REVIEW OF LITERATURE

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Corrosion not only affects the economy but it can also present a threat to life through the collapse of a structure or to the environment through the leakage of toxic chemicals. Several efforts have been made using corrosion preventive practices and the use of corrosion inhibitors is one of them. Green Chemistry provides many environmental friendly corrosion inhibitors, called "Green inhibitors". The use of inhibitors for the control of corrosion of metals and alloys which are in contact with aggressive environment is an accepted practice.

Large numbers of organic compounds have been studied and are being studied to investigate their corrosion inhibition potential. All these studies have revealed that organic compounds especially those with N, S and O show significant inhibition efficiency. However, most of these compounds are not only expensive but also toxic to living beings. It is needless to point out the importance of cheap, safe inhibitors of corrosion. Plant extracts and organic species have therefore become important an environmentally acceptable, readily available and renewable source for wide range of inhibitors. They are the rich sources of ingredients which have very high inhibition efficiency and are hence termed `Green Inhibitors'. These green inhibitors are non-hazardous and eco-friendly.

The following review gives a vivid account of natural products which are used as corrosion inhibitors for mild steel in aggressive media.

Farooqi, I H et al.,(1997) investigated the inhibitive effects of aqueous extracts of Jasminum auriculatum (leaves), Momordica Charantia (Fruits) and Hibiscus (flower) on the corrosion of mild steel for cooling water system, using 3% NaCl water. The inhibition efficiencies of the extracts were compared with that of HEDP. All the extracts were found to inhibit corrosion and their inhibition efficiencies were HEDP (93%), Jasminum auriculatum (80%), Momordica charantia (79%), and Hibiscus (76%). Polarisation measurements show that extract of Jasminum was anodic while the extracts of Momordica and Hibiscus were found to be cathodic. Impedance mesurements show the complex formation tendency of the extracts.

Minhaj. A. et al., (1999) investigated the inhibitive effects of aqueous extracts of Eucalyptus (leaves), Hibiscus (flowers), and Agaricus on the corrosion of mild steel for cooling- systems using tap water by weight loss and polarization methods. The results showed that all the plant extract inhibit corrosion of mild steel and their inhibitive efficiencies were in the order: Agaricus (85%) > Hibiscus (79%) > Eucalyptus (74%).

Corrosion inhibition of mild steel by the extracts of *Pongamia glabra* and *Annona squamosa* in HCl and H_2SO_4 media was studied by **Sakthivel et al., (1999).** Weight loss, polarization, hydrogen permeation and impedance studies were carried out at various temperatures. Polarization studies inferred that, Pongamia glabra and Annona squamosa were mixed and cathodic inhibitor respectively.

According to **Vinod kumar K P et al., (1999)**, the inhibitive action *Withania somnifera* extract, on the corrosion of mild steel in HCl was evaluated using weight loss method. This may be attributed to the chemisorption between the lone pair of heteroatoms present in the photochemical constituents of the extract on the positively charged metal surface.

Loto C A and Mohammed A I (2000) investigated the inhibitive effect of the barks, nuts and apples of the cashew tree on the corrosion inhibition of mild steel in HCl medium using weight loss and electrochemical measurements. The apple juice extract had shown good corrosion inhibition.

El-Etre. A.Y and Abdallah. M. (2000), evaluated the inhibitive action of natural honey on the corrosion of C-steel, which is used in manufacture of petroleum pipelines, in high saline water. The inhibition efficiency was calculated using weight loss measurements and potentiodynamic polarization technique. It was found that, natural honey exhibited a very good performance as inhibitor for steel corrosion in high saline water.

Aqueous extracts of Henna (Lawsonia inermis) leaves powder were evaluated as corrosion inhibitors for steel and commercial aluminum in saline, acidic and alkaline waters by **Al-Sehaibani(2000)**. Weight loss measurements showed that the

extracts can inhibit efficiently the corrosion of steel for 37days in HCl with 96% efficiency and for aluminum in NaOH up to 99.8% while no inhibition occurred for steel or aluminum in NaCl solutions.

Loto *et a l.*,(2001) investigated the corrosion inhibition effect of *Bitter* leaf (*Vernonia Amygdalina*) solution extract on the corrosion mild steel in 0.5M HCl and H_2SO_4 at ambient temperature of 28° and elevated temperature 80°. The work was performed using the weight loss method. Studies revealed that bitter leaf was a very good inhibitor.

