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INVESTIGATION OF RUBBER LATEX, *GARCINIA KOLA* AND *COLA NITIDA* EXTRACT AS CORROSION INHIBITORS FOR MILD STEEL IN HYDROCHLORIC ACID

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ABSTRACT

Synthetic corrosion inhibitors that are used in the process industries are not only very expensive but highly toxic. The present work studied extract from latex rubber tree, garcinia kola and cola nitida nuts as inhibitors with varying concentrations in combating corrosion of mild steel in one mole of hydrochloric acid solution at room temperature. Weight loss technique was used in determining samples rate of corrosion in the absence and presence of the different plant extracts. The results obtained indicated that the plant extracts exhibited good inhibitive properties. It was found that efficiencies of corrosion inhibition increased with increasing inhibitor concentration. However, the gum extract proved to be the most effective inhibitor for corrosion control, followed by garcinia kola and cola nitida at 5 hours latency period . The research has demonstrated that the plant extracts have good inhibitive property and could replace the widely used synthetic inhibitors in the process industries.

1. INTRODUCTION

Mild steel has become the base material in process and most engineering industries due to its good mechanical property, low cost and availability despite its high susceptibility to corrosion (Intetech, 2010). The internal corrosion of steel pipelines in process industries has been controlled for several decades with the application of synthetic chemical corrosion inhibitors which are very expensive, toxic and non-biodegradable, hence regulatory authority requires further treatment before disposal to environment (U.S. Congress, 1995). For these reasons, studies of several plant extracts as alternative corrosion inhibitor have been on the rise in the last couple of decades because of the numerous advantages like availability, renewability, less toxicity and cost effectiveness compared to synthetic corrosion inhibitor (Abeng et al., 2013). Majeed and Sadkhan (2013) used polyethylene glycol as corrosion inhibitor in sulphuric and hydrochloric acid environments. The study showed that corrosion rate reduced with increased inhibitor concentration because of increased adsorption on metal surface. Tobacco leaves extracts inhibition of mild steel in corrosive acidic environment showed very promising results (Fraunhofer, 1995; Fraunhofer, 2000; Davis et al., 2001; Davis and Fraunhofer, 2003;). Corrosion inhibiting ability of plant extracts such as *carica papaya* (Okafor and Ebenso, 2007), *Artemisia annua* (Okafor et al., 2012) and pineapple leaves in acidic medium using mild steel have been studied (Ekanem et al., 2010). Leaves and seeds of plant extract of *garcinia kola* and *cola acuminate* as corrosion inhibitors in hydrochloric and sulphuric acid have also been investigated and the results showed reduction in corrosion rate of mild steel with increasing concentration of the plant extracts (Okafor, 2007; Loto et al., 2011; Ikeuba et al., 2013). The natural plant juice extract from *garcinia kola, cola nitida and cola accuminata* seeds revealed presence of tannins, saponins, alkaloid, flavonoids, steroids, steroids, cardiac glycoside and saponins glycoside organic compounds (Omwirhiren., 2016; Omwirhiren et al., 2017). Furthermore, few studies on application of gum exudates of *araucaria columnaris* (Brindha et al., 2015), gum of acacia seyal var seyal (Buchweishaija and Mhinzi, 2008), gum exudates of acacia tree (Abu-Dalo et al., 2012) and *dacroydes edulis* gum (Umoren et al., 2008) as organic inhibitors against corrosion for mild steel in acidic environment have been conducted and the results indicated decrease of corrosion rate with increasing concentration. But rarely has research on free gum from rubber latex tree been studied. The present study investigates application of rubber latex gum as corrosion inhibitor of mild steel in acid medium and comparison of inhibitor efficiency to *garcinia kola* and *cola nitida* which are environmentally friendly and less expensive.

