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# Corrosion Inhibition of Crown Corks of Carbonated Drinks Using *Chyrsohyllym Albidium* Extract

Akoma Chigozie S.[1, 2], Osarolube Eziaku[2], Abumere O. E.[2], Nnanna Lebe A.[1], John Wisdom O.[1]

[1]Department of Physics Electronics, Abia State Polytechnic, Aba

[2]Department of Physics, University of Port Harcourt, Port Harcourt

***Abstract:*** **Corrosion inhibition of mild steel in carbonated drinks solutions of Coca-Cola, sprite and Fanta using plant extract of *Chrysohllym albidium* (CA) was investigated at ambient (25°C), fridge (5°C) and freezer (-3°C) temperatures by gravimetric techniques. There was a characteristic observation of high inhibition efficiencies of 93.8% at 5°C in Fanta, 90.0% in Sprite at -3°C and 92.7% in Coke at -3°C. It was deduced that weight loss reduced as the temperature decreased. Scanning electron microscopy (SEM) micrographs revealed that CA actually inhibited corrosion of mild steel when the surface morphology of the inhibited and uninhibited metal coupon were compared. The result shows that these inhibitors are effective as corrosion inhibitors for mild steel in these carbonated drinks. Scanning electron microscopy result shows that the surfaces of the metals were quite protected in the presence of these inhibitors, with evidence of adsorbent species on its surface.**

***Keywords:*** ***C*arbonated drinks solutions of Coca-Cola, sprite and Fanta, plant extract of *Chrysohllym albidium*, Corrosion inhibition of mild steel.**

## 1. INTRODUCTION

Iron and its alloys are extensively used in industries. Their usage varies with the environment in which they are used. Excessive corrosion attack is known to occur on metals deployed in service in aggressive environments. A significant method to protect such metals is the introduction of corrosion inhibitors that hinder the corrosion reaction and thus reduce the corrosion rate. Inorganic substances such as phosphates, chromates, dichromates, silicates, borates, tungstates, molybdates and arsenates have been found effective as inhibitors of metal corrosion (Oguzie, 2008).

Many synthetic compounds have shown good anticorrosive activities. Most of them are highly toxic to both human beings and environment. The safety and issues of corrosion inhibitors arising in industries have always been a global concern. Such inhibitors may cause reversible or irreversible change to the organs, disturb a biochemical process or an enzymatic system at some sites in the body. The toxicity may manifest either during the synthesis of the compound or during its application (Salghi et al., 2012).

Plant extracts have become important as an environmentally acceptable, readily available and renewable source of wide range of inhibitors. They are rich sources of ingredients which have very high inhibition efficiency (Ameer et al., 2011). *Chrysophyllum albidum* belongs to the family *Campodeoidea*. It is widely distributed in the low land rain forest zones and frequently found in villages (Madubuike and Ogbonnaya, 2003). It is often called the white star apple and distributed throughout the southern part of Nigeria (Idowu et al., 2006). In South-western Nigeria, the fruit is called “agbalumo” and popularly referred to as “udara” in South-eastern Nigeria. It is an evergreen tree that can grow up to 40 meters high and about 2 meters in girth. It has a straight and long fluted bole with small buttress at the base. The bark is thin and light brown and when incised exudes a gummy latex. The fruits usually appear in July, ripen between December and March. Its high pectin content (Inoh et al., 1977) is also suggestive of its vast medicinal benefits, which include plasma cholesterol level reduction, rate of sugar uptake as well as its detoxifying action and effectiveness in diarrhea therapy (Hulme, 1970). However, up till now, only the juice component of the fruit is consumed to a large extent, while a few people relish the gummy, tasty pulp as well. The fruit, as is the situation with most tropical fruits, is seasonal and highly perishable. These factors militate against its large scale production. It is rich sources of natural antioxidants have been established to promote health by acting against oxidative stress related disease such infections as; diabetics, cancer and coronary heart diseases (Burits & Bucar, 2002). The bark is used for the treatment of yellow fever and malaria while the leaf is used as an emollient and for the treatment of skin eruption, stomachache and diarrhea (Adisa, 2000; Idowu et al., 2006). Cotyledons from the seeds of *C. albidum* are used as ointments in the treatment of vaginal and dermatological infections in Western Nigeria and also possess anti-hyperglycemic and hypolipidemic effects (Olorunnisola et al., 2008). Antimicrobial activity (Idowu et al., 2003), anti-nociceptive, anti-inflammatory and antioxidant activities (Idowu et al., 2006) and antiplatelet effect (Adebayo et al., 2010). People take the same herbs for other medicinal purposes, ignorant of their anti-fertility effects. Ajetunmobi and Towolawi (2014) reported the methanoic extract of the leave of *C. albidum* contained alkaloids, tannin, saponin, Anthraquinones, flavonoids, terpenoids, steroids and cardiac glycoside while the distilled water extract contained same except tannin and saponin. Okoli and Okere (2010) who worked earlier showed that the fruit contained biologically active substances that include alkaloids, tannin, saponin, phenol and flavonoid.