Sahoo K et al., (2001) observed the corrosion inhibition of mild steel in aqueous environment by Neem extract through electrochemical and weight loss measurements. Experimental results indicate that the inhibition efficiency increased with increasing inhibitor concentration.

Nerium oderum (flower), Lantana camara (leaves), Aglemermolus extracts were studied by **Mohan et al., (2001),** as corrosion inhibitor for mild steel in 10% HCl by using weight loss measurements. The results inferred that inhibition increases with increase in concentration and decreases with temperature. The maximum efficiency reported for Lantana camara (100%), Nerium oderum (flower 100%), Aeglemer mould (90%).

Sethuraman et al.,(2001) observed the effect of *solonum triblobatum* extract on corrosion of mild steel in 5% HCl by weight loss measurement. It was found that inhibitor efficiency increased with increase in concentration and temperature. The presence of solanaces alkaloid in the plant was identified as responsible for inhibition.

The acid corrosion of Andiographis Paniculata was investigated in the present study towards corrosion inhibition and the inhibitive action was studied by weight loss method, Tafel polarization method and impedance studies by **Ramesh S.P. et al., (2001)**. The results reveal that this plant extract has the potential to serve as corrosion inhibitor.

Rajalakshmi et al., (2002) investigated the performance of acid extracts of Ficus benghalensis bark on the corrosion inhibition of mild steel in 1M HCl and 0.5M

H_2SO_4 by weight loss and electrochemical techniques. The presence of anthrocyanin compounds, flavanoidal compounds and reducing sugars in the bark extract may be responsible for the inhibitive action. The efficiency of the inhibitor was noticed to increase with increase in concentration of the inhibitor.

The Biocidal and inhibitive effects of aqueous extract of *Azardiracta indica* on mild steel in fresh water environment was studied by **Mohanan S et al., (2002)** using pour plate technique and weight loss measurements. The retarding of corrosive effect depends on the concentration and stability of the extract. The inhibition activity is due to the adsorption of natural compounds.

Fabrizio Zucchi and Ibrahim Hashi Omar (2002) studied the effect of various plant extracts like *Papaia, Poincianaz pulcherima, Cassia occidentalis, Datura stramonium seeds, Caltropis procera B, Azydracta indica, Autrpio turkiale sap* on dissolution of mild steel in HCl by electrochemical and weight loss measurements. It was noted that the inhibitive action is due to the products of hydrolysis of the protein content of these plants.

The extract of *Foenum graecum* were studied as corrosion inhibitors for mild steel in 5%HCl using DC electrochemical techniques. The evaluated parameters clearly indicated that the additive acted as mixed inhibitor. **(Kalpana M and Mehta G N, 2003)**

Loto C A et al., (2003) reported the effect of extracts of *Mangifera indica* barks and leaves on corrosion of mild steel in 0.1M HCl using weight loss and electrochemical techniques. Both plant extracts provide very minimal corrosion inhibition throughout the period at various concentrations of the extracts. However, the combination of the two, at a concentration of 5ml/100ml of 0.1M HCl gave very good results.

Guy D. Davis and Anthony Von Fraunhofer J (2003) tested the extracts of tobacco plants as effective corrosion inhibitor in salt water for steel and aluminium and to galvanic couples of these metals with themselves or with Cu. The results indicated that corrosion inhibition efficacy is 96% for steel/Al, 90% for steel/Cu and

79% for Al/Cu. Other measurements such as polarization resistance and visual inspection of immersed specimens individually show similar results.

Water extracts from leaves of *date palm, phoenix dactylifera, henna, lawsonia inermis, corn, zea mays* were tested as corrosion inhibitors for steel, aluminium, copper and brass in acid chloride and NaOH solutions using weight loss, solution analysis and potential studies by ***Rehan H. H. (2003)***. Date palm and henna extracts were found to be highly effective in reducing the corrosion rate of steel in acid chloride solutions and aluminum in NaOH solutions.

The inhibition of the corrosion of mild steel in HCl solutions by extract of the leaves of *Nypa fruticans* Wurmb has been studied by **K.O.Orubite and N.C.Oforka (2004)**, using weight loss and hydrogen gas evolution techniques. Inhibition was found to increase with increasing concentration of the leaves extract.

