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INTRODUCTION

1.1.Definition of corrosion

Corrosion can be defined as "an unwanted chemical attack on a metal from its surroundings". Corrosion is an electrochemical process, including metals and electrolytes[1] . All corrosion reactions are obeying the thermodynamic laws. Except for noble metals such as gold and platinum, all other metals corrode and transform into substances like their mineral ores from which they are extracted. It is important to note that, the developed countries suffer an annual loss equivalent to 2-4% of their GNP due to corrosion[2] . Approximately 20-25% can be avoided by using appropriate anticorrosion technology. Various preventive measures are used against metallic corrosion.

1.2.Various forms of corrosion

Corrosion can manifest itself in the following main forms:

1.2.1-General and local electrochemical corrosion[3]

When separate corrosion cells can be distinguished by variation of the electrode potential over the metal surface, or by the appearance of corrosion currents or of separate anodic and cathodic corrosion products, local electrochemical corrosion is said to occur.

General electrochemical corrosion occurs when separate anodic surfaces do not appear or are of small dimensions (sub micro cells) or fluctuate over the surfaces, the attack will be more uniform. Thus, there are possibilities for corrosion products to form a continuous film and delay the continuous attack. Therefore. general electrochemical corrosion leads to uniform attack whereas local electrochemical corrosion leads to localized attacks.

Many researchers [4,5] have demonstrated that galvanic corrosion is directly proportional to the ratio of the area of the cathode metal to the anode metal, and that galvanic corrosion is the maximum at the intersection of the two metals. The attack decreases as the distance from the intersection increases.

1.2.2-Galvanic corrosion or dissimilar metal corrosion

Galvanic corrosion occurs when two or more dissimilar metals in electrical contact are placed in an electrolyte. This leads a potential difference between the metals which results in the flow of current between them.

1.2.3.Crevice corrosion[6,7]

This has happened in some mineral environment combinations. Only metals and alloys that rely on oxide film for corrosion resistance subject to crevice corrosion. It is an intense localized corrosive attack that occurs within a narrow space or crevices caused by certain mechanical configurations. It is produced by surface deposits of corrosion products, scratches in paint films, etc.

1.2.4.Filiform corrosion [2]

This is a special type of crevice corrosion that produces irregular developed hair- fine lines or filaments of corrosion products below coatings of paints, tin, silver, etc. It does not destroy the component, but it does affect the appearance of the surface.

1.2.5-Intergranular corrosion[8]

Hence, localized attack occurs at adjacent to gain boundaries with relatively little corrosion of the matrix. This attack is usually rapid and penetrates deep into the metal resulting in loss of strength and causing catastrophic failures.

Most metals and alloys are subject to intergranular corrosion, when exposed to specific corrodents. The corrosion of iron, nickel and chromium alloys is mostly due to its commercial importance. Several reviews[9-11] have appeared on this topic.

1.2.6-Pitting corrosion

This is also a form of intensive localized attack, the rate of attack being nonuniform. It is most destructive form of corrosion and results in sudden failure of the equipment due to the formation of pits or holes. It is said to occur in the presence of chloride ions depending upon the concentration of chloride ions[11-14].

Loss of minerals as layers or sheets of solid metal or peeling alloy is called. This type is mostly observed in wrought products. Moreover, Al-Mg, Al-Cu, Al-Zn and Al-Mg-Si alloys are subjected to peeling.

1.2.7-Exfoliation[15]

The loss of metals as layers or leaves from a solid metal or alloy is called exfoliation. This type is observed mostly in wrought products. Further Al- Mg, Al- Cu, Al- Zn and Al- Mg- Si alloys undergo exfoliation.

1.2.8-Stress corrosion cracking[16- 18]

The cracking of metal or alloy due to the simultaneous presence of tensile stress and a specific corrosive environment is known as stress corrosion cracking.

1.2.9-Corrosion fatigue cracking[18,19]

Reduction in the fatigue strength due to the presence of a corrosive environment is known as corrosion fatigue cracking. It occurs due to the combined action of cyclic stress and corrosive environment.

1.2.10-Fretting corrosion[20]

This type of corrosion occurs between two surfaces in contact with each other in dry or humid air when exposed to slight relative motion of small amplitude. Various alternate terms such as friction oxidation, wear oxidation, chafing. False brinelling are used to describe this phenomenon.

