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Research Papers

Investigation of the Inhibition Properties of Plantain Peduncle on the Corrosion Rate of Mild Carbon Steel

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Abstract: The use of inhibitors is one of the most practical methods for protecting metal against corrosion, especially in acidic media**.** Corrosion inhibitors are common for protecting steel structures and their alloys in industry. Chemicals used as corrosion inhibitors are very toxic even in small concentrations, leading to environmental agencies requesting prohibition. Thus, there is a growing demand for environmentally appropriate inhibitors such as vegetal inhibitors. In this present work, the investigation of the inhibition properties of plantain peduncle on the corrosion rate of mild carbon steel was carried out. A mild carbon steel of 0.12 weight percentage of carbon was used for this research work. The mild carbon steel was obtained from a local market in Nigeria. The samples were machined using lathe machine into cylindrical pieces of diameter of 20 mm and length of 60 mm for samples of; sample A: 3.0 v/v concentration (5 pieces), sample B: 2.0 v/v concentration (5 pieces), sample C: 1.0 v/v concentration (5 pieces), and ample D: No Inhibitor (Control) (5 pieces). The prepared mild carbon steel samples and the inhibitors from plantain peduncles were used for the experiment to determine the weight loss and corrosion rate of the mild carbon steel. The results obtained shown that low weight loss and corrosion rate were recorded for all inhibited samples with the 3.0 v/v concentration showing the best inhibition property and this was followed by 2.0 v/v concentration. Unlike the inhibited samples, the control sample showed high tendency of corrosion rate and weight loss. Thus, plantain peduncle can be used as an inhibitor.

Keywords: Corrosion, Inhibitor, Plantain Peduncle, Weight Loss, Corrosion Rate

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INTRODUCTION

Mild steel is a vital material used especially in the manufacturing industry. Furthermost, it has several applications in the refining of crude oil, acid pickling, industrial cleaning, acid descaling, etc. [1-3]. Nevertheless, to prevent the material from corroding has become a great challenge for corrosion engineers or scientists. Corrosion can simply be defined as an electrochemical process by which metallic surfaces react with their environment causing the metal to lose its material properties due to surface deterioration [4-5]. A corrosion phenomenon is a natural process that results in considerable waste of industrial investment. This phenomenon can easily be found in different types of surfaces causing major economic losses in the industrial sector. Corrosion control involves different aspects such as environmental, economic and technical resulting in major advances of science and biotechnology [6-7]. It is estimated that more than 30% of the steel produced worldwide and used for spare parts, pieces of equipment and facilities is damaged by corrosion. Corrosion is costly due to operational downtime necessary for parts replacement. There is also concern about damage to the environment, for example the breaking of oil pipelines in the petroleum industry. Corrosion resistant products are in great demand and have been increasing in technological advances. Recent studies have estimated that annual costs worldwide related to corrosion damage are around 4% of the Gross Domestic Product (GDP) of an industrialized country. Management practices and corrosion control can reduce 20 % of direct costs [maintenance (protection processes) and/or replacement of parts or equipment] or indirect, such as downtime due to equipment failure, product contamination, production losses and personal and also environmental safety [8].

Inhibitors are chemicals (organic and inorganic) that react with the surface of a material decreasing the material's corrosion rate, or interact with the operating environment to reduce its corrosivity [1]. Inhibitors may be introduced into the environment in which the material is operating as solutions or dispersions to form a protective film. For instance, they can be injected into a completely aqueous recirculating system (e.g., automobile radiators) to reduce the corrosion rate in that system. They may also be used as additives in coating products, such as surface treatments, primers, sealants, hard coatings, and corrosion preventive compounds (CPCs). Furthermore, some inhibitors can be added to water that is used to wash a vehicle, system or component. The corrosion potential of a metal is shifted toward the anodic end by inhibiting the cathodic process. This is accomplished by using chemicals that inhibit the corrosion reactions taking place at the cathodic site of the corrosion cell, for example, blocking the hydrogen ions at the metal's surface from combining to form hydrogen gas. Likewise, the corrosion potential of a metal is shifted toward the cathodic end by inhibiting the anodic process. This is accomplished by using chemicals that inhibit the corrosion reactions taking place at the anodic site of the corrosion cell for example, by keeping the metal from dissociating into ions [9]. Preventing the permeation of ions into the metal is accomplished by forming a protective film or layer on the metal surface. Inhibitors can form a protective barrier film, which effectively isolates the metal from the corrosive environment, or they can induce the formation of precipitates that block the corrosive agents from accessing the metal. Inhibitors can also increase the electrical resistance of the metal by passivating the surface. Inhibitors are usually grouped into five different categories: passivating, cathodic, organic, precipitation, and vapor phase.