Bouyanzer A and Hammouti B (2004) studied the effects of Artemisia oil on the corrosion of steel in 1M HCl using the weight loss, electrochemical and EIS polarization techniques. It was found that the corrosion inhibition efficiency increased with the concentration. The studies revealed that adsorption follows Frumkin adsorption isotherm and it acted as cathodic inhibitor.

The influence of jojoba oil on the corrosion of iron in 1M HCl had been studied using weight loss and electrochemical polarization method by **Chetouani A et al., (2004).** It was found that the corrosion inhibition efficiency increased with the concentration of the Jojoba oil to attain 100% inhibition. The effect of temperature on the corrosion behavior of iron indicated that the inhibition efficiency decreased with the rise of temperature. It was found that the adsorption follows Frumkin isotherm.

The effect of eugenol and its derivatives extracted from the Nail of giroflier on the corrosion of steel in 1M HCl has been studied using EIS, electrochemical and weight loss measurements by **Chaieb E et al., (2004)**. The inhibition efficiency was found to increase with the rise of temperature and extract concentration. The electrochemical studies revealed that the inhibitor as mixed type.

Guar gum was tested as corrosion inhibitor for carbon steel in 1 M H_2SO_4 solution using weight loss and Tafel polarization techniques by **Abdallah. M(2004)**. The results showed that the inhibition efficiency increases with increase in inhibitor concentration, and it is a mixed type. The adsorption follows Langmuir adsorption isotherm. The effect of the presence of chloride ion in pitting corrosion was analyzed by the potentiodynamic anodic polarization technique. The pitting corrosion potential changes with the concentration of Cl^- ion according to a sigmoid S-shaped curve. This behaviour was explained on the basis of the formation of passivatable, active and continuously propagated pits.

A.K. Olusegun et al., (2004) investigated the corrosion inhibition of mild steel in HCl solution in the presence of the juice of citrus paradisi (grapefruit) in the temperature range 30-50°C using the weight loss technique. The inhibition efficiency increases with increase in inhibitor concentration but decreases with an increase in temperature. The inhibition is attributed to the adsorption of a component in the juice onto the surface of the mild steel.

In **2005, El-Etre. A.Y et al.**, tested the aqueous extract of the leaves of henna (lawsonia) is tested as corrosion inhibitor of C-steel, nickel and zinc in acidic, neutral and alkaline solutions, using the polarization technique. The inhibition efficiency increases as the added concentration of extract is increased. For C-steel and nickel, the inhibition efficiency increases in the order: alkaline < neutral < acid, while in the case of zinc it increases in the order: acid < alkaline < neutral. The extract acts as a mixed inhibitor. The adsorption of lawsonia molecules followed Langmuir adsorption isotherm.

Ananda Louise Sathiyanathan R et al., (2005) tested extracts of *Ricinus communis* leaves for corrosion inhibitory effects towards mild steel using weight loss measurement, electrochemical polarization and impedance measurements. It was found from weight loss measurements that the corrosion inhibition efficiency was about 84% and the polarization measurements indicated that plant extract as anodic inhibitor.

The efficacy of Telfaria occidentalis extract as a corrosion inhibitor for mild steel in 2M HCl and 1M H_2SO_4 solutions, and the effect of temperature and halide additives on the inhibition efficiency were investigated by **E.E. Oguzie (2005)**. Corrosion rate was monitored by careful volumetric measurement of the evolved hydrogen gas at fixed time intervals. Inhibition efficiency increased with extract concentration but decreased with rise in temperature. Synergistic effects increased the efficiency of the extract in the presence of halide additives in the order KCl<KBr<KI. Protonated species in the extract composition played a vital role in the inhibiting action.

YanLi et al.,(2005), abstracted Berberine from *coptis chinensis* and its inhibition efficiency on corrosion of mild steel in 1 M H_2SO_4 was investigated through weight loss experiment, electrochemical techniques and scanning electronic microscope (SEM) and with energy disperse spectrometer (EDS). The weight loss results showed that berberine is an excellent corrosion inhibitor for mild steel immersed in 1 M H_2SO_4.

The protective effect and the adsorption effect of *Azadirachta indica* extract in controlling mild steel corrosion in 1M H_2SO_4 and 2M HCl was assessed. **Oguzie E E (2006)** monitored the inhibitive effect using gas-volumetric technique. It was inferred that the extract function as a mixed inhibitor.

