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Effect of Chitosan on the Corrosion Protection of Aluminum in H_2SO_4 Medium

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ABSTRACT

Metal aluminium alloy 5052 is a metal that has a lightweight nature of its utilization is very wide. In addition to light also has other advantages such as a good introduction to heat. But the weakness of this material is easily corrosive in the acid environment. To reduce corrosion rate is generally used inorganic inhibitors such as cremate, but these inhibitors are toxic and can contaminate the environment. This study aims to reduce the corrosion rate of aluminium alloys by using non-toxic and environmentally friendly green chitosan inhibitors. The method used for coating on aluminium alloys by coating the metal by electrophoresis deposition (EPD). For corrosion rate testing using weight loss method in 0.5M H_2SO_4 environment and surface analysis using scanning electron microscope (SEM). The results showed that for 7 days the immersion of Al5052 alloyed uncoated a corrosion rate of 3.571 x 10^{-5}g / Cm^2 days but, after coated with chitosan inhibitor the corrosion rate decreased by 1.73 10^{-5} g / Cm^2 days.

Keywords: *Aluminum alloy 5052, corrosion, green inhibitor chitosan, electrophoresis deposition ,*

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1. INTRODUCTION

Aluminum metal is that has a lightweight nature of its utilization is very wide. In addition to light also has other advantages such as a good introduction to heat. This material is used in a wide field not only for household appliances but also for the purposes of aircraft materials, cars, ships, and construction. Aluminum has several properties of physical character, among others, has a density of about 2.65-2.8 kg / dm3, has a good electrical conductivity and heat (Duta. G. et al. 2016)

Because aluminum has high conductive properties and good mechanical properties, this metal is widely applied in the field of life. As in the medical field, health industry, manufacturing industry and household. In addition to that aluminum metal one of them is applied to the bipolar plate PEM fuel cell, one type of aluminum is in use is aluminum 5052 (Al5052) (Hou. K. H. 2011)

But in fact the aluminum metal is easily corroded in the sulfuric acid environment. Corrosion form that occurs in the form of pitting corrosion caused by destruction of the passive. Corrosion is an event of destruction of a metal because it reacts with its environment (Fontana, G. M. 1987). There is also another definition which says that corrosion is the breakdown of metals because of the substances that cause corrosion. Basically the corrosion event is an electrochemical reaction. Passivity of this film layer will be damaged by the influence of the environment, such as the decrease in pH or alkalinities of the environment or attack of chloride ions. Almost all metals are corroded which involves displacement or electron attack in the solution. All corrosion reactions in water involve anodic reactions, the potential that

accompanies the excess of electrons is always reduced at the rate of corrosion. This is the basis of cathode protection to reduce corrosion rates in pipes, hot water steel tanks, and others. All corrosion reactions are electrochemical reactions. Many corrosion reactions involve water as well as condensate vapor phase, dry corrosion reaction without involving electron transfer in solids in electrolyte state and considered as electrochemical (Fontana, G. M. 1987).

An oxidation or anodic reaction to corrosion of the metal;

$$M \rightarrow M n^{+} + ne^{-}$$

Reduction of dissolved oxygen is always observed in neutral and acidic solutions. The oxidation reduction reaction;

$$O_2 + 2H_2O + 4e^{-} \rightarrow 4OH \text{ and } O_2 + 4H^{+} + 4e^{-}$$

In the state of all reduction reactions, water will be reduced;

