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Corrosion Behavior of ZA27 and ZA27/Eggshell Composite in Pepper Fluids

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***Abstract-* This study investigated the corrosion behavior of ZA27 and ZA27/Eggshell Composite in Pepper Fluids. The objective of the study is to know the corrosion behavior such as corrosion rates, corrosion potentials and pitting potentials of ZA27 and ZA27/Eggshell composite in pepper fluids. ZA27 and ZA27/Eggshell composites were prepared in the laboratory. The prepared alloy and composite were then tested for corrosion behavior in pepper fluids by potentiodynamic method. The result of the study showed that corrosion behavior of ZA27 and ZA27/Eggshell composite is dependent on the particular pepper fluid environment.**

***Indexed Terms-* Metal matrix composites, ZA27, eggshell, particulate reinforcement, Zinc, Aluminum**

I. INTRODUCTION

The term “corrosion” is generally applied to a reaction involving oxygen. However, in the world of chemistry, the term “Oxidation” does not only apply to a reaction with oxygen. An element is “Oxidized as opposed to being “reduced”, when it gives up electrons and to form a compound. For example, sodium converts to sodium chloride in the presence of chlorine in what is referred to as an “Oxidative” reaction (Loughrey, 2018). The importance of corrosion is widespread, and goes beyond huge financial loss due to engineering material loss; Corrosion control treatment is necessary to reduce the leaching of biologically toxic metals such as lead and cadmium (Randall, 2017). Corrosion control treatment also affects consumers’ perceptions of the quality of drinks by reducing metallic tastes, water color and odors (Randall, 2017). Hence, the need for corrosion studies for better understanding of corrosion.

Zinc-Aluminum (ZA) alloys are alloys with Zinc as the base metal, with higher concentrations of Aluminum when compared to traditional Zinc alloys. These alloys have proven themselves in a wide variety of demanding applications. They are alloy materials that offer designers and casting specifiers viable, cost-effective alternatives for their component requirements. Specifically, compared to Aluminum, the Zinc-Aluminum alloys are harder and stronger, machine more easily, have superior pressure tightness, and have substantially better wear and bearing characteristics. The alloys 8 and 12 are not subject to incentive sparking. The alloys become viable choices when Aluminum is inadequate.

While many studies have reported investigations on ZA27 alloy, only Adedayo and Abdulsalam (2018) have published research efforts to characterize ZA27/Eggshell composite. The work of Adedayo and Abdusalam, (2018) dwelled on engineering management of chicken eggshell for improvement of properties of ZA27 alloy. In their work, 20% of 600 microns particles of eggshell were added to ZA27 through casting. The result of their study showed that strength of ZA27 alloy is improved with addition of 20% of eggshell.

In this present work, the corrosion responses of ZA27 and ZA27/Eggshell composite in pepper fluids are being studied. Although, peppers are important food spice, only scanty technical information is available on industrial processing of pepper, and on effect of processing equipment materials on the pepper paste. There are no information on chemical characteristics of ZA27 and ZA27/Eggshell composite in pepper fluids. Hence the need for this present study to provide useful information for engineering management of pepper processing plants. The study will equally provide vital information useful for evaluating implication of food contact of ZA27 and ZA27/Eggshell composite.

II. MATERIALS AND METHODS

The study materials are ZA27 and ZA27/Eggshell composite rods produced by melting zinc scrap with 27% Aluminum metals obtained from Aluminum cables. About 3Kg of Zinc metal scrap was melted in a lift-out crucible furnace, after which about 0.82Kg of Aluminum was dissolved in the molten zinc metal. A volume of about 850ml of the molten alloy was bailed out, and 170 ml of prepared eggshell sieved to 600 microns was added to the molten alloy and stirred vigorously. Previous researches published have used particulate sizes of a few microns, however current trend is exploring particulate sizes between 100 to 850 microns (Barnard et al., 2004; Adedayo and Abdusalam, 2018; Adedayo, 2019).The mixture of molten metal alloy and eggshell produced was then quickly poured into a prepared sand mold and cast into rods with 15mm diameter and 200mm in length. A control sample which had no eggshell content was also prepared by casting in sand molds. Produced cast rods were then machined on a lathe machine into test pieces of 10mm diameter and 10mm length. High Speed Steel (hss) cutting tool was used, with a cutting speed of 305 revolutions per minute. Micrometer screw gauge and vernier calipers were used for measuring the dimensions of the machined samples.

