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Anticorrosion Behaviour of Zinc Oxide on Aluminum in 2 M of Hydrochloric Acidic Solution

Anticorrosion Behaviour of Zinc Oxide on Aluminum in 2 M of Hydrochloric Acidic Solution

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Abstract-
The inhibitive effect of zinc oxide on the corrosion of aluminum in 2 M HCl solution was studied using gravimetric analysis. Different concentrations of the ZnO were varied for their anticorrosion behavior study on the metal. Results showed that the zinc oxide exhibited very good performance, with inhibition efficiency of up to 89%, at reducing the corrosion of aluminum in the acidic chloride environment.

Key words: Aluminum; Zinc oxide; corrosion rate; corrosion inhibitor; corrosion inhibition efficiency; gravimetric analysis; Langmuir adsorption isotherm

1. Introduction
Due to its light weight, simple workability, toughness, conductivity and tensile strength, Alu minum is one of the most favored metals in the manufacturing fields, it is very suitable for the construction of automobiles and aircraft components [1-3]. Aluminum as a metal is very prone to corrosion, corrosion has a negative effect on metals [4-6]. Corrosion inhibitor which are chemical compounds has proven to be effective in the protection of metals from corrosion [7-9]. This inhibitor affects the electrochemical reaction by altering the reactive effects of the corrosive environment on the metallic surface [10,11]. Zinc oxide (ZnO) as an inorganic inhibitor had been used in studies to reduce the effect of corrosion on mild steel [12-13]. However, there is paucity of studies on using ZnO on aluminum corrosion in the acidic chloride medium. Therefore, this article focuses on the anticorrosion behavior of zinc oxide on aluminum in 2 M of HCl.

2. Experimental
2.1 Materials and setup
The solution used for this experiment is 2 M of HCl solution with varying concentration of 1% to 5%, in increments of 1%, of ZnO inorganic inhibitor. The weight loss experiment was conducted for the period of 504hrs with 6 samples of equal sizes of 1cm by 1cm by 0.3cm, while the acidic solution of 2 M of HCl was prepared to 200ml, after being mixed with distilled H_2O, for every 200ml acidic solution an amount of inhibitor was added for making the requisite percentage. The control acidic sample had no inhibitor added into the solution. The metallic samples were placed into the acidic environment with varying inhibitor concentration for a period of 504 hours, and at every 24 hours interval and the gravimetric weight loss value was measured. From the measured weight loss value (*W*), the mild steel surface area (*A*), density of mild steel (*D*), and the immersion time (*T*), the corrosion rate (*CR*) was computed by the formula [14-15]:

$$CR = \frac{87.6W}{DAT}$$ * MERGEFORMAT (1)

From this equation, the corrosion inhibition efficiency, *IE*(%), calculation proceeds from the corrosion through the formula [15]:

$$IE(\%) = \left[\frac{CR_{control} - CR_{with\ Avocado\ oil}}{CR_{control}}\right] \times 100$$ * MERGEFORMAT (2)

3. Result and discussion

Analysis of the gravimetric weight loss, the corrosion rate, inhibitor efficiency and surface coverage values were obtained from the research experiment. From the graph in Figure 1 it is represented by the plot of result gotten from the gravimetric weight loss experiment, while Figure 2 shows the estimated corrosion rate from the weight loss of aluminum in 2 M HCL for the 504 hours of the exposure time for the experiment. From both figures, it is observed that at 0% the sample had the highest corrosion rate and loss of weight in the acidic environment and this is due to the effect of Cl^- ions on the metal which speeds up the weight loss. Results of the experiment at 1%, 2%, 3%, 4% and 5% inhibitor concentration, inhibited the samples by slowing down the dissolution of the metal in the acidic solution, from the experiment, the sample at 3% having the highest inhibition concentration percentage from the study, indicates an improved form of absorption reaction that slows down the chloride ions and the passivation on the metallic surface. This then resulted in the weight loss reduction and the corrosion rate reduction having a high inhibitor efficiency.

