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Investigations on the Inhibitive Properties of Moringa Oleifera and Psiduim Quajava Leaves Extract on the Corrosion Susceptibility of Mild Steel

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Abstract: This paper reports on the inhibitive properties of Moringa Oleifera and Psiduim Quajava Leaves Extract on the Corrosion Susceptibility of Mild Steel in an alkaline environment, in particular sodium hydroxide (NaOH). Varying volumes of the leaves extract of Moringa Oleifera (MO) and Psiduim Quajava (PQ) in the range 25 cm^3 to 100 cm^3 were used for the investigations. The mild steel were cast into rods; which were later machined and subsequently cut into coupons averaging a total surface area of 6.284cm^2. The samples were weighed and immersed into beakers containing 0.5M and 1.0M of sodium hydroxide and the different volumes of the Moringa Oleifera (MO) and Psiduim Quajava (PQ) were introduced in the respective beakers consequentially. The set up were allowed to stand for 28 days, with the coupons removed every 7 days for weight loss measurements using the normal procedures. The results show that the corrosion penetration rate was very high in the control (without inhibitor). In particular, the corrosion penetration rate was found to be decreased by > 60% in the 0.5M NaOH and by > 80% in the 1.0M NaOH at the different volumes of both inhibitors used in the study. From the findings, it was concluded that the concentration of 1.0M NaOH is the optimum conditions for reduced corrosion rate of mild steel in an alkaline media in the presence of the inhibitors.

Key words: Alkaline · Corrosion susceptibility · Inhibitor · Mild steel

INTRODUCTION

Corrosion is a natural phenomenon and its attack on metals has serious negative consequences. In the literature, some of the major causes of corrosion of metals is widely believed to be caused from their temporal existence in the state of higher energy level due to the absorbed energy, in the course of extraction from their ores which makes them quite unstable, coupled with the fact that certain environments enhance their combination chemically with elements in their environment to form compounds and return to their natural stable ore state with accompanying reduction in the free energy of the system [1-2]. Guava (*Psidium guajava* L.), is a tropical fruit which belongs to the Myrtaceae family. The use of Moringa Oleifera and Psiduim Quajava Leaves Extract for various applications has been widely reported by various research groups. For instance, (i) Deguchi and Miyazaki [3] noted that Psidium guajava Linn. (guava) is used not only as food but also as folk medicine in subtropical areas around the world due to its pharmacologic activities. In particular, the leaf extract of guava has traditionally been used for the treatment of diabetes in East Asia and other countries (ii) the leaves and fruits of guava have been reported to have an anti-diarrheal, hypoglycemic, lipid lowering, anti-bacterial in addition to antioxidant activities [4-7], (iii) as inhibitors in Quorum sensing (QS) (a process usually mediated through small molecules known as autoinducers (AI) that allow bacteria to respond and adjust according to the cell population density by altering the expression of multitudinous genes) [8], (iv) and as antimicrobial and antibacterial agents [9-10]. In the literature, there are several reports on the use of different inhibitors to reduce corrosion susceptibility of different metals, including mild steel in different media [11-15]. However, there are few reports on the use of Moringa Oleifera and Psiduim Quajava Leaves Extract as inhibitors on the corrosion susceptibility of mild steel, hence this research is novel in the contribution to knowledge in the area of corrosion of metals.

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MATERIALS AND METHODS

The materials used for the experiment were sodium hydroxide solution (NaOH), moringa oleifera leaves, psidium quajava leaves, measuring cylinder (1000 cm^3), volumetric flask (250 cm^3), beakers (1200 cm^3), funnel, spring weighing balance, electronic weighing balance (METTLER TOLEDO model ME204E with an accuracy of 0.0001g), filter cloth, mortar and pestle, hand towel, metre rule, Vernier caliper, paper sieve, masking tape, razor blade and nylon thread. The mild steel used for this study was obtained from Delta Steel Company Aladja, Delta State, Nigeria. The composition of the mild steel sample was analyzed using Metal Analyzer, Optical Emission Spectrometer.

