Rice husk extract as the inhibitor was able to obtain the lowest corrosion rate at 4.77 mmpy in concentration 25 ppm and two hours immersion time. Highest inhibition efficiency achieved is 96.60%.

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