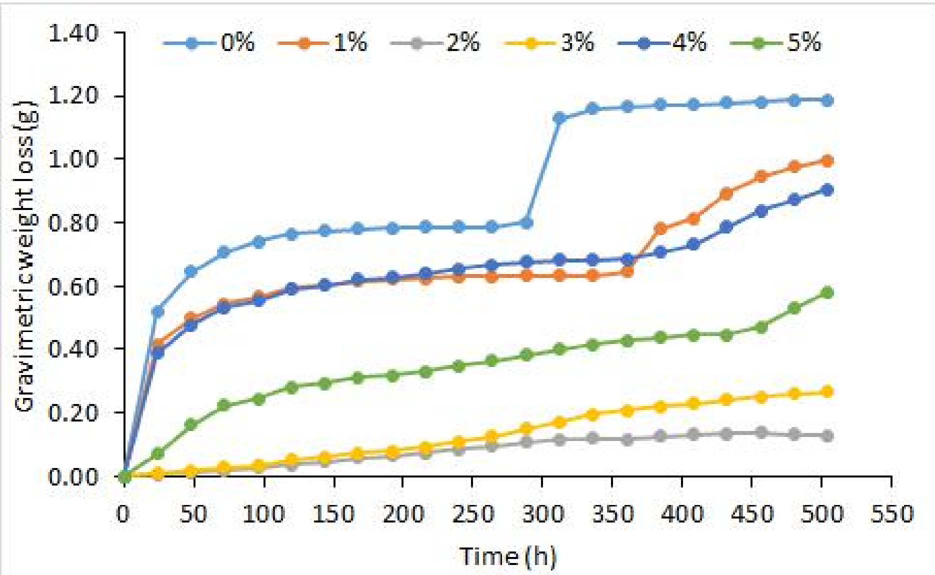

Figure 1: Plots of the gravimetric weight loss of aluminum in HCl in the presence of zinc oxide

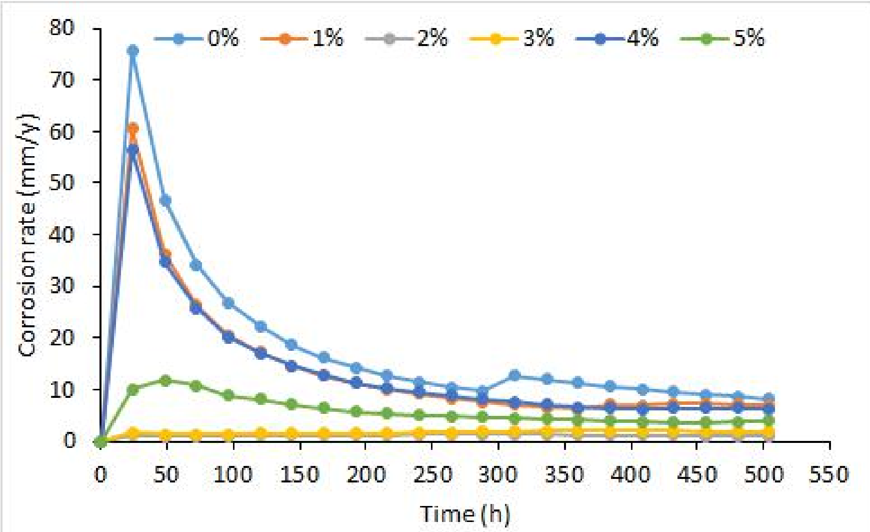

Figure 2 Plots of the corrosion rate of aluminum in HCl in the presence of zinc oxide

The result of the corrosion from figure 2 that was used for estimating the corrosion inhibition efficiency which is shown in figure 3. This graph shows the corrosion rate reduction that was observed from the experiment with the sample having 3% concentration resulted in corrosion inhibition efficiency of 89.05% from the experiment at the 504 exposure time period.