Benabdellah M et al., (2006) tested the corrosion inhibition of Artemisia oil extracted from *Artemisia herba alba* using EIS, electrochemical and weight loss measurements on mild steel in 1M H_2SO_4. The inhibition efficiency was found to increase with oil content to attain 79% and the increase in temperature decreases the inhibition efficiency. The studies revealed that extract act as cathodic inhibitor.

Abdel-Gaber ,*et al.,*(2006) have studied the effect of extracts of Chamomile (*Chamaemelum mixtum* L.), Halfabar (*Cymbopogon proximus*), Black cumin (*Nigella sativa* L.), and Kidney bean (*Phaseolus vulgaris* L.) plants on the corrosion of steel in aqueous 1 M H_2SO_4 were investigated by electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization techniques and Potentiodynamic polarization curves indicated that the plant extracts behave as mixed-type inhibitors. Inhibition was found to increase with increasing concentration of the plant extract up to a critical

concentration. The adsorption of the extracts to obey Langmuir, Flory–Huggins, and the kinetic–thermodynamic model, were tested to clarify the nature of adsorption

The polarization studies revealed the corrosion inhibitive nature of *Acacia arabica* and *Tamarix arabica* extracts on mild steel in 5% HCl. These inhibitors showed good to moderate inhibition in comparison to the K_2CrO_4. It was inferred that extracts acts as anodic inhibitor. It can be used in boiler and potable water systems due to its anti-scalant and anti-microbial properties. **(Federal Room B 2006)**

Bendahou M et al., (2006) studied the inhibitive effect of Rosemary oil for steel in acid medium using gravimetric and electrochemical techniques. It was found that the corrosion inhibition efficiency increased with the concentration of the rosemary oil. The effect of temperature on the corrosion behavior indicated that the inhibition efficiency decreased with the rise of temperature. Polarization studies showed that it acted as cathodic inhibitor.

Lakshmi et al., *(2006)*, investigated the inhibitive action of seed powder extract of Brassica juncea (mustard seed) on the corrosion of mild steel in HCl and H_2SO_4 by a weight loss method. It was shown that the mustard seed powder act as a better inhibitor in sulphuric acid medium than in HCl medium.

The inhibitive effect of the extract of khillah (*Ammi visnaga*) seeds, on the corrosion of SX 316 steel in HCl solution was determined by **El-Etre. A.Y. (2006)**,using weight loss measurements as well as potentiostatic technique. It was found that the presence of the extract reduces markedly the corrosion rate of steel in the acid solution. The inhibition efficiency increases as the extract concentration is increased.

The influence of *Calendula officinalis* towards the corrosion of mild steel in 1M HCl has been evaluated by weight loss method and polarization technique by ***Subha. R and Saratha R. (2006)***. The inhibition efficiency of the compound was found to vary with the concentration of the inhibitor and immersion time. Good inhibition efficiency was found at 0.5% (w/v) concentration of the inhibitor for 2 hours (94.67%).

Bouyanzer. A et al., (2006), extracted Natural oil from Pennyroyal Mint (*Mentha pulegium*, PM) and evaluated it as corrosion inhibitor of steel in molar HCl using weight loss measurements, electrochemical polarisation and EIS methods. The naturally oil was found to retard the corrosion rate of steel.

Mohamed Ismail Awad(2006),has tried Quinine, a natural product, as a corrosion inhibitor for low carbon steel in 1M HCl solution. Electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization were used to study the inhibition action in the temperature range 20–50 °C. The corrosion of steel was controlled by a charge transfer process at the prevailing conditions. The electrochemical results showed that quinine is an efficient inhibitor for low carbon steel and efficiency up to 96% was obtained at 20 °C.

Umoru et al.,(2006) studied the inhibitive effect of cocoa (*Theobroma Cacao*) and kolanut (*Cola Acuminata*) extracts on the corrosion of mild steel in seawater at room temperature. The study was carried out using the gravimetric technique. The results showed kola and cocoa leaves extracts as potential inhibitors of mild steel corrosion in seawater and marine environment. The highest inhibition efficiency was obtained when the concentration of the inhibitors was increased up to optimum. There was a sign of synergism when 4% of each of the extracts was used to inhibit corrosion in the seawater.

Ita. B.I., (2006), investigated the inhibition of corrosion of mild steel in HCl by isatin glycine (ING) and isatin (IN) at 30-60 ^{o}C and concentrations of 0.0001 M to 0.0005 M by weight loss method. At the highest inhibitor concentration studied ING exhibited inhibition efficiency of 87% while IN exhibited 84% at 60 ^{o}C.