The use of inhibitors is one of the most practical methods for protecting metal against corrosion, especially in acidic media [10]**.** Corrosion inhibitors are common for protecting steel structures and their alloys in industry [11]. Chemicals used as corrosion inhibitors are very toxic even in small concentrations, leading to environmental agencies requesting prohibition. Thus, there is a growing demand for environmentally appropriate inhibitors such as vegetal inhibitors [12]. Several research works have recently appeared in the literature on the topic of the corrosion of carbon steel [13-17]. More so, large numbers of organic compounds showed that nitrogen, sulphur, and oxygen containing organic compounds acted as promising inhibitors. Though, most of these compounds are not only expensive, but also toxic to living beings [18]. Consequently, considerable efforts are made to select corrosion inhibitors which are environmentally safe, readily available and of not expensive. From literatures, a growing trend in the use of natural products known as non-toxic compounds, and also called green corrosion inhibitors. Natural products such as extracts of easily available plants and trees have been used as eco- friendly corrosion inhibitors. According to [1] in their research work that focused on the analysis and evaluation of the inhibitive action of banana peduncle extract on the corrosion of mild steel in acidic medium (0.5M HCl solution), the corrosion rate decreased with increasing concentration of inhibitor to maximum level of 2.0v/v%. Also, the protective (inhibition) efficiency increased with increasing concentration of inhibitor. The adsorption of the inhibitor to the mild steel was accredited to the pairs of electron present in the functional groups which is the rich tannin and saponnin content. Their research work established that the abundant banana peduncle can be used for the corrosion inhibition of mild steel. However, nothing was reported on plantain peduncle, thus this research work.

MATERIALS AND METHODS

In this research work, different equipment was employed. A power saw was used to cut the mild carbon steel into various sizes. An analytical weighing machine was used to determine the weight of the steel samples. A lathe machine was employed in machining the steel sample to the desired shapes and sizes. Other equipment used in this research work include Retsch Planetary Ball Mill PM 400, Tong for putting and removing the sample from a plastic bowl containing the corrosive medium, a bench vice, and sand paper. The plantain peduncle was collected from a local market in Nigeria as municipal solid waste. A Retsch Planetary Ball Mill PM 400 was used for the pulverizing of the plantain peduncle. After the pulverizing, 400 g of the pulverized banana peduncle was taken in 1000 ml and enough quantity of ethanol was added as a solvent for extraction. Decantation method was then used to separate the plantain peduncle from the extract. From the separated extract, the following concentration was made:

Sample A: 3.0 v/v concentration
Sample B: 2.0 v/v concentration
Sample C: 1.0 v/v concentration
Sample D: No Inhibitor (Control)

A mild carbon steel of 0.12 weight percentage of carbon was used for this research work. The mild carbon steel was obtained from a local market in Nigeria. The samples were machined using lathe machine into cylindrical pieces of diameter of 20 mm and length of 60 mm for samples of:
Sample A: 3.0 v/v concentration (5 pieces)
Sample B: 2.0 v/v concentration (5 pieces)
Sample C: 1.0 v/v concentration (5 pieces)
Sample D: No Inhibitor (Control) (5 pieces)

The prepared mild carbon steel samples and the inhibitors from plantain peduncles were used for the experiment to determine the weight loss and corrosion rate of the mild carbon steel. Three plastic bowls were filled with different concentration of inhibitors (1.0-3.0v/v concentration-Sample A-C) while one bowl with seawater (sample D) without any trace of inhibitor. The various steel samples were weighed with an analytical weighing balance and recorded as (W_i) before being immersed into their respective labeled plastic bowls. After twenty days interval, each of the mild carbon steel samples were retrieved and weighed and as final weights (W_f). This procedure was repeated at twenty days interval for a period of 100 days. Equation (1) was used to calculate the weight loss.

$$W_L = W_i - W_f \quad (1)$$

where,
W_L = Weight loss
W_i = Initial weight
W_f = Final weight

Equation (2) was used to calculate the corrosion rate of low carbon steel.