2. MATERIALS AND METHODS

2.1. Mild Steel Preparation

A flat mild carbon steel measuring 0.2 x 0.3 x 0. 0015m used in the study was sourced from Universal Steel Company in Lagos State. Spectrometric chemical composition analysis of the mild steel using optical emission spectrometer revealed the following percentage in weight: 0.0292C, 0.0062Si, 0.152S, 0.0096P, 0.253Mn, 0.026Ni, 0.125Cr, 0.0869Cu, 0.003Co, 0.0007Al, 0.005Zn and iron (Fe) was the remaining percentage. The obtained steel plate was firstly cut into coupon dimensions of 50 x 40 x 1.5mm for easy handling and then polished with various size of silicon emery paper grades (220, 320, 600, 800 and 1200). The polishing was followed by wire brushing, rinsing in distilled water, degreasing in methanol solution, drying and then storage in a desiccator for subsequent tests.

2.2. Plant Extract and Acid

Free gum from the back of latex rubber trees were collected from Idah, Kogi State. The obtained gum was purified by dissolving in distilled water, followed by filtration to remove suspended particles and then drying in a desiccator to concentrate the gum according to Brindha et al (2015) method. The nuts of *garcinia kola* and *cola nitida* obtained from Idah market in Kogi State were crushed, ground into powder and then soaked in methanol solvent separately for a period of seven days to allow concentrated juice extract. At the end of the seven days, each of the plant extract was filtered and boiled at 85^0C for 20 minutes before squeezing or leaching in order to further concentrate the juice extract of the seed nuts in accordance with Loto et al (2011) procedures. The concentrated plant extracts juice was stored separately in scaled beaker containers. Solution of one mole hydrochloric acid was prepared by diluting concentrated 33% hydrochloric acid with distilled water.

2.3. Weight Loss Measurement

Gravimetric experiment was conducted as prescribed by ASTM (1990). All the coupon specimens were machined to 50 x 40 x 1.5 mm sizes with drilled hole of 3.0 mm diameter primarily for suspension in container and then cleaned. The coupons were initially weighed prior to immersing completely in one mole of hydrochloric acid solution at room temperature with varying concentrations (20 mg/ml, 40 mg/ml, 60 mg/ml, 80 mg/ml and 100 mg/ml) of latex rubber gum, *garcinia kola* and *cola nitida* juice extract in separate beaker container and another beaker with one mole of hydrochloric acid solution without the plant extract. Weight loss measurements of the coupons were taken at interval of 1 hour for a total exposure period of 5 hours. Corrosion rate and inhibitor efficiency were estimated using Equations (1) and (2) respectively:

$$CR = \frac{W}{At} \quad (1)$$

$$\%E = \frac{W_{ab} - W_{in}}{W_{ab}} \text{x} 100 \quad (2)$$

where, CR = corrosion rate, W = weight loss, At =total surface area of the coupon, t = exposure time, %E = percentage efficiency, W_{ab} = weight loss in the absence of inhibitor and W_{in} = weight loss in the presence of inhibitor

3. RESULTS AND DISCUSSION

Figures 1 to 4 represent plots of corrosion rate against exposure time, corrosion rate against inhibitors concentration at 5 hours exposure time, inhibitors efficiency against varying concentration and exposure time at 100 mg/ml respectively. Figure 1 revealed highest corrosion rate ($208.8 \text{ x } 10^{-4}$mpy) for the control specimen in 1.0M HCL solution after 1 hour exposure and then decreased gradually with increasing exposure time to $91.4 \text{ x}10^{-4}$mpy. Clearly, Figure 1 demonstrates sharp decrease in corrosion rate for the first 2 hours of exposure time after which the rate of corrosion decreased steadily for the control sample. Furthermore, the corrosion rate value decreased from $208.8 \text{ x } 10^{-4}$mpy in control condition to $53.4 \text{ x } 10^{-4}$mpy, $74.6 \text{ x } 10^{-4}$mpy and $74.09 \text{ x } 10^{-4}$mpy with addition of rubber gum, garcinia and nitida kola inhibitors at the same 1hour exposure time respectively. The sharp reduction could be explained by film formation and adsorption mechanisms of the respective plant extract by blocking active sites on the corrodent surface (Majeed and Sadkhan, 2013).