The electrochemical responses of ZA27 alloy and ZA27/eggshell composite in pepper fluids were evaluated by potentiodynamic tests. The pepper fluids were obtained from bell pepper, long pepper and scotch bonnet pepper, by squeezing the fluid out of the pepper fruits ground to paste by a blender. The ZA27 and ZA27/Eggshell composite samples used for the potentiodynamic test were metallographically prepared by grinding successively with abrasive papers of 60p, 120p and 220p before they were polished. The polished samples were then mounted in balielite with connected flexible conducting wires for potentiodynamics test. The prepared samples were made the working electrodes, and the counter electrode is platinum. The reference electrode is Ag/AgCl. A scan rate of ~ 1mv/s was used with open circuit potential (OCP) for 600s. The polarization curve was studied with potentiostat equipped with VERSASTAT 4 software. The entire electrochemical test were performed at room-temperature

III. RESULTS AND DISCUSSION

The results of the electrochemical corrosion of the test samples by potentiodynamic method are presented as potentiodynamic polarization curves in the Figures 1 to 6, while Table 1 presents Corrosion rates and potentials of ZA27 and composite in pepper fluids. Figures 1a to 6a present the potentiodynamic polarization curve of the specimens in pepper fluids while Figures 1b to 6b shows the microstructure of the samples after they were exposed to pepper fluid through potentiodynamic test.

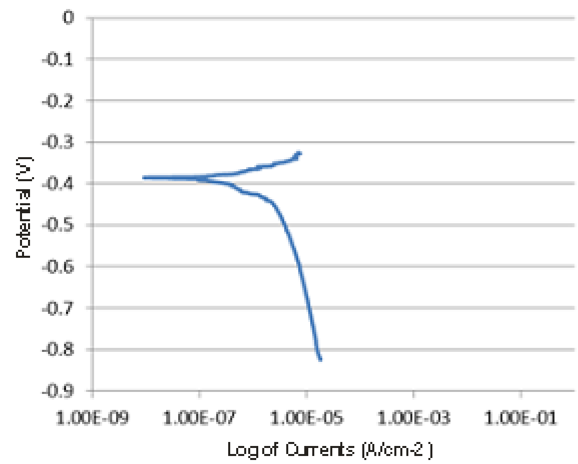

Figure 1a: Polarization curve of ZA27 in Bell Pepper fluid

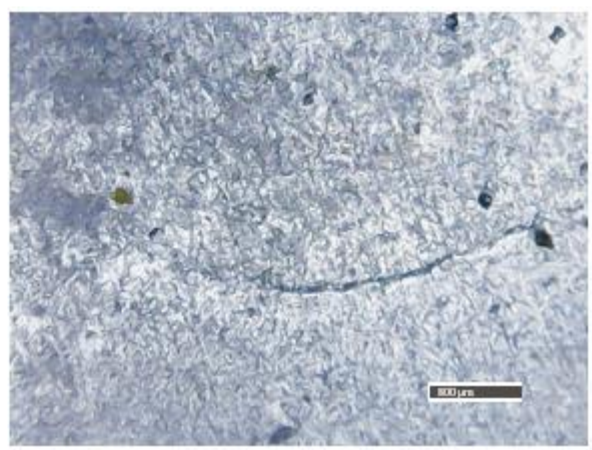

Figure 1b: Microstructure of ZA27 exposed to Bell Pepper fluid through potentiodynamic test