1.2.11-Erosion corrosion

Erosion corrosion is defined as an increase in the rate of corrosion to the relative movement between the metal surface and the liquid or gaseous environments. This type of corrosion is also known as impingement corrosion[20]. This corrosion occurs in agitators, copper pipes, centrifuge etc. Localized attack due to erosion corrosion usually has bright surface from corrosion products. eg. Pits, rounded holes and valleys.

1.2.12-Cavitation corrosion[21]

This is a special type of erosion corrosion caused by the formation of vapor bubbles in a corrosive environment near a metal surface and when a bubbles collapse attack arises. For example, hydraulic turbulence, ship propellers etc.

1.3.Theories of corrosion

Corrosion of metals in aqueous solutions is an electrochemical process as established in the first half of the nineteenth century. Whitney[22]gave the most widely accepted electrochemical theory. the other theories such as acid theory[23] chemical attack theory, colloidal theory[24,25]   and biological theory[26] have been established regardless of electrochemical theory

Electrochemical theory of corrosion

An atom has a massive positively charged central nucleus surrounded by a cloud of negatively charged electrons. This electron cloud is absorbed in a series of shells. The outer shell must contain eight electrons in the case of the most stable element. If the electrons are insufficient to fill the outer most shell, the atom tends to obtain a cloud of complete shells by gaining or losing electrons to cause modified atoms called `ions

Evans[27] explained the role of these ions in the corrosion of metals and alloys under the influence of the exchange of ionic charges. This has laid down the basis of the electrochemical theory of corrosion. When a metal object is immersed in a corrosive medium the metallic surface is divided into regions with different potentials under the influence of different metallic phases, grain boundaries stress and strain, impurities etc. in the electrolyte the metal under disintegration due to the displacement of a hydrogen ions in the electrolyte by those of the anode metal, resulting in the formation of a galvanic cell.

a- Corrosion occurs by an electrochemical process. the phenomenon is like that which takes place when a carbon-zinc "dry" cell generates a direct current. basically, an anode (negative electrode), a cathode (positive electrode), an electrolyte (environment), and a circuit connecting the anode and the cathode are required for corrosion to occur (see fig.(1.1)). dissolution of metal occurs at the anode where the corrosion current enters the electrolyte and flows to the cathode. the general reaction (reactions, if an alloy is involved) that occurs at the anode is the dissolution of metal as ions:

$$M \longrightarrow M^{2+} + 2e \qquad \text{anodic reaction (oxidation)}$$

(1.1)

<u>where</u>

m = metal involved

n = valence of the corroding metal species

Examination of this fundamental reaction reveals that a loss of electrons, or oxidation, occurs at the anode. Electrons are lost at the anode, flow through the metallic circuit to the cathode and allow a cathodic reaction (or reactions) to occur. In alkaline and neutral aerated solutions, the predominant cathodic reaction is

$$O_2 + 2H_2O + 2e^- \longrightarrow 4OH^- \quad \text{cathodic reaction (reduction)}$$
(1.2)

the cathodic reaction that usually occurs in deaerated acids is
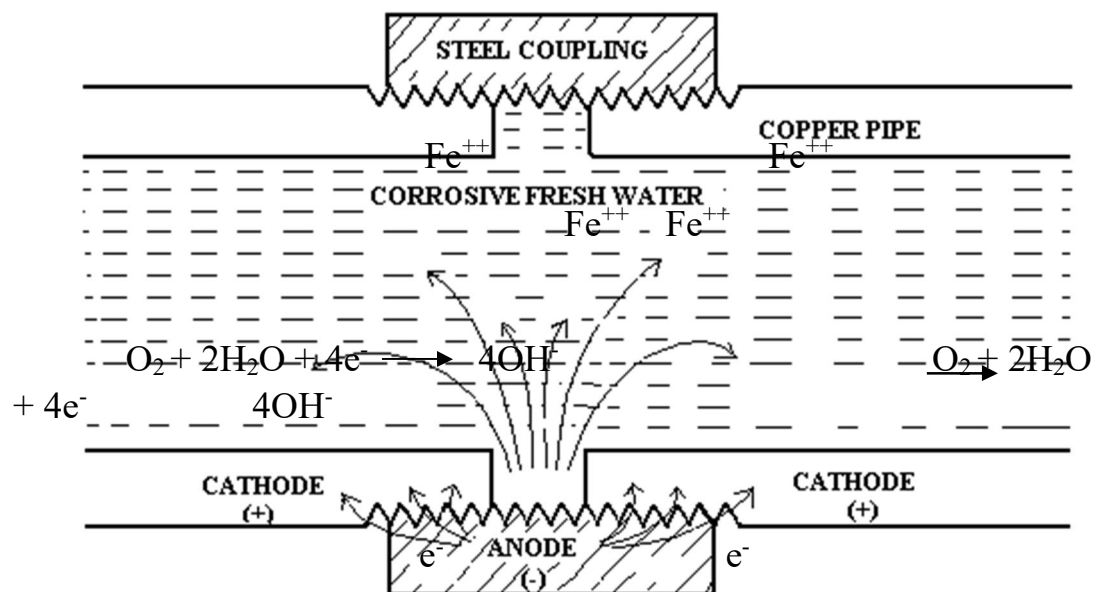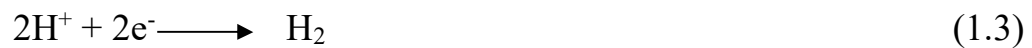
$$2H^+ + 2e^- \longrightarrow H_2 \quad (1.3)$$