The plot of corrosion rate against inhibitors concentration (Figure 2) showed decrease in corrosion rate with increasing concentration. This observation could be attributed to increasing inhibition adsorption on the mild steel coupons leading to thick film protection layer formation. This is in agreement with work of Majeed and Sadhkan (2013). However, the reduction rate was initially high with the first 20 mg/ml concentration but subsequent increment resulted in gradual reduction, and this could probably be due to a decrease in corrosion active sites (Oguzie, 2007). The observation appeared to be in agreement with those of Brindha et al. (2015) who concluded that increased inhibition concentration performance may decline after certain concentration.

Figure 3 indicated inhibition efficiency increment with increased inhibitor concentration at 5 hours exposure time as a result of multiplied number of inhibitive molecules leading to continuous isolation of the corrosive medium from the corrodent (Ikeuba et al., 2013). The efficiency increments with concentration further agreed with the report of Matheswaran and Ramasamy (2010). Figure 4 which showed plot of inhibition efficiency versus exposure time at 100 mg/ml concentration indicated maximal efficiency (79.59%) for rubber gum while garcinia kola and cola nitida revealed maximal efficiencies of 95.04% and 69.32% respectively after latency period of 3 hours. But at 5hours latency period, the maximal efficiencies of rubber gum, garcinia kola and cola nitida are 82%, 69% and 62% respectively. The *garcinia kola* and *cola nitida* efficiencies increased initially with increasing latency period and later declined after 3 hours. However, the rubber gum efficiency was seen rising steadily up to latency period of 5 hours.

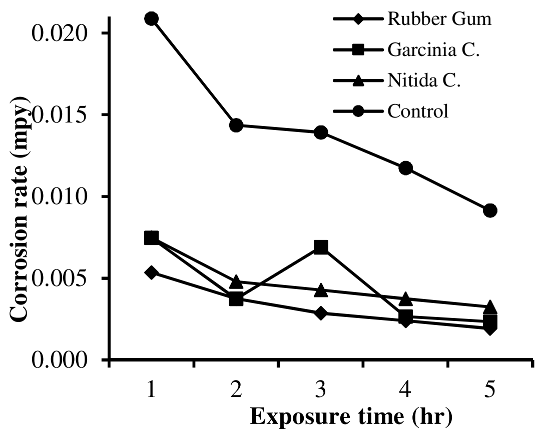

Figure 1: Corrosion rate with exposure time at 100mg/ml inhibitors concentration

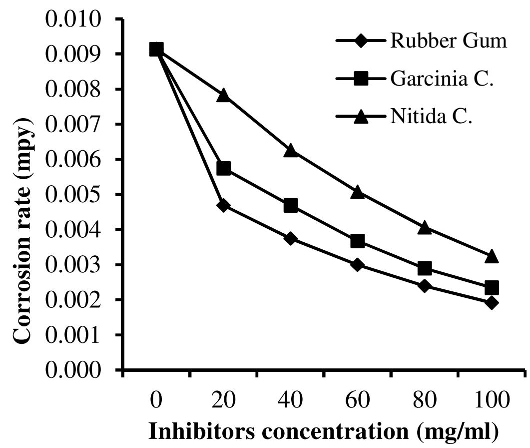

Figure 2: Corrosion rate with inhibitors concentration at 5hr exposure time

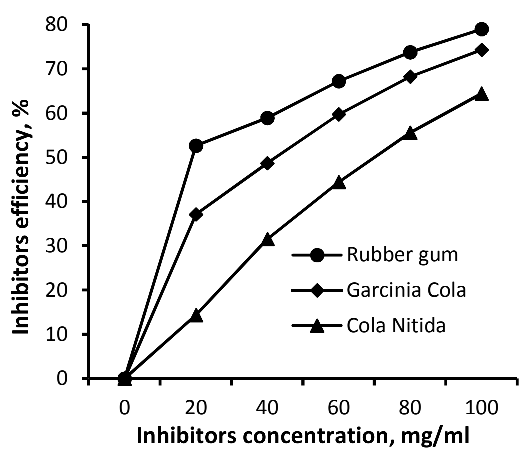

Figure 3: Inhibitors efficiency with inhibitors concentration at 5hr exposure time