Most corrosion inhibition research work have been centred on aggressive environment such as in acids or alkaline solutions and the application has not been at food industries such as carbonated drinks bottling companies. Crown corks of carbonated drinks corrode over time because of presence of carbon dioxide – an acid gas used in preserving the drinks. The crown corks is made of low carbon steel mostly electroplated with chromate which serve as a surface finisher and a corrosion inhibitor. In spite of the surface coatings, most times the crown corks get corroded. This has led to negative word of mouth effect on the product and consequently, decline in the demand of the product. This also has led to consumer dissatisfaction, hence producers of carbonated drinks have drifted to the use of plastic containers for carbonated drinks production.

This work therefore seeks to create the possibility of using CA fruit extract as an effective corrosion inhibitor for use in the inhibition of crown corks of carbonated drinks by bottling industries.

## 2. MATERIALS AND METHOD

**Materials:**

The materials required to carry out this experimental research are mild steel, *Chrysophllum albidum* fruit sap, silicon emery paper (grade nos 200, 400, 600), digital weighing balance, refrigerator with freezer and fridge compartments, thread, filter paper, vernier callipers, micrometer screw guage, desiccators, hydrochloric acid, acetone, ethanol, distilled water, SEM machine.

***METHOD:***

***Preparation of coupons:***

The mild steel sheet was purchased from the materials marked in Aba South LGA of Abia State and the spark analysis was conducted at Petroleum Training Institute, Effurun, Warri, Nigeria. The mild steel compositions are C = 0.05, Mn = 1.13, Si = 0.05, P = 0.91, S = 0.85, Cu = 0.09, Pb = 0.15, Ve = 0.13, Mo = 0.08 and Fe = 96.56.

The mild steel sheet was cut into coupons of dimensions 20 mm X 20 mm and a hole of 2.5 mm was drilled at the centre but to one end of the coupon. The hole was drilled on the coupon to enable for insertion into the corrosive media. The metal specimens were polished with silicon emery abrasive paper, degreased with ethanol and dried in acetone.

***Corrosive environment:***

The corrosive media used for this experiment were carbonated drinks – sprite, Fanta and coke which are all products of Nigerian Bottling Company (NBC).

***Preparation of Plant extract:***

The inhibitor, CA was sourced out from Aba. The CA was squeezed out from the fruit pulp. The sap was collected in a sterilized bottle and stored in a refrigerator for preservation. The method of extraction was refluxing method. The sap was mixed with the corrosive media in the ration of 1:24 and thereafter refluxed in the refluxing machine for 3 hours.

***Dipping of Coupons:***

The blank experiment was conducted by dipping the air dried coupons into the respective drinks and letting them remain in the medium for six weeks. They were checked and retrieved on weekly basis to obtain the weight of the uninhibited metal. This served as the control experiment.