Corrosion inhibition of mild steel in 2 M HCl and 1 M H_2SO_4 by leaf extracts of Occimum viridis was studied by **Emeka E. Oguzie(2006)** using the gasometric technique at temperatures of 30 and 60 °C. The extracts inhibited the corrosion in both acid media .the inhibition efficiency increased with concentration and decreased with rise in temperature. Synergistic effects increased the inhibition efficiency. Corrosion activation energies increased in the presence of the extract.

Prunus cerasus juice inhibition effects on the corrosion of steel in HCl solution were investigated by **Ashassi-Sorkhabi. H. et al., (2006)** using polarization and electrochemical impendence techniques. The inhibition efficiency increased with an increase in inhibitor concentration. The inhibition is attributed to adsorption of the inhibitor on the steel surface.

The Influence of acid extract of Acalypha indica on the corrosion of mild steel in 1M H_2SO_4 has been studied by **Kasthuri. P.K et al.,(2006)** using weight loss method. The Inhibition efficiency increases with the inhibitor concentration and immersion time. The effect of temperature on the corrosion behaviour of mild steel in1M H_2SO_4 with and without inhibitor was studied. The adsorption of the inhibitor on the metal surface obeys the Langmuir adsorption isotherm. The inhibition action of the plant extract may be due to the presence of phytochemical constituents like Aclyphine and Aclyphamide.

Osabor,V.I *et al.*, (2007) have been investigated the inhibitive effect of ethanol extracts of *Garcinia kola* (EXG) for the corrosion of mild steel in H_2SO_4 solutions. The inhibition efficiency has been evaluated using the hydrogen evolution technique at 30-60°C. The results obtained indicate that the inhibition efficiency increases with an increase in the concentration of ethanol extracts and decreasing temperature. The experimental data obeyed the Langmuir adsorption isotherm.

Gravimetric and gasometric techniques were used to study the mechanism of corrosion inhibition of mild steel in H_2SO_4 using acid extracts of different parts of *Carica papaya* by **Okafor P C, Ebenso E E (2007)**. Inhibition efficiency increased with extra concentration but decreased with temperature. The inhibitor action is due to physical adsorption of the phytochemical components of the plant on the metal surface.

The extract of Datura stramonium has been studied by **Raja et al., (2007)** as a possible source of green inhibitor for corrosion of mild steel in HCl and H_2SO_4 media using weight loss and electrochemical techniques. The studies reveal that the plant extracts acted as a good inhibitor in both the acid media and had better inhibitive

capacity in H_2SO_4 medium. It has been found that inhibitor efficiency increase with increase in temperature along with Ea values serve as proof for chemisorptions.

This paper by **Andrés A. Torres-Acosta (2007)** presents results on the corrosion performance of reinforcing steel in alkaline media when dehydrated Opuntia Ficus Indica (Nopal) was used as an admixture. The dehydrated Nopal material was mixed with saturated calcium hydroxide (SCH) at 0.5, 1.0, and 2.0% by weight. Half cell potentials and Linear Polarization Resistance (LPR) measurements were performed at different time periods. Results showed good corrosion inhibiting effect. The polarization resistance value increased for Nopal-added chloride-contaminated SCH solutions.

The work carried out by **Chauhan. L.R. and Gunasekaran. G. (2007)**,on the inhibition effect of *Zenthoxylum alatum* plant extract on the corrosion of mild steel in 5% and 15% aqueous hydrochloric acid solution by weight loss and electrochemical impedance spectroscopy (EIS) exhibited that corrosion inhibition efficiency increases on increasing plant extract concentration upto 2400 ppm.

Afidah A. Rahim et al.,(2007), studied the inhibitive behaviour on steel by flavanoid monomers that constitute mangrove tannins namely catechin, epicatechin, epigallocatechin and epicatechingallate in an aerated HCl solution using electrochemical methods. The monomers were found to be mainly cathodic inhibitors and the inhibition efficiency was dependent on concentration.

In a second part, the use of mangrove tannin, extracted from the mangrove barks as steel corrosion inhibitors in acidic media was investigated and its inhibitive efficiency was compared with that of commercial mimosa, quebracho and chestnut tannins. The inhibitive performance of mangrove tannins was comparable to the other tannins investigated, indicating their potential in corrosion protection.