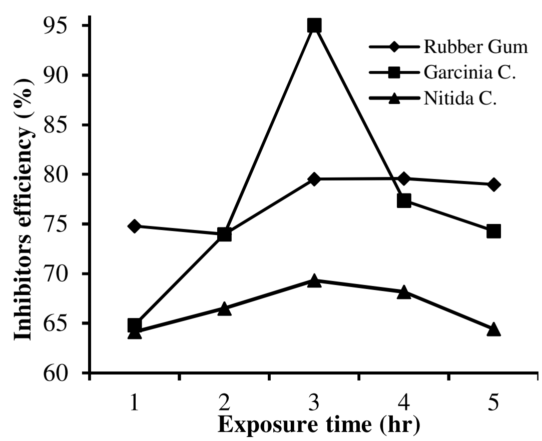

Figure 4: Inhibitors efficiency with exposure time at 100 mg/ml inhibitors concentration

4. CONCLUSION

The research has established that gum exudate of latex rubber tree, *garcinia kola* and *cola nitida* have excellent inhibitive properties for corrosion control in hydrochloric acid environment. The corrosion rate decreased with varying inhibitors concentration due to adsorption on the mild steel. Inhibitive efficiencies of the plants extract at 5 hours latency period was found to increase with increase in concentration. The inhibitors efficiency was equally observed to depend on latency period and the exudate of rubber tree gum showed longest latency period compared to *garcinia kola* and *cola nitida* nuts extracts. Furthermore, rubber gum proved to be the most efficient over the longest latency period of 5hours exposure time.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

REFERENCES

Abeng, F.E., Ekpe, U.J., Ikeuba, A.I, Ugi, B.U. and Nna, P.J. (2013). Inhibitive Action of Alkaloids and Non-alkaloid Fraction of Ethanolic Extracts of Phyllanthusamarus on the Corrosion of Mild Steel in HCL Solution. *Global Journal of Pure and Applied Science*, 19, pp. 107-117.

Abu-Dalo, M.A., Othman, A.A. and Al-Rawashdeh, N.A.F. (2012). Exudate Gum from Acacia Tree as Green Corrosion Inhibitor of Mild Steel in Acidic Media. *International Journal Electrochemical Science*, 7, pp. 9303 - 9310.

ASTM (1990). Standard Practice for Laboratory Immersion on Corrosion Testing of Metal, American Society for Testing and Material, G31-72, Philadelphia, PA.

Brindha, T. Revatti, P. and Mallika, J. (2015). Corrosion Inhibition of Naturally Occurring Gum Exudates of Araucaria Columnaris on Mild Steel in IM $H_2 SO_4$, *International Research Journal of Environment Science*, 4(4), pp. 36-43.

Buchweishaija, J. and Mhinizi G.S. (2008). Natural Products as a Source of Environmentally Friendly Corrosion Inhibitors: The Case of Natural Free Gum Exudates from Acacia Seyal Var Seyal. *Portugaliae Electrochemic Acta*, 26, pp. 257-265.

Davis, G.D. and Fraunhofer, J.A. (2003). Tobacco Plant Extracts as Environmentally Benign Corrosion Inhibitors. *Material Performance*, 2, pp. 56-60.

Davis, G.D., Fraunhofer, J.A., Krebs, L.A. and Dacres, C. M (2001), The Use of Tobacco Extract as Corrosion Inhibitors, NACE Paper 58, Houston, USA.

Ekanem, U.F., Umoren, S.A., Udousoro, I.I. and Udoh, A.P. (2010). Inhibition of Mild Steel Corrosion in HCL Using Pineapple. *Journal of Material Science*, 48, pp. 55-58.