$$C_R = \frac{87.6W_L}{DAT} \quad (2)$$

where,
C_R = Corrosion Rate (mm/y)
W = Weight loss (mg)
D = Density of Low Carbon Steel = 7.85g/cm^3
A = Area of medium carbon steel samples used (cm^2)
T = Exposure time to sea water (days)

RESULTS AND DISCUSSION

The corroion process started with colour transformation to yellow deposits in the first five (5) days and this was a confirmation of presence of ions concentration in the sample used. As the exposure continues, the yellow deposits turned dark brown colouration that surrounded the surface of the samples of mild carbon steel. On withdrawal of the used samples, the dark brown deposits of were noticed on them which is a confirmation of corrosion on the samples. Figure 1 to Figure 2 shows the graph of corrosion rate of mild carbon steel in exposed different concentration of inhibitors and sea water for sample A-sample D. From the graph, the corrosion rate of all the samples increases steadily for the first forty (40) days with the peak on the forty (40) day. However, this was followed by continuous decrease in the corrosion rate of all the samples. Nevertheless, the corrosion rate of the samples become partially uniform after eighty (80) days and the pattern remain the same for the remaining twenty (20) days. The decreased in the corrosion rate of all the samples between the period of 40th day and 80th day can be attributed to the aggressiveness of the chemical reactivity, transport properties of the corrosion medium, pH of the corrosion medium which is within neutral, concentration of the corrosion species in the used sea water, and most importantly the metallurgy of the alloy sample and temperature of the sea water which served as the corrosion medium as reported by [2].

Besides, there was a continuous decline in corrosion rate for all inhibited mild carbon steel. Also, the brown colouration formed on the samples surfaces confirmed some inhibitive property on the mild carbon steel. Subsequently, low weight loss and corrosion rate were recorded for all inhibited samples with the 3.0 v/v concentration showing the best inhibition property and this was followed by 2.0 v/v concentration. Unlike the inhibited samples, the control sample showed high tendency of corrosion rate. Thus, large weight loss and corrosion rate were recorded.