Fig.(1.1): The basic corrosion cell consists of an anode, a cathode, an electrolyte, and a metallic path for electron flow. Note that the corrosion current (i) enters the electrolyte at the anode and flows to the cathode.

In aerated acids, the cathodic reaction could be

$$O_2 + 4H^+ + 4e \longrightarrow 2H_2O \tag{1.4}$$

All these reactions involve a gain of electrons and a reduction process.

b- The number of electrons lost at the anode must equal the number of electrons gained at the cathode. For example, if iron (Fe) was exposed to an aerated, corrosive water, the anodic reaction would be

$$Fe \longrightarrow Fe^{++} + 2e^- \tag{1.5}$$
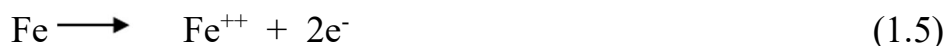
At the cathode, reduction of oxygen would occur

$$O_2 + 2H_2O + 4e^- \longrightarrow 4OH^- \tag{1.6}$$

because there can be no net gain or loss of electrons, two atoms of iron must dissolve to provide the four electrons required at the cathode. thus, the anodic and cathodic reactions would be

$$2\,Fe \longrightarrow 2Fe^{++} + 4e^- \qquad (anodic) \tag{1.7}$$

$$O_2 + 2H_2O + 4e^- \longrightarrow 4OH^- \qquad (cathodic) \tag{1.8}$$
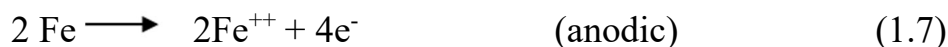
these can be summed to give the overall oxidation reduction reaction

$$2Fe + O_2 + 2H_2o \longrightarrow 2Fe^{++} + 4OH^- \tag{1.9}$$
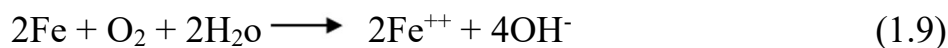
c- After dissolution, ferrous ions (Fe^{++}) generally oxidize to ferric ions (Fe^{+++}); these will combine with hydroxide ions (OH$^-$) formed at the cathode to give a corrosion product called rust (FeOOH or Fe$_2$O$_3$ .H$_2$O).

1.4. Corrosion monitoring techniques.

1.4.1 Non-electrochemical techniques.

(i) Thermometric method:

A simple, fast and specific method for comparing the inhibition efficiency of different additional agent[28]. It was originally developed for iron and its alloys. According to this test, a piece of metal of specified area is dropped into a definite volume of a corrosive solution. The variation of the temperature of the system is followed by a function of time. After an initial period of approximately constant temperature, they rise rapidly to reach a maximum value, which in some cases approaches the boiling point of the solution. A reaction number, R.N., was defined by Mylius as follow:

$$\text{R.N.} = \frac{T_m - T_i}{t} \qquad \text{K/min} \; . \tag{1.10}$$

where: T_m = maximum temperature in K.

T_i = initial temperature in K.

t = time in minutes from the start of the experimental to attain T_m.

The reaction number is proportional to the rate of the corrosion of the metal. The extent of corrosion inhibition by a certain concentration of additive is evaluated from the percentage reduction in the reaction number.

$$\% \, \text{Reduction in R.N.} = \frac{(R.N)_{free} - (R.N)_{add}}{(R.N)_{free}} \tag{1.11}$$

where, (R.N.) $_{free}$ = reduction in R.N. in the corrosive medium.