Material Preparation: The cylindrical samples of diameter 1cm and height of 1.5cm were carefully cut from a long rod of mild steel (total surface area of coupon 6.284 cm^2). The weight of each piece of the coupon was taken and recorded. An abrasive paper was used to remove any millscale and rust stains on the mild steel specimens before they were cleaned with acetone. The samples were then polished. The coupons were degreased by washing them in absolute ethanol, rinsed in acetone and allowed to dry. The dried coupons were stored in moisture free desiccators until required for use. The chemicals and reagents used in this study were of analytical grade and distilled water was used to prepare them.

Preparation of Leaves Extract: The Moringa Oleifera and Psiduim Quajava leaves used for the study were sourced locally. The leaves extracts were prepared by extracting weighed amount of the fresh leaves of Moringa Oleifera and psidium guajava for two hours under ambient conditions. After this, it was manually squeezed by pounding with mortar and pestle to obtain corresponding juice extracts without addition of water and then filtered. Further, the solution was filtered and stored securely. The concentrations of the extracts were expressed in (cm^3). The prepared extracts were measured using a measuring cylinder and were later poured into the different 36 beakers used, each beaker measuring 25 cm^3, 50 cm^3, 75 cm^3 and 100 cm^3 respectively, for each of the tested extracts in 0.5M and 1.0M NaOH environment.

The mild steel rods were cut into cylindrical shapes of 1.5cm by 1cm using the hacksaw, to obtain one hundred and forty four coupons. The whole coupons were weighed individually and recorded, using the electronic digital weighing balance. The beakers containing the media were carefully labeled against the medium, that each contained. The 0.5M and 1.0M of NaOH solution were prepared by dissolving the appropriate amount of NaOH respectively in the desired volume of distilled water. The beakers were rinsed with distilled water before use. A total of thirty six (36) beakers were rinsed and left to dry, before the experiment was set up, so as to avoid additional water (mass). The coupons were immersed in the different media by means of a nylon thread hung on a retort stand and tied to the coupons. The four coupons were immersed in each of the beakers and it was ensured that none of the coupons touched one another to avoid crevice and galvanic corrosion.

RESULTS AND DISCUSSION

Fig. 1 depicts the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH environments in the absence of the Moringa Oleifera and Psiduim Quajava leaves extacts and with 25 cm^3 of the Moringa Oleifera and Psiduim Quajava leaves extract included.

The variation of the corrosion penetration rate with the exposure time was computed using standard relations from the literature. The corrosion penetration rate (CPR) as the consequence of the physiochemical interactions mostly expressed in mm/year is an important corrosion monitoring index that gives reliable information on the degree of corrosion in a given material independent of the environment. The mathematical computation of CPR is based on the formula [16-17];

$$CPR = \frac{K\Delta W}{\rho At} \quad (1)$$

In equation 1, ΔW is the weight loss after the exposure time t, ρ is the density, A is the exposed specimen area and K is a constant with its magnitude depending on the system of units used. In general, it has been argued by various authors that this estimation is suitable only for uniform corrosion and becomes somewhat erratic with local instability [18].

As indicated in Fig. 1, the effect of the inhibitor on corrosion penetration rate is glaringly clear in the plots (Fig. 1), indicating that when the inhibitor (Moringa Oleifera and Psiduim Quajava leaves extacts) has been included, the plots were reduced by > 60% of the control. The decrease of the corrosion profile for the presence of the Moringa Oleifera leaves extract was more pronounced especially at exposure time > 300 hrs, indicatinag the effectiveness of the Moringa Oleifera leaf extract compared to the Psiduim Quajava leaves extacts in that environment.