The inhibitive action of the aqueous extract of olive (*Olea europaea* L.) leaves toward the corrosion of C-steel in 2 M HCl solution was investigated by **El-Etre. A.Y. (2007)**, using weight loss measurements, Tafel polarization, and cyclic voltammetry. It was found that the extract acts as a good corrosion inhibitor for the

tested system. The inhibition efficiency increases with increasing extract concentration.

Khamis. E. et al., (2007) monitored the acid cleaning of mild steel dissolution by 1M sulfuric acid/10 % methanol (test solution) in presence of *Arghel* herb extract as green inhibitor by potentiodynamic and electrochemical impedance techniques in the temperature range 30-60°C. At all temperature, the corrosion rate decreased with increasing inhibitor concentration. Potentiodynamic polarization measurements indicated that the inhibitor has strong effect on the corrosion behavior of the steel and behave as mixed type inhibitor.

Electrochemical impedance spectroscopy and potentiodynamic polarization measurements were used to study the effect of aqueous extract of fenugreek leaves and seeds on the corrosion of mild steel in HCl and H_2SO_4 solutions by **Ehteram A. Noor (2007)**. In both acids, the inhibitor act predominately as anodic type inhibitors. The inhibition efficiency of both inhibitor increases with increasing concentration of both acids, but at certain concentration of both extracts it decreases with increasing concentration of both acids. In HCl solutions, the inhibition efficiency of both inhibitors was greater than in H_2SO_4 solutions. In HCl solutions the adsorption of both inhibitor obeys the Langmuir adsorption isotherm, while obeys the Temkin adsorption isotherm in H_2SO_4 solutions. It was found that the obtained results from EIS and PDP measurements are in good agreement.

Vasudha. V.G. and, Saratha. R. (2007) investigated Efficiency of acid extract of dry seeds of Erythrina Suberosa as corrosion inhibitor for mild steel in HCl medium in the present study. Experimental methods include weight loss and polarization studies. The results indicate Erythrina suberosa seeds to be a good corrosion inhibitor of a mixed type and having efficiency as high as 98% at 1% inhibitor concentration. Adsorption isotherms reveal that it obeys Temkin, Freunlich, Langmuir and Flory-Huggins isotherms.

El-Etre. A.Y. (2008), investigated the inhibitive action of the aqueous extract of the root of shirsh el zallouh (*Ferula harmonis*) toward the corrosion of C-steel in HCl solution. The inhibition efficiency was measured using weight loss and potentiostatic polarization techniques. The electrochemical behavior was studied

using cyclic voltammetry. It was found that the addition of the extract reduces the corrosion rate of C-steel. The inhibition efficiency increases with increasing extract concentration.

Ekop A S and Eddy N (2008) determined the inhibitive and adsorption properties of orphendrine for the corrosion of mild steel in 2.5 M H_2SO_4 using hydrogen evolution and thermometric methods. Inhibition efficiency was found to increase with increase in concentration of orphendrine but decrease with increase in temperature. Based on values of activation energy and free energy of adsorption, physical adsorption mechanism has been proposed for adsorption of inhibitor on the metal and also the process was spontaneous. The studies also revealed that adsorption follows Langmuir and Frumkin adsorption isotherm.

The alcoholic extract of stem bark, leaves and fruit from the *Prosopis cineraria* are tested for their effectiveness to combat corrosion of mild steel in HCl, H_2SO_4 and in acid mixture by **Sharma M K et al., (2008)** using mass loss method. It was found that the presence of the extract reduces the corrosion rate of mild steel in acidic solution. The fruit extract shows maximum IE in the acidic mixture solution compared to leaves and stem bark extracts.

The corrosion inhibition of mild steel by ethanol extract of *Piper guinensis* was investigated by **Ebenso E E et al., (2008)** using gravimetric, gasometric and thermometric methods. Inhibition efficiency of the extract was found to vary with concentration, temperature and period of immersion. The trend of the inhibition efficiency with temperature and the values of some kinetic and thermodynamic parameters revealed that the adsorption of the inhibitor was by physical adsorption mechanism and also follows Langmuir adsorption isotherm. The evaluated parameters clearly indicated that adsorption of the inhibitor on mild steel is spontaneous.

The inhibition of the corrosion of mild steel by ethanol extract of *Musa sapientum* peels in H_2SO_4 has been interpreted using gasometric and thermometric methods **(Eddy N O and Ebenso E E, 2008).** Inhibition efficiency of the extract was found to vary with concentration, temperature, period of immersion and pH. It was

also determined that the adsorption follows Langmuir and Frumkin adsorption isotherm and the process is spontaneous.