The main experiment was conducted by first dipping the cleaned and weighed metal coupon in to the CA plant extract for 5 minutes. This was to form a protective thin film of the inhibitor on the metal coupon. The coupons were retrieved after the 5 minutes and allowed to air dry. This coupons were then introduced into the corrosive media – coca cola, sprite and Fanta. The set up was such that six of each medium were placed at temperatures of 25°C (ambient), 5°C (fridge) and -3°C (freezer). The experimental set up were allowed to stand for six weeks of which identified coupons were retrieved weekly and subsequently washed, dried and reweighed to obtain the weight loss.

The corrosion rates were calculated using the formula in equation 1 (Martínez et al., 2010):

$$CR = \frac{k\Delta w}{\rho A t} \quad (1)$$

Where $CR =$ Corrosion rate in mm/yr

$k =$ Corrosion rate constant (534 mpy; mils per year).

$\Delta w =$ Weight loss in grams

$\rho =$ Density of the steel (g/cm3)

$A =$ The exposed area of the coupon (cm2)

$t =$ Immersion time (hrs)

The inhibition efficiency which is the percentage of reduction of corrosion rate without and with the inhibitor was calculated using the formula:

$$I\% = \left(1 - \frac{W_1}{W_2}\right) \times 100 \quad (2)$$

where $W_1$ and $W_2$ are the corrosion rates of inhibited coupons and uninhibited coupons respectively.

***Scanning Electron Microscopy:***

The XL-30FEG Scanning Electron Microscope was used to study the surface morphology of the metal specimen before and after immersion in the different corrosive media in the absence and presence of CA. The mild steel specimens were those used in the gravimetric analysis.

## 3. RESULTS AND DISCUSSION

The obtained results for the use of CA as a corrosion inhibitor are presented in the figures 1-9 below. The results obtained reveal that CA afforded a significant effect on the corrosion inhibition of mild steel in Coke, Sprite and Fanta, respectively. In the presence of CA, both the weight loss and corrosion rate values reduced as well and better protection of the mild steel surface was observed also.

***Weight loss and effect of temperature:***

The effect of temperature is inevitable in corrosion studies hence its investigation in the presence of CA. It was observed that temperature has a pronounced effect on the corrosion behaviour of mild steel even when CA was introduced into the aggressive solutions. It was deduced the higher the level of temperatures of the corrosive solutions, the higher the corrosion rates and hence, the weight loss increases. The study was performed in the absence and presence of CA at various temperatures and the results presented in Fig. 1 to 9, respectively. The obtained results revealed that at higher temperatures both weight loss and weight losses increased.

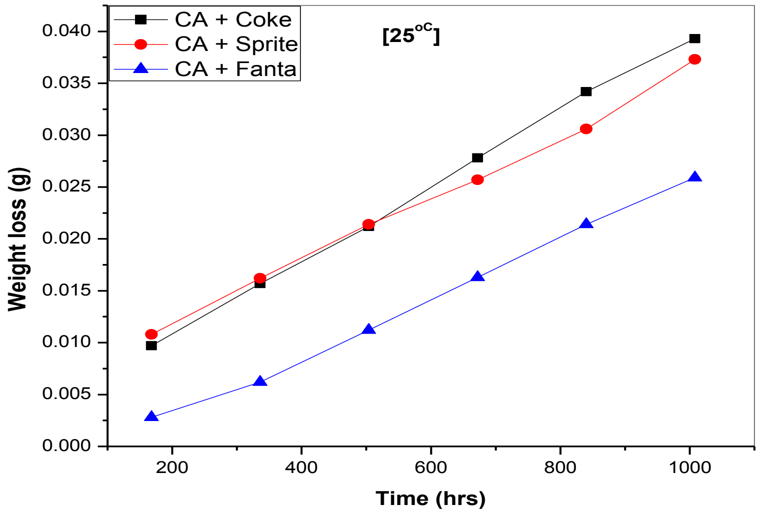



Fig. 1: Variation of weight losses of CA in the various corrosive solutions and at 25°C.