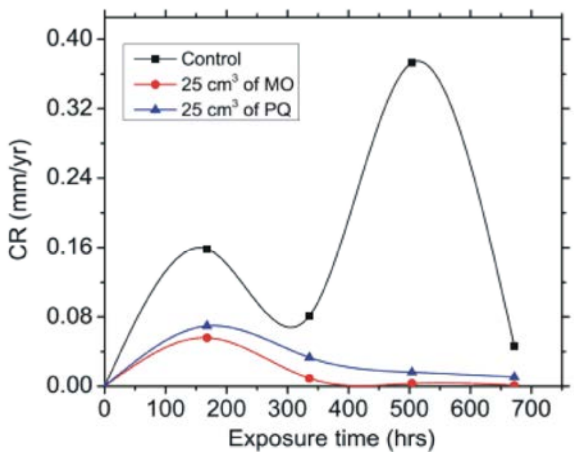

Fig. 1: Plots of corrosion rate against time (25 cm^3 of the inhibitors at 0.5M NaOH)

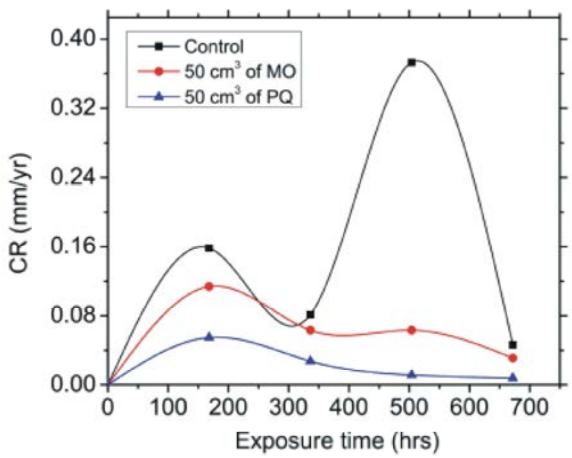

Fig. 2: Plots of corrosion rate against time (50 cm^3 of the inhibitors at 0.5M NaOH)

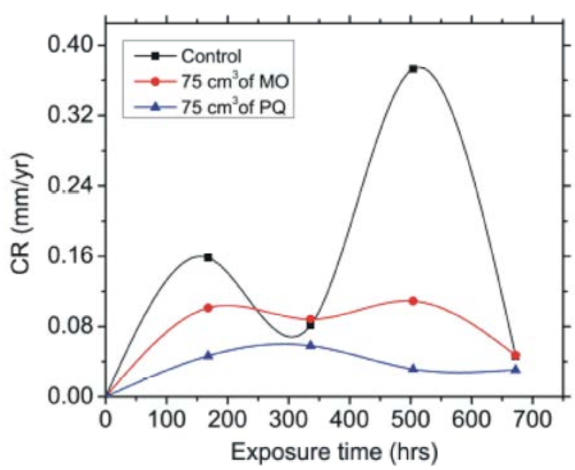

Fig. 3: Plots of corrosion rate against time (75 cm^3 of the inhibitors at 0.5M NaOH)

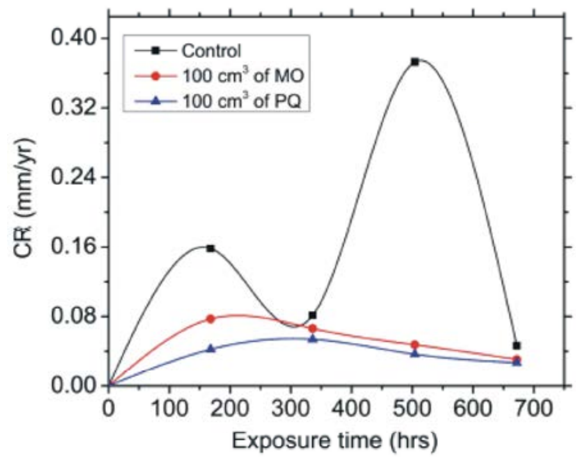

Fig. 4: Plots of corrosion rate against time (100 cm^3 of the inhibitors at 0.5M NaOH)