Oguzie E E (2008) assessed the inhibiting action of the calyx extract of *Hibiscus sabdariffa* on mild steel corrosion in 2M HCl and 1M H_2SO_4 solution by gasometric technique. The results showed that the extract suppressed the corrosion reaction in both acid media and the inhibition efficiency increased with extract concentration, with slightly higher values for 1M H_2SO_4. Synergistic effects increased the efficiency of the extract in presence of halide additives. Adsorption characteristics were approximated by the Langmuir adsorption isotherm. It was inferred that extract function as mixed inhibitor. The molecular as well as protonated organic species in the extract contribute to the inhibiting action.

The effect of naturally occurring exudate gum from *Raphia hookeri* on the corrosion of mild steel in H_2SO_4 was made by **Umoren S A et al., (2008)** in the temperature range 30-60°C using weight loss and hydrogen evolution techniques. The studies showed that the inhibition efficiency increased with an increase in exduate gum content up to 5 g/l to reach 70% at 30°C and decrease with increase in temperature. The adsorption follows Langmuir isotherm and the process is spontaneous. The addition of halide ions to the exduate gum enhanced the inhibition efficiency due to synergistic effect. Results obtained by weight loss and hydrogen evolution technique are in good agreement.

The inhibitive action of leaves, seeds and a combination of leaves and seeds extracts of Phyllanthus amarus on mild steel corrosion in HCl and H_2SO_4 solutions was studied by **Okafor. P. C. et al., (2008)** using weight loss and gasometric techniques. The extracts functioned as a good inhibitor in both environments and inhibition efficiency increased with extracts concentration and with rise in temperature and activation energies decreased in the presence of the extract. The adsorption characteristics of the inhibitor were approximated by Temkin isotherm.

Pandian Bothi Raja et al., (2008) evaluated the corrosion inhibitive effect of the extract of black pepper on mild steel in 1 M H_2SO_4 media by conventional weight loss studies, electrochemical studies. Results of weight loss study reveal that the

inhibitor acts as a good inhibitor even at high temperatures. The inhibition is through adsorption which followed Temkin adsorption isotherm. Tafel polarization method revealed the mixed mode inhibition.

The inhibitive effect of the gum exudate from *Acacia seyal* var. *seyal* on the corrosion of mild steel in drinking water was investigated by **J. Buchweishaija et al., (2008)** using potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques. The inhibition increases with increasing the concentration of the gum at 30 °C. The percentage inhibitor efficiency above 95 % was attained at gum concentration ≥400 ppm. The gum behaves predominantly as an anodic inhibitor. The inhibition efficiency was insignificantly affected by the temperature rise of the medium.

Evaluation of the effective performance of acid extracts of poultry waste (Hen feather) on the corrosion inhibition of mild steel in 0.5M H_2SO_4 at ambient temperature was made by **Subhashini S. et al.,(2008)**. Conventional weight loss and electrochemical measurement techniques were used for evaluation. The maximum efficiency was found to be 95.5% for a period of 6 hours with 0.5% concentration of the hen feather extract. Experimental results were fitted to Langmuir adsorption isotherm. Electrochemical studies confirm the inhibitive nature of the hen feather extract and also the mixed nature of the inhibitor.

Corrosion inhibition of mild steel in 2 M HCl and 1 M H_2SO_4 by extracts of selected plants was investigated using a gasometric technique at temperatures of 30 and 60 °C by **Emeka E. Oguzie (2008)**. The studied plants materials include leaf extracts *Occimum viridis*, *Telferia occidentalis*, *Azadirachta indica* and *Hibiscus sabdariffa* as well as extracts from the seeds of *Garcinia kola*. The results indicate that all the extracts inhibited the corrosion process in both acid media by virtue of adsorption and inhibition efficiency improved with concentration. Synergistic effects increased the inhibition efficiency in the presence of halide additives.

Subhashini S. et al.,(2008) studied the use of aquatic waste – fish scale extract as corrosion inhibitor for mild steel in 0.5M H_2SO_4 by the classical weight loss measurements and electrochemical polarization measurements. The acid extract could bring out a maximum of 96.5% inhibition of mild steel corrosion in 0.5M H_2SO_4.The

extract was temperature resistant. Thermodynamic parameters of the corrosion process were calculated from temperature study. The absorptive behaviour of fish extract in acid solution may be approximated by Langmuir isotherms. Values of Tafel constant ba and bc confirmed that the fish scale extract acts like mixed type inhibitor.