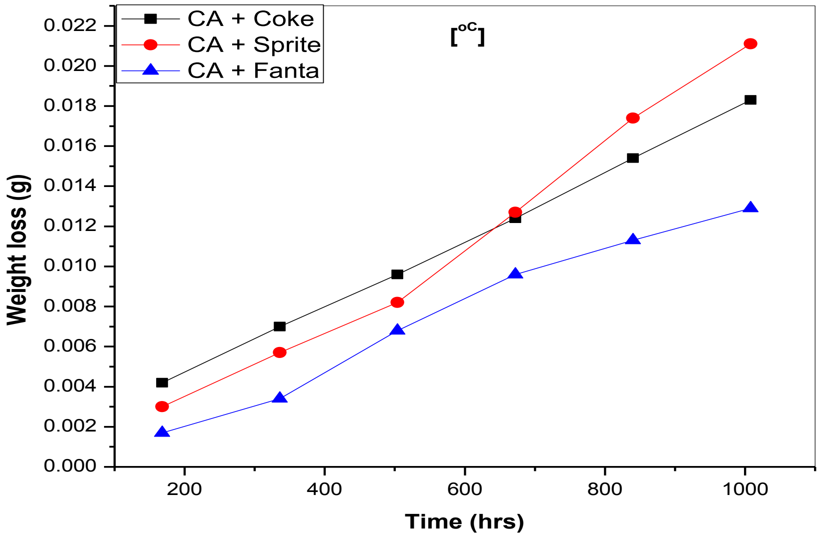



Fig. 2: Variation of weight losses of CA in the various corrosive solutions and at 5°C.

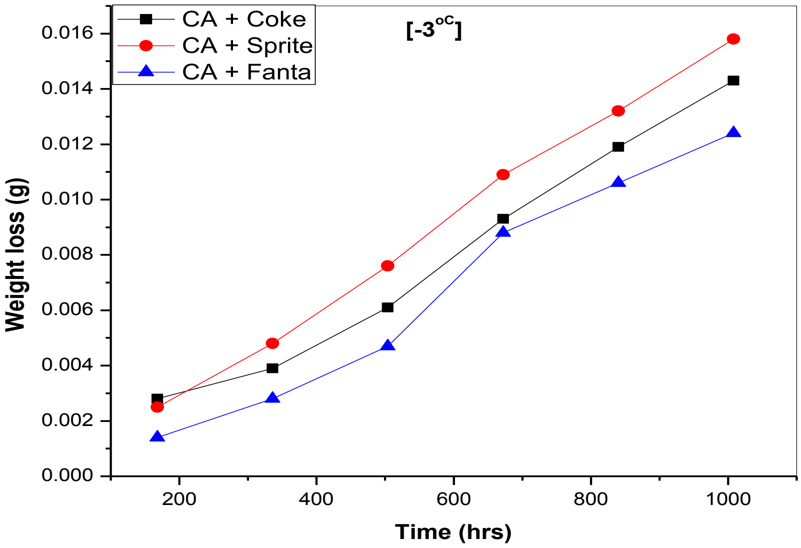



Fig. 3: Variation of weight losses of CA in the various corrosive solutions and at - 3°C.

***CORROSION RATE AND EFFECT OF IMMERSION TIME:***

The results show that immersion time has a significant effect on the corrosion of mild steel. In the presence of CA, it was observed that inhibition efficiency reduced with an increase in immersion time. The values of weight loss and corrosion rate increased considerably, as observed in the case of DG the rate/magnitude of corrosion gradually reduced. This was attributed to the gradual adsorption of more CA species onto the mild steel surface with time, couple with the formation of corrosion products both in the inhibited and uninhibited environment. The presence of inhibitor species adsorbed on the metal surface and the corrosion products formed helped to resist the aggressive attack by these corrosive species. Also, the observed effects account for the reduction of corrosion rates over time as shown in Figures 4 to 6.