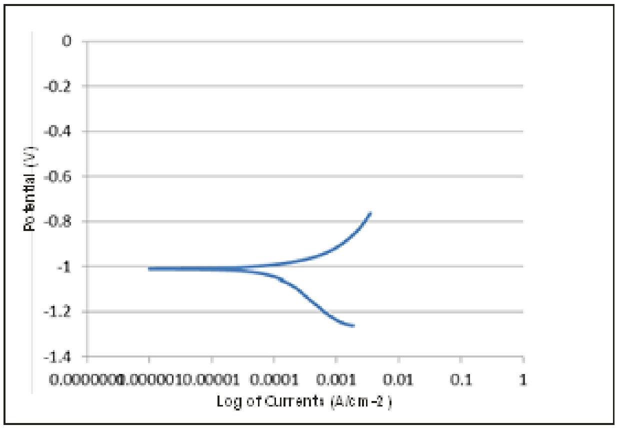

Figure 2a: Polarization curve of ZA27-Eggshell composite in Bell Pepper fluid

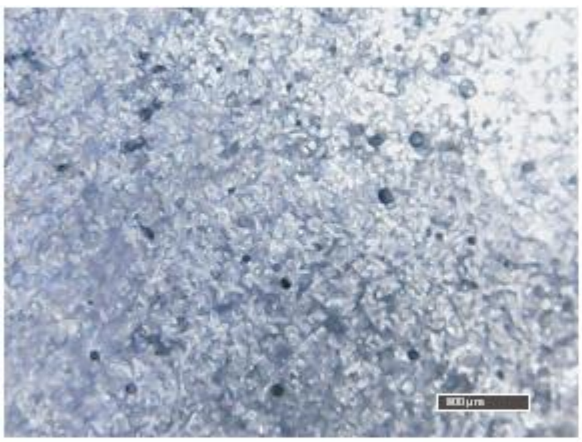

Figure 2b: Microstructure of ZA27-Eggshell composite exposed to Bell Pepper fluid through potentiodynamic test

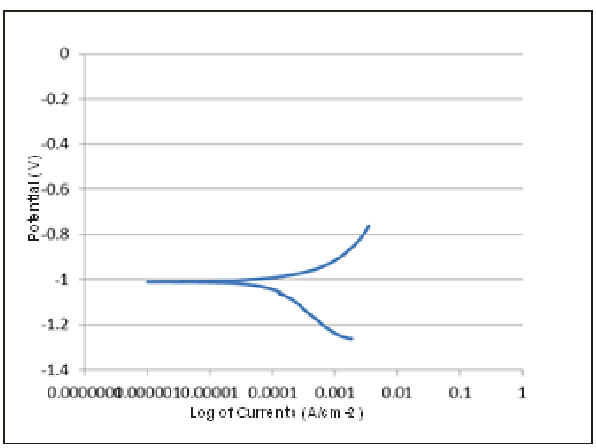

Figure 3a: Polarization curve of ZA27 in Long Pepper fluid

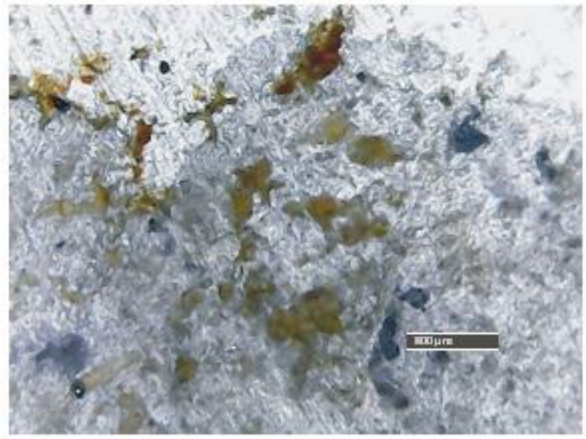

Figure 3b: Microstructure of ZA27 exposed to Long Pepper fluid through potentiodynamic test

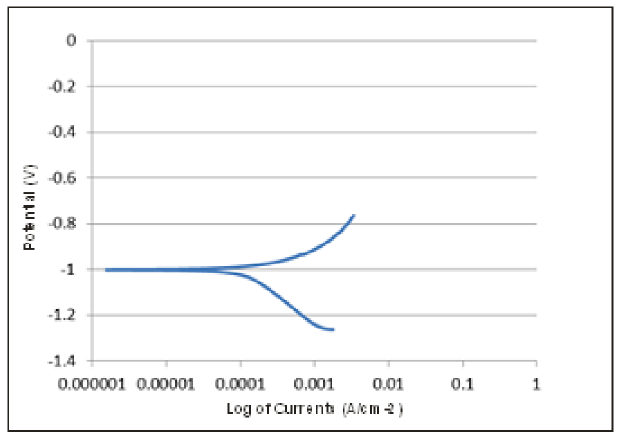

Figure 4a: Polarization curve of ZA27-Eggshell composite in Long pepper fluid

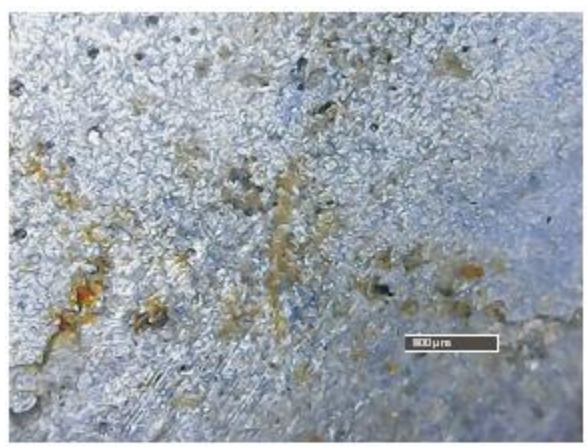

Figure 4b: Microstructure of ZA27 Eggshell composite exposed to Long Pepper fluid through potentiodynamic test