Fraunhofer, J.A. (1995). Tabaco Extract Composition and Methods, United State Patent, 48:941.

Fraunhofer, J.A. (2000). Inhibiting Corrosion with Tobacco, *Advance Material Processing*, 158(2), pp. 33 – 36.

Ikeuba A.I., Okafor, P.C., Ekpe, U.J. and Ebenso, E.E. (2013. Alkaloid and Non-alkaloid Ethanolic Extract from Seed of Garcinia Kola as Green Corrosion Inhibitor of Mild Steel in H_2SO_4 Solution. *International Journal of Electrochemical Science*, 8, pp. 7455-7467.

Intetech Consultancy Ltd (2010). Corrosion and Selection of Materials for Carbon Capture and Storage, *Technical Report*, IEAGHG Programme,.

Loto, C.A., Loto, R.T. and Popoola, A.P.I. (2011). Corrosion and Plants Extracts Inhibition of Mild Steel in HCL. *International Journal of the Physical Science*, 6, pp. 3616-3623.

Majeed, J.G. and Sadkhan, B.A. (2013). Comparison of the Corrosion Inhibition Efficiencies of Low Carbon Steel in Different Acidic Medium Using some Polyethylene Glycol. *Journal of Engineering and Development*, 17, (4), pp. 165-181.

Matheswaran, P. and Ramasamy, A.K. (2010). Influence of Benzotriazole on Corrosion Inhibition of Mild Steel in Citric Medium. *E-Journal of chemistry*, 7(3), pp. 1090-1094.

Oguzie, E.E, (2007). Corrosion Inhibition of Aluminum in Acidic and Alkaline Media by Sanservieria Trifasciata. *Corrosion Science*, 46, pp. 159-167.

Okafor, P.C. (2007). Eco-friendly Corrosion Inhibitors: Inhibitive Action of Ethanol Extract of Garcinia kola for the Corrosion of Mild Steel in H_2 SO_4 Solutions, *Pigmen & Resin Technology*, 36, pp. 206 – 211.

Okafor, P.C. and Ebenso, E.E. (2007). Inhibitive Action of Carica Papaya Extracts on the corrosion of Mild Steel in Acidic Media and their Adsorption Characteristics. *Pigmen & Resin Technology*, 36, pp. 134-140.

Okafor, P.C., Ebiekpe, V.E., Azike, C.F., Egbungi, G.E., Brisibe, E.A. and Ebenso, E.E. (2012). Inhibiting Action of Artemisia Annua Extract and Artemisinin on the *Corrosion of Mild Steel in* H^2SO_4 *Solution, International Journal of corrosion, 2012, pp. 1 – 8.*

Omwirhiren, E.M., Abass, A.O. and James, S.A. (2017). The Phytochemical Constituents and Relative Antimicrobial Activities against Pathogens of Different Seed Extracts of Cola Nitida (Vent), Cola Acuminata (Beouvior) and Garciia Kola (Heckel) Grown in South West, Nigeria. *Journal of Pharmacognosy and Phytochemistry*, 16(1), pp. 493-501.

Omwirhiren, E.M., James, S.A. and Abass, A.O. (2016). The Phytochemical Properties and Antimicrobial Potentials of Aqueous and Methanolic Seed Extract of Cola Nitida (Vent) and Cola Acuminata (Beauvoir) Grown in South West, Nigeria. *Saudi Journal of Medical Pharmaceutical Science*, 2(12), pp. 354-363.

U.S. Congress (1995). Office of Technology Assessment, Environmental Policy Tool: Users Guide, OTA-ENV-634, Washington DC, US.

Umoren S.A., Obot, I.B., Ebenso, E.E, and Obi-Egbedi, N. (2008). Studies on the Corrosion Inhibition of Dacroydes Edulis Exudates Gum for Aluminum in Acidic Medium, *Portugaliac Electrochemical Acta*, 26, pp. 199-209.