(R.N.) $_{add.}$ = reduction in R.N. in the presence of additive.

(ii) Hydrogen evolution method:

Reactions in which gases are given of or taken up can be monitored by studying the change of gas amount over time. This method is also limited. The efficiency of a given inhibitor can be evaluated as the percentage reduction in reaction rate (K), so the percentage inhibition efficiency (%IE) can be calculated as follows:

$$\% \text{ IE} = \frac{K_{free} - K_{add}}{K_{free}} \times 100 \qquad (1.12)$$

where: K_{free} = specific reaction rate in the corrosive medium.

$K_{add.}$ = specific reaction rate in the inhibited solutions.

and specific reaction rate constants (K) are calculated from the relation,

$V = K.t$, where, (V) is the volume of hydrogen evaluated in cm^3 and (t) is the time in minutes.

(iii) Weight loss method:

Weight loss measurements are comprehensive testes for laboratory and field [29-34]. It is useful for metals or alloys, which are not subjected to special types of attack and form, which which corrosion products can be removed easily To determine the inhibition efficiency of inhibitor using these measurements, the metal sample must be polished, degreased, weighed and then immersed in the corrosive medium with and without inhibitor for certain time intervals at fixed temperature. Weight loss is determined after removing corrosion products and then thoroughly wash the specimens by distilled water dry and weight.

The efficiency of inhibition is calculated from the weight loss values using the following equation:

$$\% \text{ IE} = \frac{W_{free} - W_{add}}{W_{free}} \times 100 \qquad (1.13)$$

where, W_{free} = weight loss in the corrosive medium in mg cm^{-2}.

$W_{add.}$ = weight loss in the inhibited solutions in mg cm^{-2}.

Also, the corrosion rate is determined by the relationship:

$$C. R._{(mmpy)} = \frac{\text{wt. loss}_{(mg)} \times 87.6}{\text{area}_{(cm^{-2})} \times \text{time}_{(hrs)} \times d_{(gm.c\,m^{-3})}} \times 100 \qquad (1.14)$$

(iv) Electrical resistance method:

This method involves the measurements of the change in the resistance of corroded metal by the equation:[29-33]

$$R_{metal} = \frac{\rho \times L}{A} \qquad (1.15)$$

where, R_{metal} = resistance of metal.

ρ = specific resistance.

A = area of cross section.

On corrosion, the area of specimen (A) is decreased. Hence the resistance (R) is increased. This means that the change in R value is correlated to corrosion rate (Kelvin or Wheatstone bridge).

1.4.2 Electrochemical techniques.

(i) Open circuit potential method:

This method is used to measure the steady state potential (E_{ocp}), of the metal or alloy in the absence and in the presence of additives[35]. In this method, the potential of the corroding material is measured against reference electrode at different time periods until a steady state is reached. The steady state represents an equilibrium state at which ($I_{ox.}$) is equal (i_{red}).

(ii) Potentiodynamic polarization method:
(a) Tafel plots.

In this method, corrosion current can be determined from polarization curves by intercept method based on anodic and / or cathodic Tafel curves[36-37]. The corrosion rate of the system involves the measurements of potential of the working electrode for various applied current densities.

The relation between (E) against log (i) gives polarization diagram (Tafel plot). The intercept of anodic and cathodic Tafel lines provides the corrosion current and Tafel slopes give anodic (b_a) and cathodic (b_c) Tafel slopes.

(b) Linear polarization method.

This technique is an accepted method of monitoring corrosion rate[37-41]. For a corroding electrode, the polarization resistance (R_p), at small applied range of potential (5-20 mV) is related to the corrosion current density ($i_{corr.}$) by the equation:

$$i_{corr} = \frac{b_a . b_c}{2.3(b_a + b_c)} \times \frac{1}{R_p} = \frac{B}{R_p} \qquad (1.16)$$

where, b_a and b_c are anodic and cathodic Tafel slopes respectively and R_p is the polarization resistance.

A controlled potential scan is applied over a small range, typically ±25mV with respect to E_{corr}. At a scan rate of 0.1 mV/sec, the resulting current is plotted against the potential. The slope of this linear potential-current plot at $E_{corr.}$is identical with the polarization resistance which used together with the measured Tafel constants to determine the rate of corrosion.