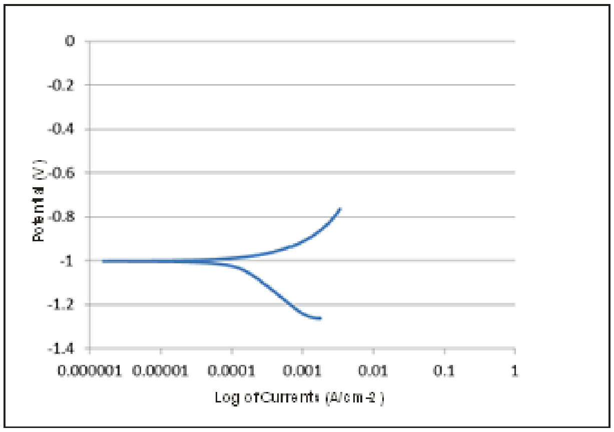

Figure 5a: Polarization curve of ZA27 in Scotch bonnet Pepper fluid

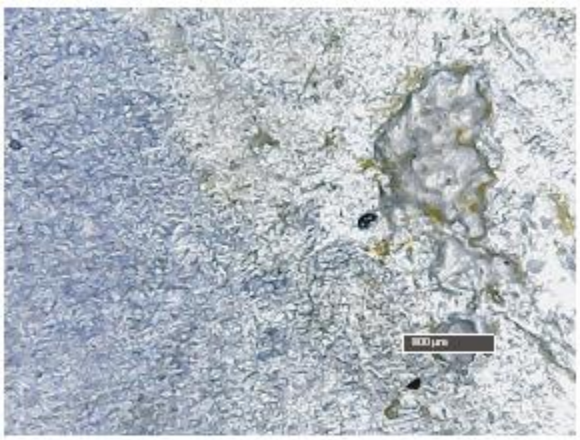

Figure 5b: Microstructure of ZA27 exposed to Scotch Bonnet Pepper fluid through potentiodynamic test

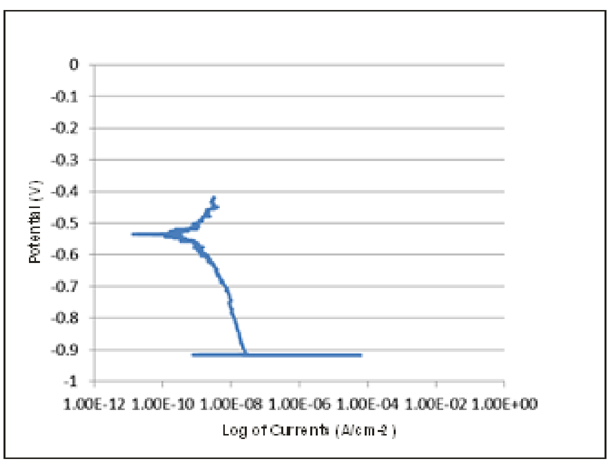

Figure 6a: Polarization curve of ZA27-Eggshall composite in Scotch bonnet pepper fluid

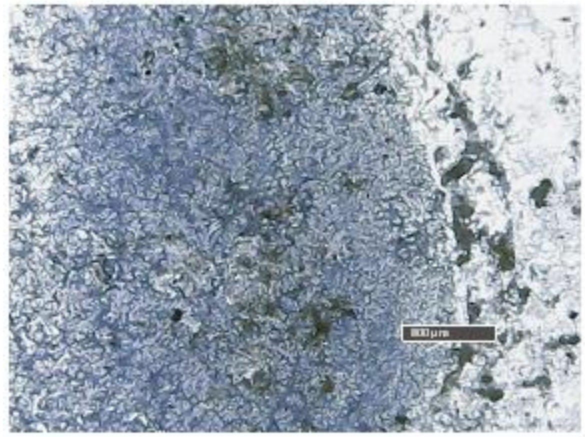

Figure 6b: Microstructure of ZA27- Eggshell composite exposed to Scotch Bonnet Pepper fluid through potentiodynamic test

Table 4.1: Corrosion rates and potentials of ZA27 and composite in pepper fluids

Sample and Type of Pepper fluid	Ecorr	Corrosion Rate
ZA27 in Ata Rodo fluid	-1.005 V	1.872 mmpy
ZA27/Eggshell in Ata Rodo fluid	-543.149 mV	$2.34e^{-05}$ mmpy
ZA27 in Bell Pepper fluid	-1.013 V	1.8617 mmpy
ZA27/Egg in Bell Pepper fluid	-394.499 mV	0.059682 mmpy
ZA27 in Long Pepper fluid	-1.004 V	2.7247 mmpy
ZA27/Eggshell in Long Pepper fluid	-253.723 mV	0.00021388 mmpy

