World Academics Journal of Engineering Sciences **Review Paper**
Vol.6, Issue.1, pp.47-51, October (2019) **E-ISSN:** 2348-635X

Plants Extract for Corrosion Control of Mild Steel in Acidic Medium

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Available online at: www.isroset.org

Received: 15/Oct/2019, Accepted: 23/Oct/2019, Online: 31/Oct/2019

***Abstract*-** Corrosion control of metals is of technical, economical, environmental and aesthetical importance. The use of inhibitors from plant extract is one of the best option of protecting metals and alloys against corrosion as it is environmentally acceptable, readily available and renewable. This review paper exposed the use of some of the commonly available extracts, in addition to showing how hybridization of plant extract can enhance performance in the prevention of corrosion.

***Keywords*:** Acids, corrosion, extract, inhibitors, plants

I. INTRODUCTION

The word mild steel (MS) stands for an alloy of carbon and iron in which carbon is present in less amount due to this less amount of carbon mild steel have wide range of applications in mechanical industries like water cooling system, pipelining, in welding etc. due to its properties like ductility, malleability etc. so it preferred then other metals and steels with high amount of carbon but mild steel comes with a huge drawback that it can easily undergo corrosion [1,2]. MS is also called as the carbon steel which is a low carbon (0.3%) steel with superior strength. It is used when large amount of steel is needed and can be twisted and welded into an infinite range of shapes for uses in vehicles, construction material and vessels fabrication etc. In many industries, MS is the material of choice in the fabrication of reaction vessels, storage tanks etc. which get corroded easily in the presence of acids [3,4].

The study of corrosion of MS and iron is a matter of tremendous theoretical and practical concern and as such has received a considerable amount of interest. Acid solutions, widely used in industrial acid cleaning, acid descaling, acid pickling, and oil well acidizing, require the use of corrosion inhibitors in order to restrain their corrosion attack on metallic materials [5]. Corrosion control of metals is of technical, economical, environmental and aesthetical importance [6,7,8,9,10,11]. The use of inhibitors from plant extract is one of the best option of protecting metals and alloys against corrosion as it is environmentally acceptable, readily available and renewable [8]. Green corrosion inhibitors are biodegradable and do not contain heavy metals or other toxic compounds. Some research groups have reported the successful use of naturally occurring substances to inhibit the corrosion of metals in acidic and alkaline environment [5]. The aim is to review on different plant extract use for corrosion control of MS in acidic medium.

II. CORROSION

Corrosion is defined as the deterioration of a substance or its properties due to interactions between the substance and its environment [2,12]. Corrosion can cause disastrous damage to metal and alloy structures causing economic consequences in terms of repair, replacement, product losses, safety, and environmental pollution. Due to these harmful effects, corrosion is an undesirable phenomenon that ought to be prevented [13]. Numerous factors were reported to show a great influence on metallic corrosion. The followings are some of the factors; Biological effects Concrete /Soil Interface, DC Transit Systems, High Voltage Direct Current (HVDC) Electric Transmission, Dissimilar alloys or metals, Impurities in Metal, Marred or Scratched Surface, Moist/Dry Electrolyte, Non-Homogeneous Soil, Oxygen Concentration, Stressed Metallic Section, Temperature among others.

II.I CORROSION INHIBITORS

Corrosion inhibition occurs via adsorption of their molecules on the corroding metal surface, and the efficiency of inhibition depends on the mechanical, structural, and chemical characteristics of the adsorption layers formed

under particular condition [11,14]. The use of inhibitors for the control of corrosion of metals and alloys which are in contact with aggressive environment is one among the acceptable practices used to reduce and/or prevent corrosion. A corrosion inhibitor is a substance which, when added in small concentration to an environment, effectively reduces the corrosion rate of a metal exposed to that environment [13]. The use of many inorganic inhibitors, particularly those containing phosphate, chromate, and other heavy metals, is now being gradually restricted or banned by various environmental regulations because of their toxicity and difficulties faced in their disposal especially in the marine industry, where aquatic life is at threat [15]. Corrosion inhibitors can be divided into two broad categories, namely, those that enhance the formation of a protective oxide film through an oxidizing effect and those that inhibit corrosion by selectively adsorbing on the metal surface and creating a barrier that prevents access of corrosive agents to the metal surface [13].