Fig. 2 gives the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH environments in the absence of the Moringa Oleifera and Psiduim Quajava leaves extracts and with 50 cm^3 of the Moringa Oleifera and Psiduim Quajava leaves extract included. The results (Fig. 2) show that the effect of the two inhibitors were relatively the same in that the profile for the corrosion penetration rate increased in both cases up to an exposure time of 168 hrs and then decreased thereafter. However at this particular volume of the inhibitors, the decrease of the corrosion penetration rate of the Psiduim Quajava leaves extacts was more pronounced compared to that of the Moringa Oleifera leaf extracts. This behaviour observed herein is explained on the basis of the fact that with the increasing leaves extract content, the amount of these precipitates increases, thus limiting the corrosion rate. However, the more pronounced decrease observed in the case of the Psiduim Quajava leaves extacts could be due to a localized uniform inhibitive effects compared to the former. According to the literature, Shingh *et al.* [19-20] reported on the inhibitive properties of Moringa oleifera fruit extract on the corrosion of mild steel in hydrochloric acid and noted that the inhibition was found to increase with increasing concentration of the extract. The authors also noted that the inhibition occurred via adsorption of the inhibitor molecules on the mild steel surface, obeying the Langmuir adsorption isotherm in their observations.

Fig. 3 indicates the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH environments in the absence of the Moringa Oleifera and Psiduim Quajava leaves extracts and with 75 cm^3 of the Moringa Oleifera and Psiduim Quajava leaves extract included. This observation as indicated in Fig. 3, show that at 0.5M of sodium hydroxide concentration with different volumes (75 cm^3) of the inhibitor introduced, the decrease in the corrosion penetration rate was relatively the same to that when 25cm^3 was introduced.

This could be due to the sparingly marginal difference in the range of the volumes of the inhibitors used.

Fig. 4 show the corrosion rate profile against the exposure time for the coupons in the 0.5M NaOH environments in the absence of the Moringa Oleifera and Psiduim Quajava leaves extracts and with 100 cm^3 of the Moringa Oleifera and Psiduim Quajava leaves extract included.

As indicated in the plots (Fig. 4), the corrosion rate (in the presence of inhibitor) exhibited a uniform increase up to an exposure time of 168 hrs and then decreased uniformly thereafter. This behaviour indicates that at the volume of 100 cm^3 of both inhibitors, a uniform corrosion was achieved.

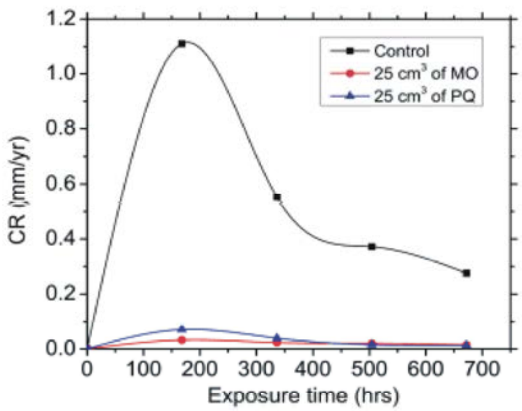

Fig. 5: Plots of corrosion rate against time (25 cm^3 of the inhibitors at 1.0M NaOH)

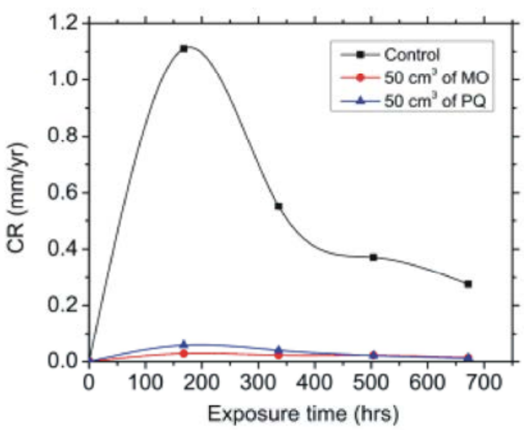

Fig. 6: Plots of corrosion rate against time (50 cm^3 of the inhibitors at 1.0M NaOH)