$$2H_2O + 2e^{-} \rightarrow H_2 + 2OH^{-}$$

From the above reaction it is assumed that water decomposition becomes H + and water reduces OH- from both sides of the reaction. The corrosion rate will increase faster if affected by temperature increase, the potential difference between two metals, the heat treatment of the metal. Green corrosion inhibitor is a biodegradable inhibitor that serves to protect metals and alloys so that the corrosion rate can be reduced (Sharma et al.2015). From some literature studies there are several types of green inhibitors that can be used to protect the metal so as to reduce the rate of corrosion among them Aloe Vera, Arabic gum and chitosan (Neha et al. The coating on the metal surface will prevent the release of metal ions and inhibit the rate of corrosion that occurs (Ameh et al., 2014; Ameh et al. 2012). In general, industry uses chromate inhibitors as corrosion inhibitors in metals. However, it is toxic and harmful to the surrounding environment. Therefore, the type of biodegradable green inhibitor is a contemporary alternative that is key to today's technological development (Patni et al. 2013: Peter & Sanjay 2015; Sangeetha et al. 2011). Use of green inhibitors as an alternative material that can reduce the cocaine on metal containing polar atoms such as Oxygen (O), Nitrogen (N), Phosphorus (P) and Sulphur (S). which forms a passive film layer on metal aging (Rani & Basu 2012). Based on the literature study it is necessary to use to protect metals by using large green molecular weight inhibitors such as Arabic gum and chitosan which are capable of increasing passivation on metal surfaces (Kesavan et al. 2012; S.A. Umoren, Obot & Ebenso 2008; Abu Dalo et al. 2012 ; Savior A Umoren & Eduok 2016). There are several types of methods that can be used for coating on metal surfaces such as through electrophoresis deposition method (EPD), where the equipment is easy and inexpensive and more homogeneous results (L.Bestra et al. 2007). Green inhibitors such as chitosan are obtained by converting chitin, while chitin can be obtained from shrimp skin. Chitin production is usually performed in three stages, namely demineralization, de proteinase, and depigmentation. While chitosan was obtained by de acetylation of chitin with high concentration base solution. De proteinase uses a base with high concentrations and demineralization using acid (Emma et al. 2010). The de proteinase stage is a protein removal process found in shrimp waste, where the protein content in the shrimp is about 21% of the dry matter (Solomon, 1980). The stronger the base and the temperature used by the separation process are more effective (Karmas, 1982). The optimum condition for this process was to use a 3.5% NaOH (b / v) solution at 65 ° C. for 2 hours at a ratio of 1 gram: 10 mL between shrimp powder and NaOH solution volume (Emma et al. 2010).The demineralization stage aims to remove the inorganic compounds found in shrimp waste, for example $CaCO_3$ and $Ca_2(PO)_4$. The optimum conditions at this stage were carried out using 1NHCl solution slowly at room temperature with a ratio of 1 g sample: 15 ml of 1NHCl solution for one hour. Depigmentation stage, the phase of color removal occurs after demineralization stage. The result of a depigmentation process is called chitin to convert chitin into chitosan, done de acetylation (Emma et al. 2010)

2. METHODS

2.1. Materials and Instrumentation

In this study used aluminium alloy 5052 (Al5052), with size 1 cmx 1 cm x 2 mm with composition (2.5% magnesium and 0.25% chromium). Before testing the metal is sand rated with sand paper from a grid of 800 grid 1200, then cleaned by using acetone so that the metal surface is free of dirt and clean. Method for corrosion testing using weight loss method by immersion of test metal in 0.5M H2SO4 solution without and with coating using inhibitor. Duration of corrosion testing for 1 to 7 days. Coating of test metals using 0.5% solid chitosan Inhibitor solution. The dissolution process of chitosan using acetic acid (CH3COOH). Coating method used with electrophoresis deposition (EPD) technique equipped with power supply tool with 30 minute coating time, 10 Volt voltage and current 0.8 A. Analysis of surface metal morphology using TM 3000 Scanning electron microscope (SEM) model, Hitachi.

2.2. Process Electrophoretic Deposition (EPD)

Electrophoretic Deposition (EPD) is a technique used to coat metals. The EPD process occurs where the particle suspended in the liquid medium will move toward the electrode imposed under the drive which is applied externally by the electric field (L. Besra and M. Liu. 2007).

The presence of particle deposits on electrodes or metals forms particles of the surface. Let stand overnight for the inhibitor layer to dry completely. Furthermore, the metal coating results are weighed to find out how much weight the material after in the inhibitor layer. Immersion of aluminium into 0.5 M H_2SO_4 solution for 1; 3; 5 and 7 days. After finish immersion let dry and then weigh in to find out how much weight loss aluminium after soak in 0.5 M H2SO4

3. PURPOSE OF OUTCOMES AND DISCUSSION

3.1. SEM Results (Electric Scanning Microscopy)

Analysis of surface morphology with SEM of 5052 aluminum metal before and after immersion for 7 days without inhibitor and with chitosan inhibitor in environment 0.5 M H_2SO_4. In Figure 1 it is shown that the test sample as shown from SEM photograph with 3000x magnification without immersion on Al5052 metal surface has not been damaged, but on the surface is not homogen.