III. PLANT EXTRACTS AS CORROSION INHIBITORS

Plants are sources of naturally occurring compounds, some with complex molecular structures and having different chemical, biological, and physical properties. The naturally occurring compounds are mostly used because they are environmentally acceptable, cost effective, and have abundant availability. These advantages are the reason for use of extracts of plants and their products as corrosion inhibitors for metals and alloys under different environment [13]. Plant extracts have potential to replace synthetic organic and inorganic inhibitors given their success story in literature. The mechanism of action of green inhibitors depends on the structure of the active ingredient and thus many researchers have to date postulated many theories to explain this phenomenon [2,16]. Different plant extracts can be used as corrosion inhibitors commonly known as green corrosion inhibitors. In the present review, we have worked on the extracts of *Camellia sinensis, Datura stramonium, Moringa oleifera, Cocos nucifera, Gongronema latifolium, Acalypha torta and Curcuma longa* as corrosion inhibitors.

III.I EXTRACTS OF CAMELLIA SINENSIS (GREEN AND BLACK TEA)

Yahaya *et al.*, [17] investigated the inhibitive behavior of Green Tea Extracts (GTE) and Black Tea extracts (BTE) on mild steel in acidic environment using gravimetric and spectroscopic methods. Results showed that the inhibition efficiency of both extracts increases with increasing the concentration of extract and decreases with increasing the temperature. Maximum inhibition efficiency of 83.1 and 81.7% were obtained for GTE and BTE respectively at 0.25g/L inhibitor concentration. Adsorption behavior of both inhibitors on the mild steel surface obeyed the Langmuir adsorption isotherm and they inhibited the corrosion of mild steel by adsorption mechanism where the adsorption process involved was spontaneous, exothermic and physisorptive. The FTIR spectra also indicated the formation of active compound-Fe complex. GTE and BTE from *C. sinensis* thus represent potential and inexpensive environment friendly corrosion inhibitors for mild steel in acid environment.

The effect of *C. Papaya* (pawpaw) leaves and *C. Sinensis* (tea) extracts as an organic green inhibitor on the corrosion of α β (duplex) brass (65-35% Cu-Zn alloy) in 1M HNO_3 (nitric acid) was studied by [18] at ambient Temperature. Weight loss/corrosion rate and potential measurement techniques were used for the experimental work. The tea extract was obtained from the green tea leaves. The results obtained showed effective corrosion inhibition of the extracts on the brass test specimens in the 1M nitric acid used. The different combined extracts concentrations also gave good corrosion inhibition performance. They also exhibited effective corrosion reactions synergism. The test specimen (duplex brass) gave some appreciable corrosion resistance in the test environment. In another study carried out by [19], the effect of green tea extract as an organic 'green' inhibitor on the corrosion of mild steel in dilute sulphuric acid was studied at ambient temperature. Weight loss/corrosion rate and potential measurement techniques were used for the experimental work. The tea extract was obtained from the green tea leaves. The results obtained showed effective corrosion inhibition of the extract on the mild steel test specimens in the different concentrations of sulphuric acid used. There was no apparent significant difference in the corrosion inhibition performance of the selected extract's concentrations. The different acid strength used did not give any clear adverse corrosive effect on the performance of the inhibitor.

III.II *DATURA STRAMONIUM LEAF EXTRACT*

D. stramonium leaf extract as corrosion inhibitor in 1M HCl acid solution was assessed using phytochemical screening, atomic absorption spectroscopy (AAS), gravimetric (mass loss), and electrochemical (Tafel and potentiodynamic polarization) methods [20]. The extract was found to efficiently inhibit the corrosion process and the inhibition efficiency increased with increasing extract concentration (over 400% increases) at room temperature. The maximum inhibition efficiency of DSLE in 1M HCl was found to be 98.69% at 0.5g/l concentration. The potentiodynamic polarization results revealed that DSLE functioned as mixed-type inhibitor acting on both the anodic and cathodic sites (but predominantly anodic control). The AAS analysis shows that the concentration of Fe^{2+} in the electrolyte decreases with increase in the extract concentration. The adsorption studies of the extract on the metal surface showed that there was a physiosorption process as the concentration increases and the chemisorption process is also prevalent. The adsorption studies fitted the assumptions of Temkin and Freundlich isotherm models.