In Figure 1a, the potentiodynamic polarization curve of ZA27 in Bell Pepper fluid is presented. The polarization curve has both anodic and cathodic domains (Blasco-Tamarit et al., 2011). The cathodic domain includes potentials below the corrosion potential (E_{corr}), where current density determined by the cathodic reaction shows a continuous increase in the current density of the cathodic branch as the potential decreases (Saadawy, 2012). The Ecorr for the system of ZA27/Bell Pepper fluid system is -

394.499mV and the corrosion rate is 0.056982 mmpy. The polarization curve indicates a distinctive active corrosion behaviour of ZA27 in Bell pepper fluid. The microstructure of the ZA27 sammple exposed to Bell Pepper fluid through potentiodynamic test is presented in Figure 1b.

In Figure 2a, the potentiodynamic polarization curve of ZA27-Eggshell composite in Bell Pepper fluid is presented. This polarization curve also has anodic and cathodic domains. The corrosion potential for the system is -1.013 V and a corrosion rate of 1.8617 mmpy. The polarization curve indicates an active corrosion behavior of ZA27/Eggshell composite in Bell Pepper fluid. The microstructure of the sample after exposure to Bell pepper fluid through potentiodynamic test is presented in Figure 2b.

Polarisation curve of ZA27 in Long Pepper fluid is presented in Figure 3a. Here, the corrosion potential is -253.723 mV and the corrosion rate is 0.00021388 mmpy. The polarization curve shows a strong passive corrosion behavior with excessive metastable pitting potentials. The presence of pits is evidenced in the microstructure of the sample presented in Figure 3b. In Figure 3b, patches of adhesion of pepper layers are seen in the microstructure of the sample immersed in the long pepper fluid. This adhesion layers serve as passivating layers which strongly inhibit corrosion in the fluid. The corrosion rate is extremely low value of 0.00021388 mmpy.

In Figure 4a, the potentiodynamic polarization curve of ZA27/Eggshall composite in Long pepper fluid is presented. This polarization curve is distinctively active with corrosion potential of -1.004V and corrosion rate of 2.7247 mmpy. The microstructure of the tested sample is presented in Figure 4b.

In Figure 5a, the potentiodynamic polarization curve of ZA27 in Scotch Bonnet fluid is presented. The polarization curve is significantly active corrosion behavior, where current density increased with applied voltage. Corrosion potential for this system of pepper fluid and ZA27 is -1.005V and corrosion rate is 1.872 mmpy. The microstructure of the ZA27 sample immersed in scotch bonnet presented in Figure 5b revealed the presence of some intergranular corrosion, which suggest the susceptibility of ZA27 alloy to intergranular corrosion in scotch bonnet.

In Figure 6a, the polarization curve of ZA27/Eggshell composite in Scotch Bonnet Pepper fluid is presented. The Ecorr for the system is-543.149mV, and the corrosion rate is $2.34e^{-05}$ mmpy. The curve is active, but weakly passivating with some pitting potentials at about -0.45 mV. Presence of pits is confirmed in the microstructure of the sample presented in Figure 6b
Comparing the performance of ZA27 and ZA27/Eggshell in the pepper fluid, it is evident that the ZA27/Eggshell composite show lower corrosion rates and therefore exhibit better corrosion resistance. Overall, the ZA27/Long pepper has the lowest corrosion rates, and therefore exhibits the best corrosion resistance.This suggests that introducing eggshell into ZA27 alloy to improve corrosion resistance should be encouraged.

CONCLUSION

ZA27 alloy generally exhibits good corrosion resistance in pepper fluids. However, comparing the performance of ZA27 and ZA27/Eggshell in the pepper fluid, it is evident that the ZA27/Eggshell composite show lower corrosion rates and therefore exhibit better corrosion resistance. Overall, the ZA27/Long pepper has the lowest corrosion rates, and therefore exhibits the best corrosion resistance. This suggests that introducing eggshell into ZA27 alloy to improve corrosion resistance should be encouraged. The use of ZA27 as a material for producing grinders in processing pepper fruits to paste is recommended. The use of eggshell particules as reinforcement composite particulates in ZA27 alloy materials for producing pepper grinding product is also recommended.

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