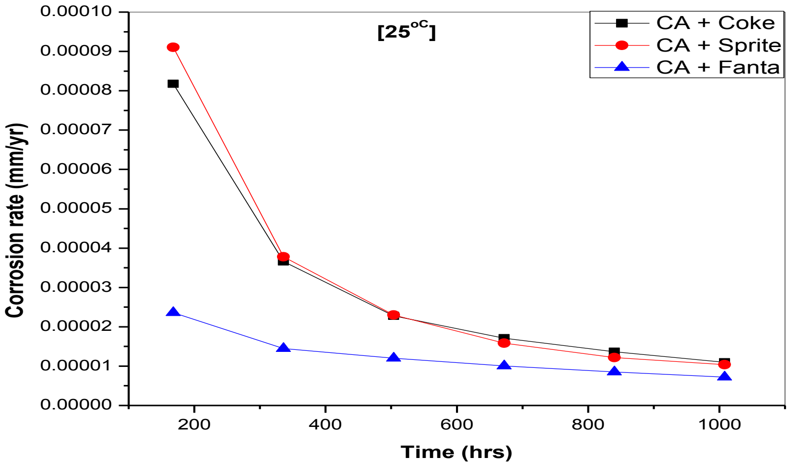



**Fig. 4: Variation of corrosion rates of CA in the various corrosive solutions and at 25°C.**

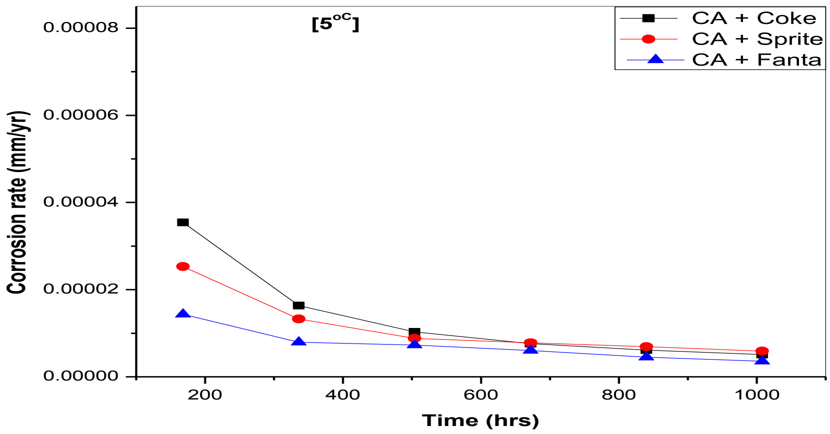



**Fig. 5: Variation of corrosion rates of CA in the various corrosive solutions and at 5°C.**

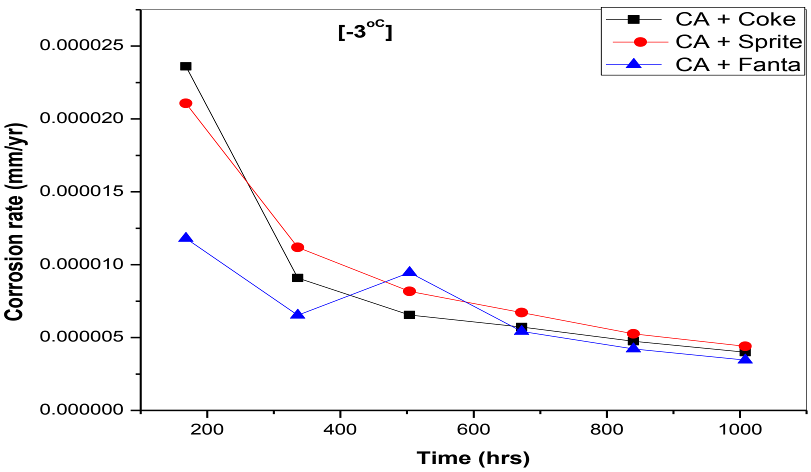



**Fig. 6: Variation of corrosion rates of CA in the various corrosive solutions and at - 3°C.**

***INHIBITION EFFICIENCY:***

The Inhibition efficiency was calculated using the formula as stated in equation (2):