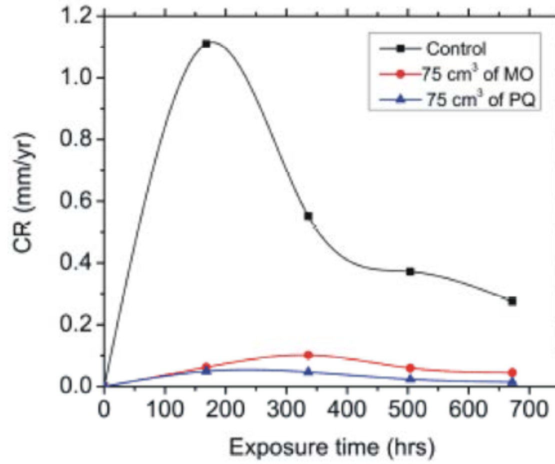

Fig. 7: Plots of corrosion rate against time (75 cm^3 of the inhibitors at 1.0M NaOH)

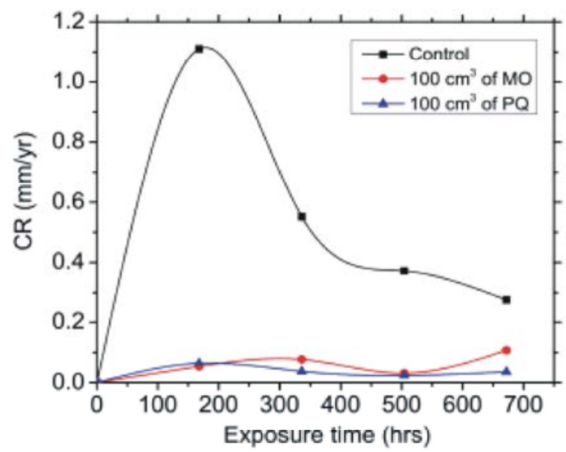

Fig. 8: Plots of corrosion rate against time (100 cm^3 of the inhibitors at 1.0M NaOH)

Figs. 5 -8, indicates the corrosion rate profile against the exposure time for the coupons in the 1.0M NaOH environments in the absence of the Moringa Oleifera and Psiduim Quajava leaves extracts and with 25 cm^3 to 100 cm^3 of the Moringa Oleifera and Psiduim Quajava leaves extract included. A close observation of the plots in Figs. 5-8, reveal that the corrosion penetration rates were all decreased by > 80 % at the respective volumes of the inhibitors (Moringa Oleifera and Psiduim Quajava leaves extract). In particular, the decrease was more pronounced at volumes of the inhibitors $\leq$ 50 cm^3 as the values were relatively close to zero for exposure time $\geq$ 300 hrs. This behaviour was attributed to uniform corrosion attack at that range, or to the uniform adsorption of the formed oxide layer on the metal surface, thus resulting in the decrease of the corrosion at a uniform rate. These observations strongly suggest that the optimised conditions for decreased corrosion rate is within the range 25cm^3 to 50 cm^3 of both inhibitors at 1.0M sodium hydroxide environment.

CONCLUSION

In this study, the inhibitive properties of Moringa Oleifera and Psiduim Quajava Leaves Extract on the Corrosion Susceptibility of Mild Steel in an alkaline environment is investigated. The results show a general trend of decreasing corrosion rate with the exposure time for both inhibitors. In particular the decrease was quite exponential at the higher concentration independent of the volumes of the inhibitors (Moringa Oleifera and Psiduim Quajava Leaves Extract). At 1.0M concentration of the sodium hydroxide, the decrease was more pronounced at volumes of the inhibitors $\leq$ 50 cm^3 as the values were relatively close to zero for exposure time $\geq$ 300 hrs. The study further concludes that this observation is an indication that these conditions can be used to obtain minimum corrosion effect on mild steel in an alkaline environment under the influence of such low cost inhibitors.

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