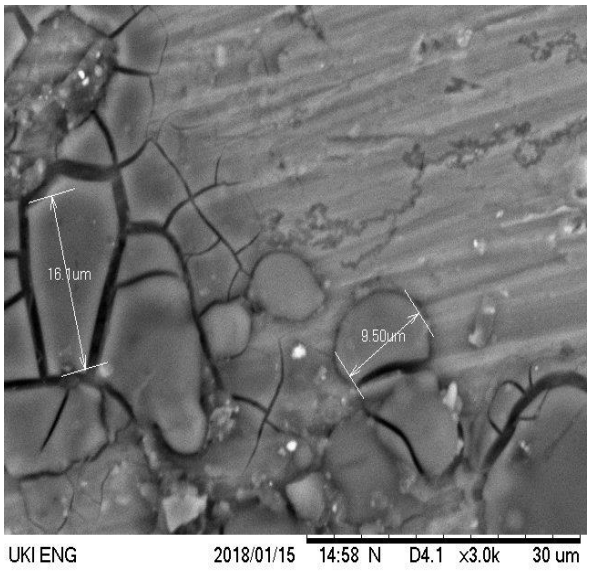

Fig. 1. SEM Photo Al5052 without immersion 0.5M H_2SO_4

While the Al5052 test metal immersed in a 0.5M H2SO4 environment on metallic surfaces uncoated chitosan inhibitors seen in certain localized locale was damaged by a passive layer formed hole in a predetermined area of pitting corrosion. This occurs because it is locally initiated by damage or defects in the metal, so that the locality is firstly damaged in the corrosive sulfuric acid environment. While in certain locales the passive nature of aluminum alloys still protect the metal well, as shown in Figure 2.

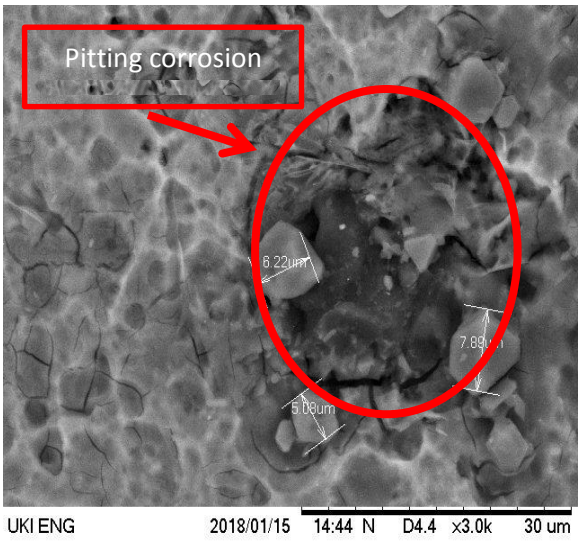

Fig. 2. Photo SEM aluminum 5052 with immersion 0.5 M H_2SO_4 for 7 days.

When compared to the Al5052 metal test coated with 0.5% chitosan inhibitor with a 30-minute EPD coating on 10 V and a current of 0.8 A. From the SEM analysis, there is no visible surface of the surface of the hole, due to the presence of chitosan inhibitors absorbed into the metal surface Al5052. This shows higher corrosion resistance properties when compared to uncoated metals, for more details seen in FIG. 3.

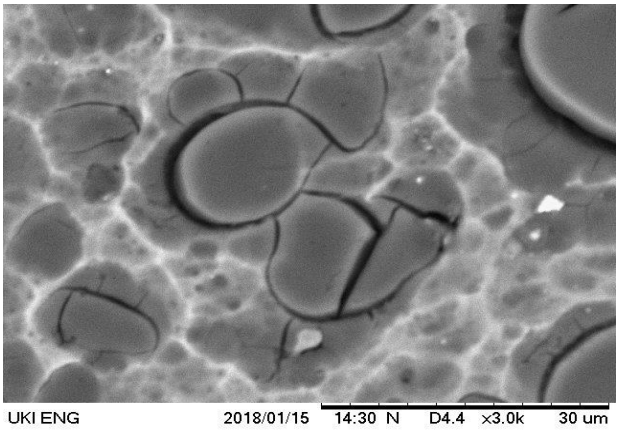

Fig. 3. Photo SEM Al5052 coated 0.5% Chitosan with EPD.