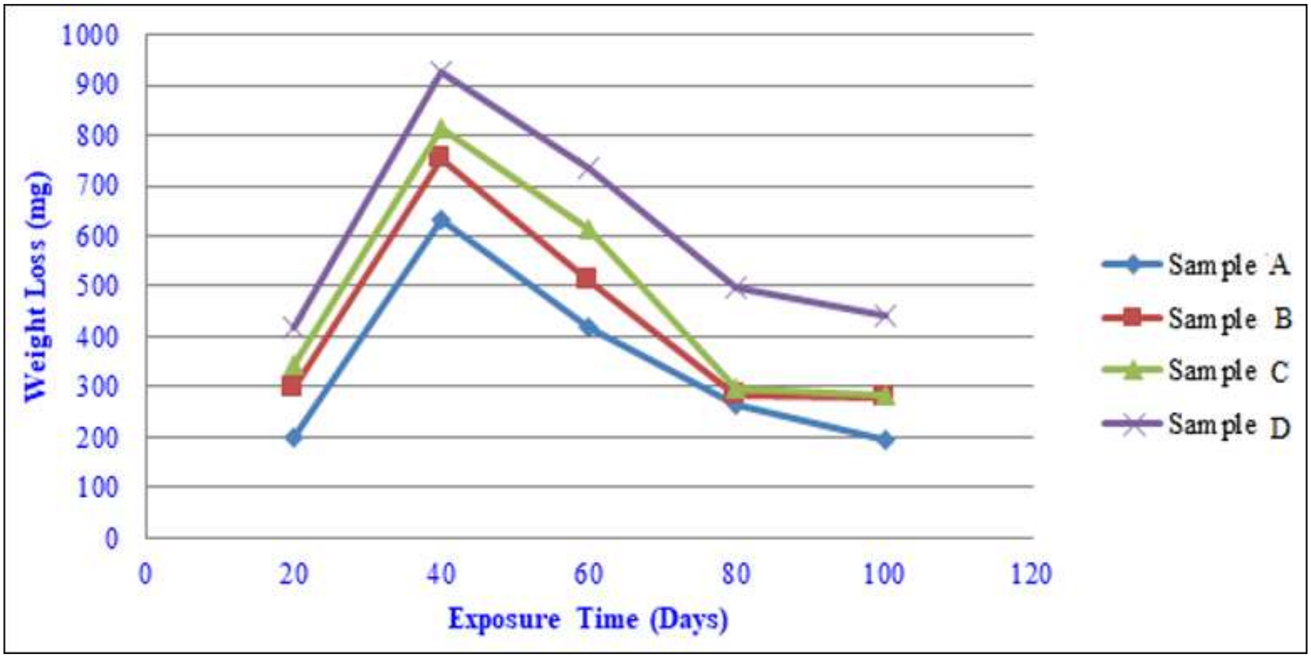

Figure 1: Weight loss against exposure time for mild carbon steel using plantain extract as inhibitor

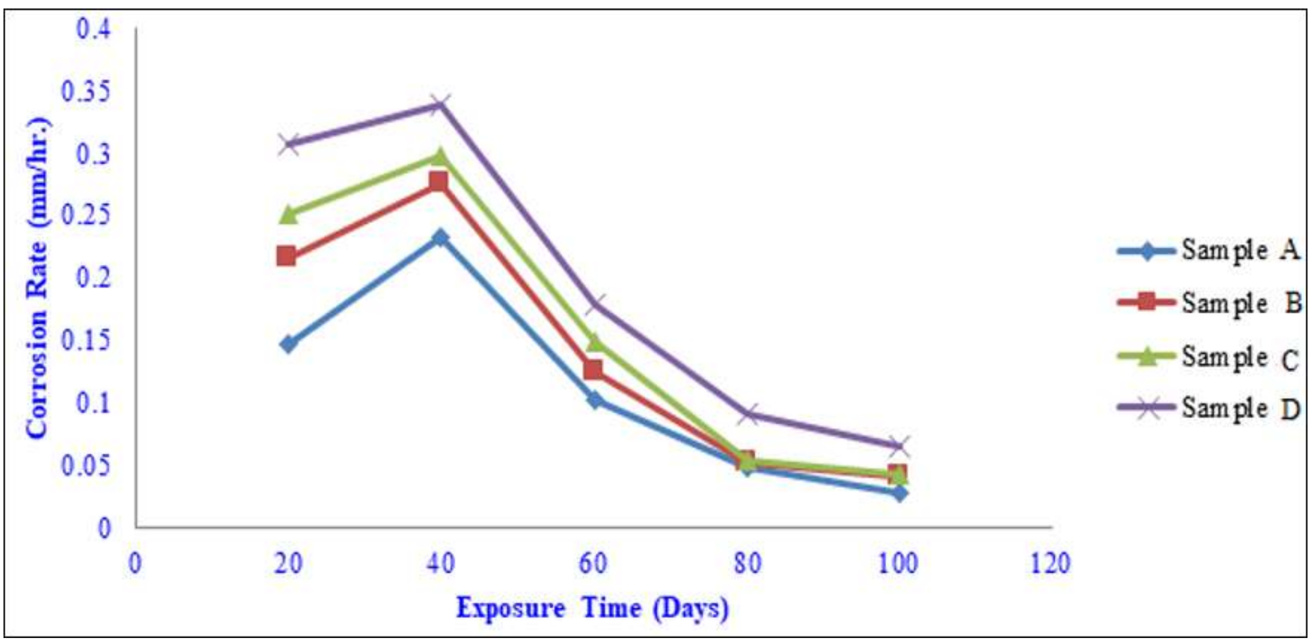

Figure 2 Corrosion rate against exposure time for mild carbon steel using plantain extract as inhibitor

CONCLUSION

Corrosion is a constant and continuous problem, often difficult to eliminate completely. Prevention would be more practical and achievable than complete elimination. Corrosion processes develop fast after disruption of the protective barrier and are accompanied by a number of reactions that change the composition and properties of both the metal surface and the local environment. In this research work, the investigation of the inhibition properties of plantain peduncle on the corrosion rate of mild carbon steel was successfully accomplished. The outcome of the research work revealed a continuous decline in corrosion rate for all inhibited mild carbon steel. Also, a low weight loss and corrosion rate were recorded for all inhibited samples with the 3.0 v/v concentration showing the best inhibition property and this was followed by 2.0 v/v concentration. Unlike the inhibited samples, the control sample showed high tendency of corrosion rate. Thus, large weight loss and corrosion rate were recorded.

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