$$I\% = \left(1 - \frac{W_1}{W_2}\right) \times 100 \quad (2)$$

The values of inhibition efficiency obtained for CA in the aggressive environments studied are presented the graphs as shown in Figures 7 to 9. For Fanta, the highest inhibition efficiency was gotten to be 93.8%, 90.0% for Sprite and 92.7% for Coke. These maximum inhibition efficiencies were all gotten at lowered temperature which goes in line with the findings that inhibition efficiency is lowered at higher temperatures due to the fact that the environment becomes more aggressive at such high temperatures.

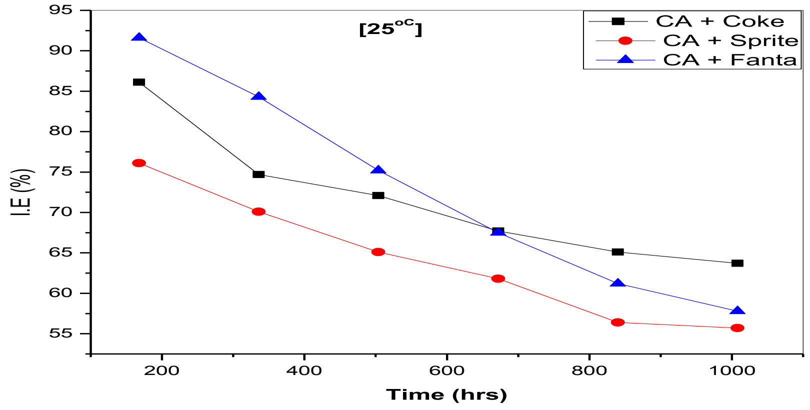



**Fig. 7: Variation of inhibition efficiencies of CA in the various corrosive solutions and at 25°C.**

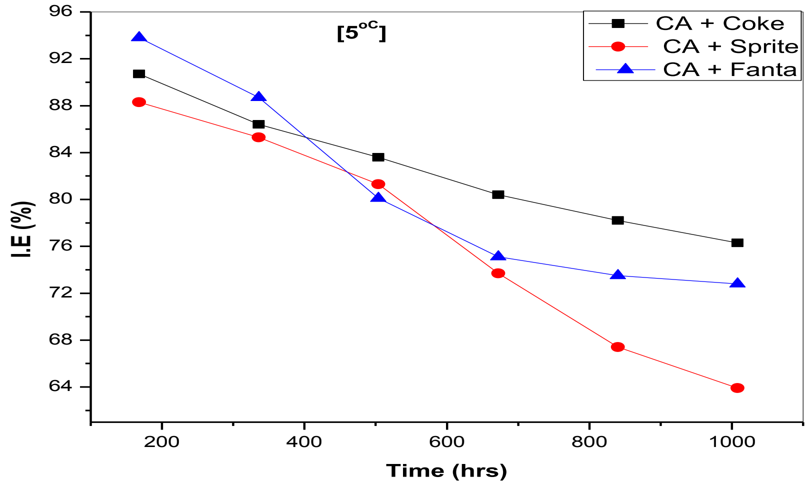



**Fig. 8: Variation of inhibition efficiencies of CA in the various corrosive solutions and at 5°C.**

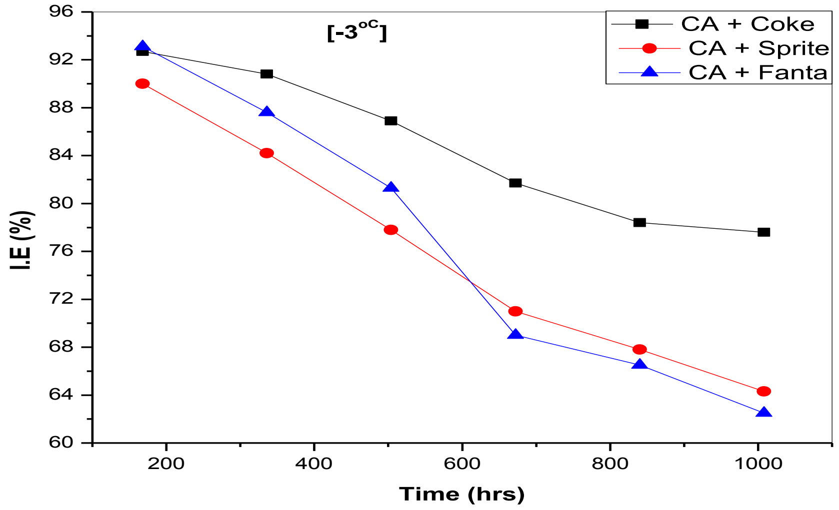
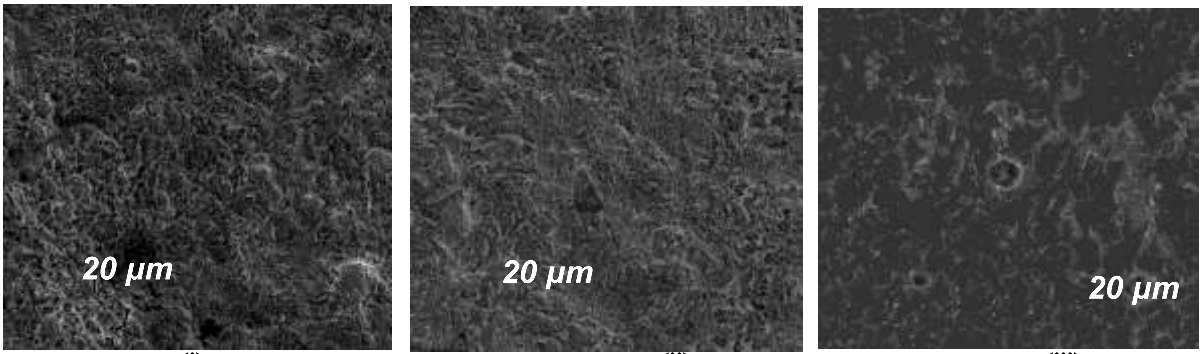



**Fig. 9: Variation of inhibition efficiencies of CA in the various corrosive solutions and at - 3°C.**

***SCANNING ELECTRON MICROSCOPY:***

Scanning Electron microscopic images (Fig. 9 and 10) of the mild steel immersed with and without the inhibitor was captured. Careful observation of the images which showed the fact that the uninhibited metal had a smoother surface than the inhibited coupon implied the presence of the constituents of CA molecules (alkaloids, tannin, saponin, Anthraquinones, flavonoids, terpenoids, steroids