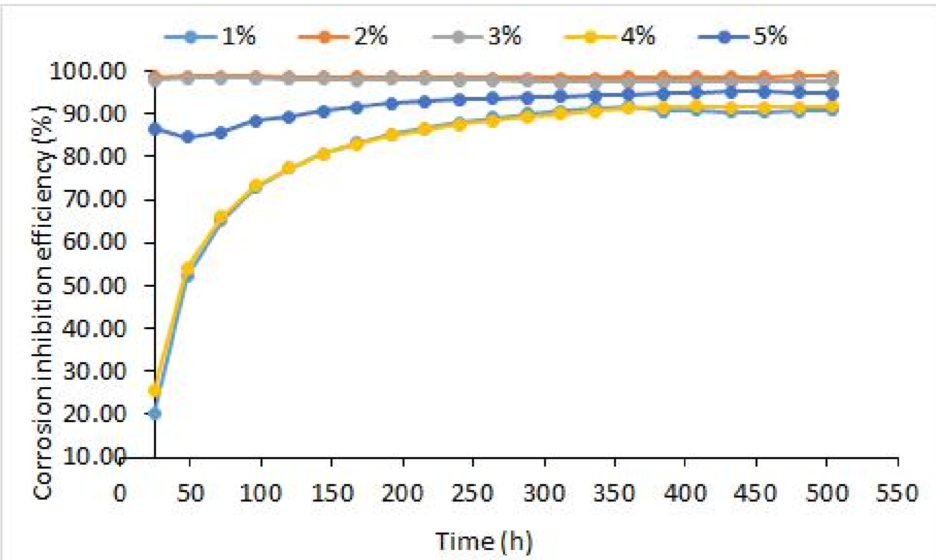

Figure 3: Plots of the corrosion inhibition efficiency of zinc oxide on aluminum in 2 M HCl

Other concentrations of zinc oxide that were used in the experiment showed, in the overall, a decreasing trends of corrosion inhibition through the 504 hours of experimental period. The exception to this was the increasing trends of corrosion inhibition efficiency from the 2% and 3% zinc oxide test-system. The implication of these could be due to a system of low adsorption mechanisms on the aluminum surface as the experimental time progresses. However, consistent corrosion-protection of the aluminum material was maintained throughout the experimental period by the system having 2% zinc oxide, which is indicative of the consideration that the low concentration of zinc oxide effectively mitigated mild steel corrosion in the acidic chloride environment. These modes of results spark interest on the study of the adsorption characteristic of the zinc oxide on aluminum metallic surface.

The graph of the absorption isotherm study is shown in Figure 4. The Langmuir adsorption isotherm modeling approach was used for the experiment, from the plot it shows a quasi-linear trends for most of experimental measurement times. From the isotherm model the following estimated parameters were analyzed; adsorption-desorption coefficient K_{ads}, the model fitting efficiency, R^2, the Gibbs free energy of adsorption, ΔG_{ads} and the separation factor, $R_{L.}$

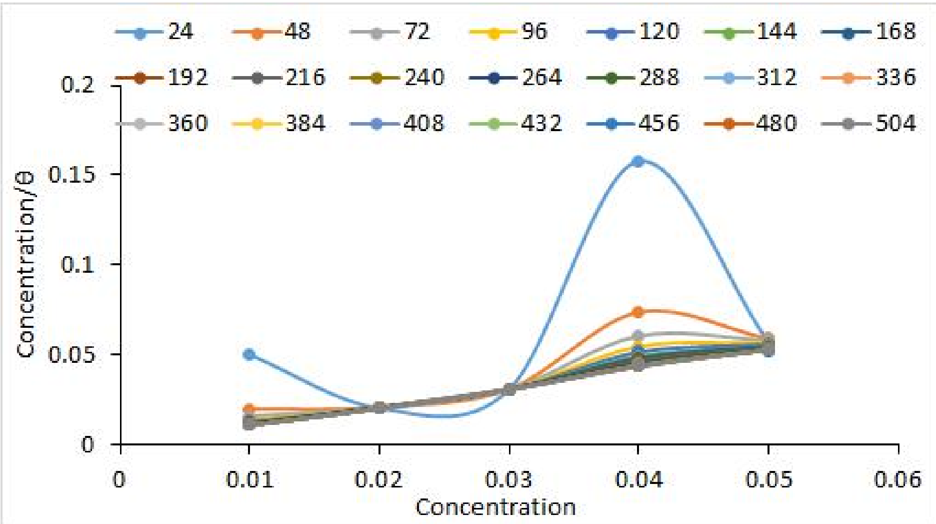

Figure 4: Langmuir adsorption isotherm model of zinc oxide on aluminum in 2 M HCl

The graph of the K_{ads} and of the R^2 are shown in Figure 5 while the plots of the Gibbs free energy, ΔG_{ads} (kJ/mol), and of the separation factor, R_L, gotten from the modelling analyses are showed in Figure 6. The plotted values in Figure 5 shows that decreasing nagative values of the adsorption coefficient, K_{ads}, as well as an excellent fitting models by the Langmuir adsorption isotherm to the aluminum corrosion data, via the R^2 that decreased from 98.54 to 87.73 and predominantly increased again to 89.059 at the 504th hour