Rajalakshmi. R. et al., (2008) studied the role of seed extracts of Phaseolus aureus on corrosion of mild steel in 1M HCl by weight loss method and potentiodynamic polarization technique. The Potentiodynamic polarization results reveal that the seed extract behaved like mixed type inhibitor. Maximum inhibition efficiency of Phaseolus aureus in 1M HCl was found to be 93%.

Evaluation of the performance of acid extract of Ficus Benghalensis bark on the corrosion inhibition of mild steel in 2N, 3N, and 4N HCl medium at different temperature were studied by **Subhashini. S. et al., (2008)**. Weight loss, electrochemical polarization and impedance measurement techniques were conducted. The efficiency of the inhibitor was noticed to increase with increase in concentration of the inhibitor.

Inhibition of the corrosion of mild steel by ethanol extract of Musa Acuminate peel has been studied using hydrogen evolution and thermometric methods by **Eddy. N. O. et al.,(2008)**. The results revealed that inhibition efficiency was found to vary with concentration, temperature, period of immersion, pH and electrode potentials. Adsorption of extract was spontaneous and obeyed Langmuir and Frumkin isotherms.

Acid extracts from mature leaves of Combretum bracteosum were used as mild steel corrosion inhibitors by **Dr. Peter C Okafor et al., (2009)** in various tests at 30 - 60°C. The gravimetric and hydrogen evolution measurements were conducted. Extracts inhibited the corrosion of mild steel in H_2SO_4 to reasonable extent. Inhibition efficiency increased with the plant extracts concentration and decreased with temperature. The Frumkin adsorption isotherm was obeyed.

Inhibitive and adsorption properties of ethanol extract of *Vernonia amygdalina* for the corrosion of mild steel were studied using weight loss, thermometric, gasometric and IR methods of monitoring corrosion. The results revealed that inhibitor function by being adsorbed on surface of mild steel and also as

the concentration of inhibitor increases, the inhibition efficiency also increases. The adsorption follows Langmuir adsorption isotherm. Phytochemical studies revealed that extract contains tannin, saponins, flavanoid and anthraquinone and all of them contributing to the corrosion inhibition. **(Odiongenyi A O et al., 2009)**

The inhibitive effect of lupine (*Lupinous albus* L.) extract on the corrosion of steel in aqueous solution of 1 M H_2SO_4 and 2 M HCl was investigated by **A.M. Abdel-Gaber et al.,(2009)** using potentiodynamic polarization and electrochemical impedance spectroscopy techniques.. Potentiodynamic polarization curves indicated that the lupine extract acts as a mixed-type inhibitor. Electrochemical impedance spectroscopy measurements showed that the dissolution process is under activation control. The inhibition efficiency was found to increase with increasing concentration of the extract, the lupine extract serves as effective inhibitor in acid media and it was more effective in case of HCl.

Badiea. A. M. et al., (2009) evaluated the effects of radish leaves and black cumin extracts on the corrosion behavior of low carbon steel in industrial water in the temperature range of 30 – 80 ^{o}C and velocity range of 1.44 – 2.02 m s^{-1} using potentiodynamic polarization, EIS and mass loss measurements. The inhibition efficiency increased with increasing concentration of the extracts but it slightly decreased with increasing temperature. Values obtained from mass loss and potentiodynamic were in reasonable agreement. Both extracts acted as anodic inhibitors. SEM indicated that the film formed on the metal surface was smooth. The adsorption behavior obeyed Flory-Huggins isotherm. A better improvement in protection was obtained by black cumin that of radish leaves.

Nnabuk Okon Eddy (2009) investigated inhibitive and adsorption properties of ethanol extract of *Colocasia esculenta* for the corrosion of mild steel in H_2SO_4 using weight loss, hydrogen evolution and IR methods of monitoring corrosion. The results obtained indicated that extract is a good inhibitor. Calculated values of activation energy and inhibition efficiency at 303 and 333 K revealed that the mechanism of adsorption extract on mild steel surface is physical adsorption. Also the adsorption of the inhibitor on mild steel surface was found to be spontaneous, endothermic and consistent with the assumptions of Langmuir adsorption isotherm.