3.2. Results Corrosion testing using weight loss method

Tests for Al5052 metals without and with chitosan coatings were performed with each of the 3 test samples. For each test sample to be coated the chitosan inhibitor surface was firstly cleaned then coated with EPD technique for 30 minutes using 10 V voltage and current 0.8 A. Subsequently the sample was dried by silencing for 24 hours. To determine the initial weight of the uncoated test sample and the coated chitosan inhibitor before immersion in a 0.5M H_2SO_4 solution the test sample was weighed first. The testing process of immersion of test

Samples was conducted for 1, 3, 5, and 7 days. After the immersion process is finished the sample is cleaned and weighed back to find out the final weight (Wt.). The result of weight loss method is then calculated corrosion rate for each test sample by using formula:

Corrosion rate (CR) = (w / At) mg / cm^2 Days

The corrosion rate of aluminum 5052 in the environment of 0.5 M H2SO4 without inhibitor with immersion time of 1;3;5 and 7 days from the calculation of corrosion rate value decreased with increasing immersion time up to 7 days. For testing of 3 samples found corrosion rate rate between 1.917x 10^{-5} g / cm^2 days to 3.571 x10^{-5} g / cm^2 days, for more details seen in figure 4.

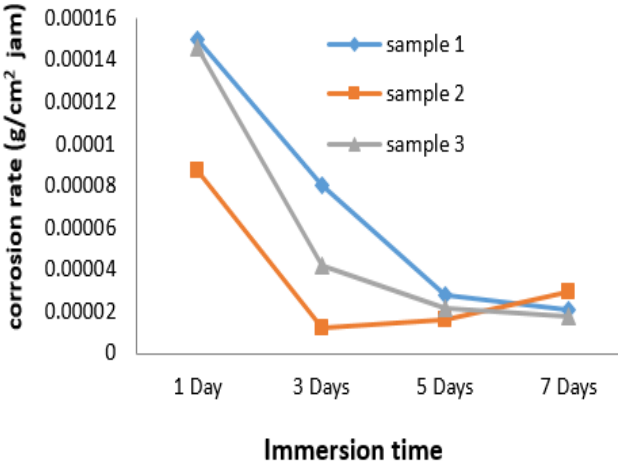

Fig. 4. Graph of Al5052 metal corrosion rate in 0.5M H_2SO_4

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The corrosion rate during soaking up to 7 days seems to decrease as the nature of the aluminum metal is easily oxidized by forming the metal oxide on the metal surface. However, Al5052 coated metal 0.5% chitosan with coating using EPD technique, has a decreasing corrosion rate but its value is smaller when compared with Al5052 uncoated metal that is between 1.5 x 10^{-5} g / cm2 hours to 1.73 x10^{-5} g / cm^2 as seen in figure 5. This indicates that the presence of a polar element of a chitosan atom containing elements such as elements O, P, F and N which are adopted on a metal surface so that the metal surface of Al5052 has better passivation properties when compared to uncoated metal see to figure 5. The increasing nature of passivity which causes metal corrosion resistance is increasing in H2SO4 environment, this is in accordance with the results reported by other researchers (Abu Dalo et al. 2012; Umoren et al. 2008 ; Umoren 2016).

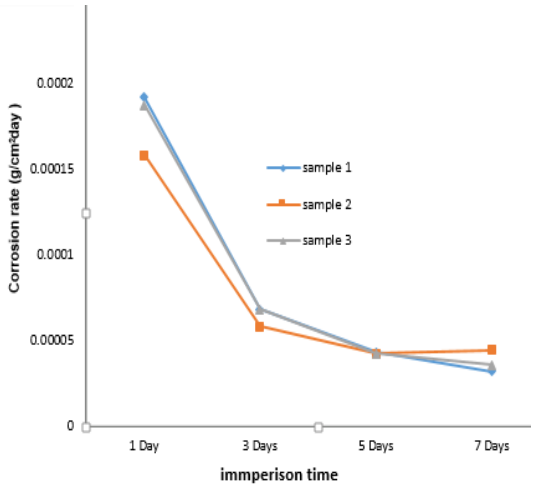

Fig. 5. Graph of corrosion rate of Al5052 coated metal 0.5% chitosan inhibitor in medium 0.5M H_2SO_4