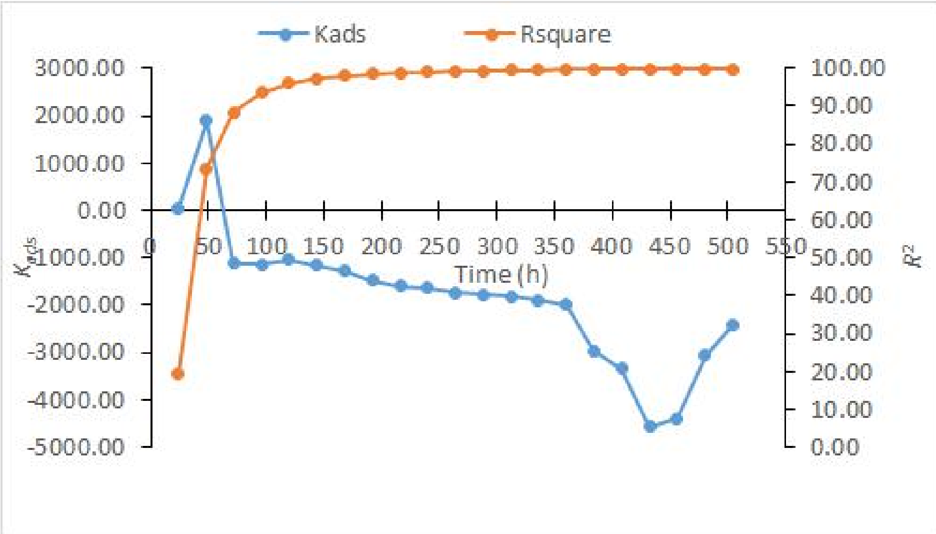

Figure 5: Langmuir adsorption isotherm model of zinc oxide on aluminum in 2 M HCl

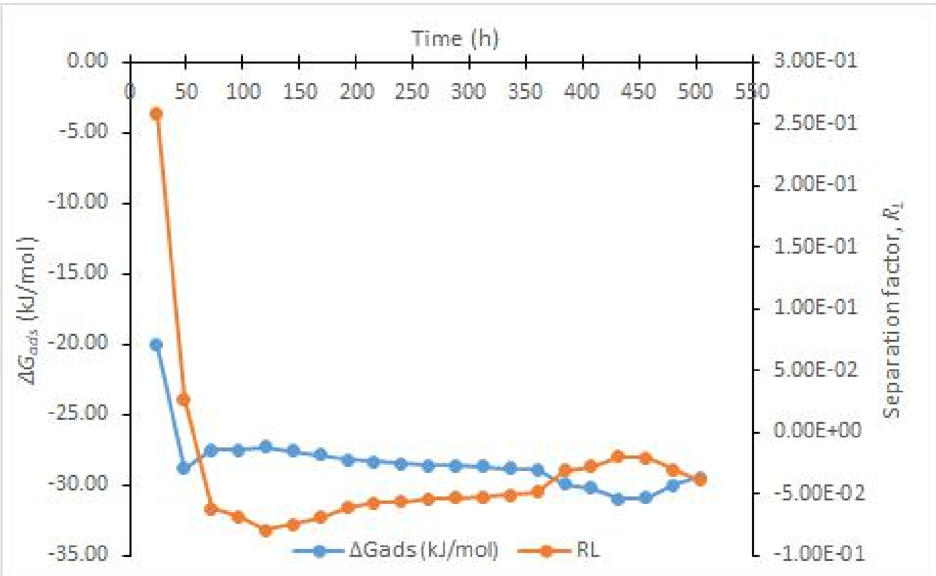

Figure 6: Langmuir adsorption isotherm model of zinc oxide on aluminum in 2 M HCl

Also, the Gibbs free energy plots in Figure 6 showed that negative values, ranging from -20.00 kJ/mol to the more negative value of -29.25 kJ/mol were estimated for this parameter, which indicates spontaneity of the adsorption process by the zinc oxide on the aluminum. These results showed that the prevalent mechanism of zinc oxide adsorption on mild steel is physisorption, due to the ΔG_{ads} that were valued at more negative vaues -20 kJ/mol, but which could be said to exhibit some degrees of chemisorption due to the observed decreasing trend towards -30 kJ/mol. Also, the values of the separation factor, R_L, that was in the range $0 < R_L < -2$, throughout the experimental period as shown in Figure 6, indicate favourable adsorption by zinc oxide on the aluminum metal.

4. Conclusion

The corrosion resistance of aluminum in Zinc oxide inorganic inhibitor was effectively enhanced in 2M dilute HCl solution. The inhibitor performed excellently with strong adsorption on the surface of the aluminum with optimal inhibition efficiency of 89% thereby passivating the aluminum samples to reduce the active sites of electrochemical reaction occurring on the samples.

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