Raja and Sethuraman [21] studied the extract of *D. stramonium* as a possible source of green inhibitor for corrosion of MS in HCl and H_2SO_4 media at different temperatures. The anticorrosion effect was evaluated by conventional weight loss studies, electrochemical studies (Tafel polarization, ac impedance) and SEM studies. The studies reveal that the plant extract acts as a good inhibitor in both the acid media and better in H_2SO_4 medium. Tafel polarization method indicate that the plant extract behaves as a mixed mode inhibitor. Double layer capacitance and charge transfer resistance values derived from Nyquist plots obtained from ac impedance studies give supporting evidence for the anticorrosive effect.

III.III *COCOS NUCIFERA* LINN

The corrosion inhibitive effect of coconut water as an eco-friendly inhibitor for the corrosion control of mild steel in 0.5 Molar solution of H_2SO_4 acid have been investigated using the weight loss method which is considered more informative than other laboratory techniques [22]. The studies were carried out using 30-110ml of the coconut water. The test coupons were totally immersed in the corroding medium containing various concentration of the inhibitor at the time intervals of 24-192 hours. The results obtained showed that the concentration of the inhibitor in the corrodent impacted differently on the test coupons. The corrosion rate was found to decrease while the inhibitor efficiency increases as the inhibitor concentration was increased. The work reported maximum inhibition efficiency of 89.07% and 81.57% at the concentration of 90ml and 110ml for 24hours and 48hours immersion time respectively. The study showed that coconut water possesses inhibiting properties for reducing the corrosion of mild steel in the acidic medium. In another study, Vijayalakshmi *et al.,* [23] investigated the inhibitive effect and adsorption properties of petiole extract obtained from destructive distillation of *C. nucifera* for the corrosion of mild steel in 0.5 M H_2SO_4 and 1 M HCl using mass loss, polarization and electrochemical impedance techniques of monitoring corrosion. The results obtained indicate that petiole extract of *C. nucifera* behaves as good inhibitor for the corrosion of mild steel in 0.5 M H_2SO_4 and 1 M HCl. Activation energy of thermodynamic parameter was evaluated from temperature studies result. The adsorption of the inhibitor on mild steel surface was found to be spontaneous, endothermic and consistent with the assumptions of Langmuir adsorption isotherm. The electrochemical measurements reveal that the petiole extract behaved like mixed type inhibitor. Efforts are made to analyze the effectiveness of petiole extract of coconut palm in industrial processes.

III.IV *MORINGA OLEIFERA LEAF EXTRACT*

The inhibiting effect of *M. oleifera* leaf extract on the corrosion of a reinforced steel bar in 2M solution of HCl was studied using gravimetric, gasometric and potentiodynamic polarization techniques [24]. The study revealed that as the concentration of the extract increases, the inhibition efficiency increases in all three investigation scenarios. 1.0 g/l attained the efficiency of 92.31 % after 120 hours exposure during gravimetric measurement. The volume of the hydrogen gas evolved reduces with an increase in the exposure time during the gasometric test. It was noted that the extract slowed down the corrosion rate and the rate at which the hydrogen gas evolved. The formation of an adsorption layer on the surface of the metal reduces the rate at which hydrogen gas is evolved, which is a function of the concentration of the extract. Potentiodynamic polarization results revealed that the *M. Oleifera* leaf extract modifies the mechanism of anodic dissolution and cathodic hydrogen evolution. It was also observed that the corrosion current density decreases with the increase in the concentration of the extract. This decrease in corrosion is due to increased blocking of the metal surface by adsorption of the leaf extract.

Investigation on corrosion inhibiting abilities of *M. oleifera* and *Lettuciae dibeliais* in acidic medium by weight loss method were carried out [25]. The significance of the corrosion inhibition in the 1N, 2N HCl medium and 1N, 2N H_2SO_4 medium has been discussed. The corrosion rate was found to decrease with increase in concentration of both the inhibitors in HCl medium. But the corrosion rate was observed to be high in the presence of inhibitors in H_2SO_4 medium.