4. CONCLUSION

In this study it can be concluded that the influence of corrosion properties on Al5052 metal that has been coated by using green inhibitor green inhibitor 5% chitosan can reduce the corrosion rate. Proven by using SEM analysis on Al5052 metal visible surface of aluminum metal without inhibitor pitting corrosion occurs in marked by the presence of black and hollow, while the aluminum metal coated inhibitor chitosan looks smoother metal surface. Based on this it is clear that, on the metal surface there has been absorption of chitosan inhibitor resulting in decreasing corrosion rate. This has been demonstrated by the method of weight loss in which there is a decrease in the rate of corrosion of the original metal Between 1.917x 10^{-5} g / cm^2 days to 3..571 x10-5 g / cm^2 days, whereas after coating with chitosan inhibitor by EPD method during 30 minute corrosion rate is between 1.5 x 10-5 g / cm^2 hour to 1.73 x10^{-5}. Based on this research, it is expected that Al5052 which has been coating chitosan this by using EPD technique can be applied to the equipment in related industries, so the longer life of metal.

5. REFERENCES

Abu-Dalo, M.A., Othman, A.A., & Al-Rawasahdeh, N.A.F. 2012). Exudate Gum from Acacia Trees as Green Corrosion Inhibitor for Mild Steel in Acidic Media. International Journal Electrochemical Science Ameh, P. O. 2014. Inhibitory action of Albizia zygia gum on mild steel corrosion in acid medium 8(2): 37–46.8(2):37–46.

Ameh, P. O. 2014. Inhibitory action of Albizia zygia gum on mild steel corrosion in acid medium 8(2): 37–46. doi:10.5897/AJPAC2014.0549

Ameh, P. O., Magaji, L. & Salihu, T. 2012. Corrosion inhibition and adsorption behaviour for mild steel by Ficus glumosa gum in H 2 SO 4 solution. *African Journal of Pure and Applied Chemistry* 6(7): 100–106. doi:10.5897/AJPAC12.001

Bhakat, D., Barik, P. & Bhattacharjee, A. 2018. Electrical conductivity behavior of Gum Arabic biopolymer-Fe 3 O 4 nanocomposites. *Journal of Physics and Chemistry of Solids* 112(September 2017): 73–79. doi:10.1016/j.jpcs.2017.09.002

Dutta, G. P. & Gupta, P. 2016. An Introduction to the Aluminum Industry and Survey of or Applications in an Integrated Aluminum Plant. Indian Institute of Management

Emma, S., Soeseno, N., Adiarto, T., 2010. Sintesis Kitosan, Poli (2-amino-2-deoksi-D-Glukosa), Skala Pilot Project dari Limbah Udang sebagai Bahan Baku Alternatif Pembuatan Biopolimer, Prosiding Seminar Nasional Teknik Kimia Hou, K. H. 2011. Analysis on the corrosion behavior of Al-alloy bipolar plate and pH value of water product for the PEMFC 8: 313–317

Kesavan, D., Gopiraman, M. & Sulochana, N. 2012. Green Inhibitors for Corrosion of Metals : A Review. Chemical Science Review and Letters 1(1): 1–8.

L. Besra and M. Liu, "A review on fundamental and applications of electrophoretic deposition (EPD)," Prog. Mater. Sci., vol. 52, pp. 1– 61, 2007

Patni, N., Agarwal, S. & Shah, P. 2013. Greener Approach towards Corrosion Inhibition. Chinese Journal of Engineering 2013: 1–10. doi:10.1155/2013/784186

Umoren, S. A. 2008. Inhibition of aluminium and mild steel corrosion in acidic medium using Gum Arabic. *Cellulose* 15(5): 751–761. doi:10.1007/s10570-008-9226-4

Umoren, S. A. & Eduok, U. M. 2016. Application of carbohydrate polymers as corrosion inhibitors for metal substrates in different media: A review. *Carbohydrate Polymers* 140: 314–341.

Books

Fontana, G. M. (1987). Corrosion Engineering. USA : McGraw Hill Higher Education.