and cardiac glycoside) which reduced the active dissolution of the mild steel by formation of a protective film, which accounts for a different layer, adsorbed on the surface of the metal.




(i) (ii) (iii)

**Fig. 10: SEM images of the mild steel surface after 1008 hrs immersion at 25°C in (i) Coke, (ii) Sprite and (iii) Fanta: in the absence of the various inhibitors studied.**


(i) (ii) (iii)

**Fig. 11: SEM images of the mild steel surface after 1008 hrs immersion at 25°C in: (i) Coke, (ii) Sprite and (iii) Fanta: in the presence of CA.**

## 4. CONCLUSION

Green inhibitors are a good replacement for the synthesized inhibitors which pose threats to our health and environment. *Chrysohllymalbidium*, after being experimented on using gravimetric method can be said to be a good inhibitor of corrosion of crown corks both at low temperatures and at room temperatures. The inhibition efficiencies of 93.8% at 5°C in Fanta, 90.0% in Sprite at -3°C and 92.7% in Coke at -3°C gotten from calculations using the experimental data reveals this and hence can be used as a substitute for the chromate used in the electroplating of the crown corks before it is being used in the bottling companies.

Moreover, for further studies, the thin film deposition of the inhibitor should be studied to know the thickness of the inhibitor molecules that are adsorbed onto the metal.

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