III.V *GONGRONEMA LATIFOLIUM* EXTRACT

Onwumelu and co-workers [26] studied the corrosion inhibition effect of methanol extract of *Gongronema latifolium* mild steel in HCl solution using gasometric methods at 303K, 313K and 323K. The inhibition efficiency was found to increase as the concentration of extracts increased from 0.1%w/v to 0.5%w/v and decreased with increase in temperature. The maximum efficiency of inhibition was found to be 77.17% at 303K. Values of activation energy for the inhibited system were greater than the values obtained for the uninhibited system. Physical adsorption mechanism was proposed for the adsorption of the inhibitor from the trend of the inhibition efficiency with temperature and the values of Ea,ds and $\Delta Gads$ obtained. The adsorption of *G. latifolium* extract on the surface of the mild steel followed Langmuir, Freundlich and El-Awardy adsorption isotherms.

Extract of *Gnetum africanum, Gongronema latifolium Chromolena odaratum* was investigated as corrosion inhibitor of stainless steel in 1M HCL and H_2SO_4 using conventional weight loss [27]. Results were obtained at intervals of 24, 48, 72 and 96 hours respectively. The corrosion rate and inhibition efficiency were calculated. The results revealed that all the plant extract act as inhibitors in the acid medium while *C. odaratum* proved to be better corrosion inhibitor than *G. africanum* and *G. latifolium*

extract as it recorded the highest inhibition efficiency of 90.95% in 1M HCL for 20 ml concentration.

III.VI *ACALYPHA TORTA* AND *CURCUMA LONGA* LEAF EXTRACT

The inhibitive action of ethanol extract of *Acalypha torta* leaves (EAL) on corrosion of mild steel in 1 M HCl solution was investigated by weight loss, potentiodynamic polarization, electrochemical impedance spectroscopy, chronoamperometric measurements, and scanning electron microscopic observations [28]. The adsorption of EAL on mild steel follows a Langmuir adsorption isotherm, and the activation parameters governing the adsorption process were calculated and discussed. Polarization measurements reveal that the EAL acts as a mixed-type inhibitor. The inhibition efficiencies obtained from weight loss measurements and electrochemical tests were in good agreement.

The inhibitor property of *C. longa* L. extract in different concentrations of simulated refinery wastewater (0.05% - 2% wt) and at various temperatures (30, 35 and 40 ˚C) was investigated using weight loss method [29]. The results showed that the presence of about 1.2 % (v/v) of curcuma extract gave about 84% inhibition indicating its effectiveness on mild steel corrosion in simulated refinery wastewater, besides the adsorption process on the mild steal surface obeyed the Langmuir adsorption isotherm.

III.VII *CENTROSEMA PUBESCENS* AND *BRASSICA OLERACEA CAPITATA* LEAF EXTRACT

Reference [30] investigated the influence of *Centrosema pubescens* leaf extract on electrochemical corrosion behaviour of MS in stimulated acidic medium. The presence of secondary metabolites including flavonoid, tannins, anthraquinones, terpenoids, alkaloids, phenols and saponnins were revealed. The FTIR also revealed aromatics and functional groups such as R-OH, C=O, C-O and C-H which are attributes of good inhibitors. They also evaluated the performance of the extracts was evaluated using gravimetric method of monitoring corrosion rate in different concentrations of 0.1, 0.2, 0.3, 0.4 and 0.5 w/v. *C. pubescens* gave an inhibition efficiency of 74.91%.

Chinweuba [31] focused on inhibition action of *B. o. capitata* extract on mild Steel and Zinc corrosion in 2.0M H_2S0_4 solution using weight loss technique. The results obtained indicate the decrease in the corrosion rate of the metal as the concentration of the extract increase. Inhibition efficiency was found to increase with *B. o. capitata* concentration. Optimum inhibition efficiency (IE) for mild steel and Zinc were found to be 97.1% and 91.3% respectively at 50ml volume of the extract.

IV. CONCLUSION

Corrosion of metals is the major problem in industries. Considering environmental and ecological reasons, green inhibitors are found to be effective. The above discussion show that the natural plant extracts are very efficient for Mild steel corrosion protection, and we can uses green inhibitor in replacement of other chemical which used for control corrosion, green inhibitors are eco – friendly, and also very less expensive, in feature we can uses the plant extract as corrosion inhibitor to protect our environment.

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