The percentage inhibition efficiency (%IE) can be expressed as:

$$\% \, IE = \frac{i_{free} - i_{add}}{i_{free}} \times 100 \qquad (1.17)$$

where,

i $_{free}$: corrosion current in the corrosive medium.

i $_{add}$: corrosion current in the presence of additive.

1.4.3. Electrochemical impedance spectroscopy

The electrochemical impedance spectroscopy technique has been widely used to measure the rates of corrosion of metals [42-43]. The main advantage of this method is the complete elimination of the solution resistance. The equivalent circuit of a corrosive metal having anodic and cathodic reactions under activation controlled can be represented as a parallel combination of charge transfer resistance (R_t), double layer capacitance (C_{dl}) and the solution resistance (R_s) in series.

From (R_t) value, the i_{corr} is obtained from the relationship:

$$i_{corr} = \frac{b_a . b_c}{2.303(b_a + b_c)R_t} \qquad (1.18)$$

An alternating voltage of 10-20 mV is applied, the resulting current and the phase angle (θ) is measured for various frequencies where, the impedance [Z = voltage/a.c] is resolved to a real part [z' = z cos (θ)] and imaginary part [z'' = z sin (θ)]. Plots of z' against z'' is a semicircle which cuts the real axis at high frequency corresponds to (R_s) and at low frequencies corresponds to ($R_s + R_t$) and the difference between the two values gives (R_t).

1.4.4 Surface examination techniques.[44-45]
(i) Scanning electron microscopy (SEM):

SEM is used to examine and analyze the microscopic surface.. It gives resolution of about (25A). It is useful for a quantitative identification of phases especially, for assessing the geometry of microscopic structures by image analysis

Corrosion is studied by scanning electron microscopy to distinguish the type of corrosion and the kinetic of the processes. Degradation of microstructures during the morphological changes such as grain growth, particle coarsening and recrystallization are also investigated using (SEM).

The combination of x-ray, mapping and (SEM) is used to quantify the fractured areas in the ductile and brittle phases, the depth of dimples, and the size of the process zone in front of the crack and the mode of crack propagation to establish a quantitative model for fracture of the material.

(ii) Optical microscopy:

It is the most important tool for microstructure studies. Identifying unknown constituents may be aided noting their rigidity relative to the matrix, and their natural color, by their response to polarized light and by their response to selective etchants. These notes are compared to known details about the physical metallurgy of the examined material. The basic components of the optical microscope are illumination system, condenser, light filter, objective lends and eye piece. Three types of illumination are used which they are:

 - Bright field for the observations of microstructure.

 - Oblique for the three dimensional appearance.

 - Dark field for strong image contrast.

(iii) X-ray analysis:

It is used to study the crystal perfection, crystal structure, and dimension of phase diagrams, order-disorder transformation and chemical composition. Quantitative analysis is also possible because the intensities of the diffraction lines due to one constituent of a mixture depend on the proportion of that constituent in the specimen.

(iv) Auger electron spectroscopy (AES):

AES together with x-ray photoelectron spectroscopy (XPE) are the two major surface analysis techniques. (XPS) is more sensitive and gives more useful chemical information's while, AES has the advantages of greater speed and the potential of high speed resolution. The idea of the two techniques depends on the ejection of electron from an inner shell, where the energy released appears either as an x-ray photon or transferred to another electron, which is ejected, from the atom with energy. The basic components of an (AES) are electron gun, electron spectrometer and electron detector.

(v) X-ray photoelectron spectroscopy (XPS):

It has wide applications in the case of polymers organics, biological specimens, fibers films, powders and particles. In this technique the specimen is excited by the excitation source and its subsequent response in the form of an emission of some species is observed by some types of microscopy.

1.5. Corrosion inhibitor.

Among the methods for corrosion control and prevention, certain types of chemicals can be added to the environment to reduce the aggressiveness of the environment or to slow down the corrosion process.

Inhibitors function by adsorption of ions or molecules onto the surface of the metal. They reduce the corrosion rate by

(i) Increasing or decreasing the anodic and/or cathodic reaction

(ii) Reducing the diffusion rate for reactants to the surface of the metal

(iii) Reducing the electrical resistance of the metal surface

The types of environment that can be modified include aqueous, partly aqueous and gaseous. Aqueous and partly aqueous conditions are often found in at near neutral pH range such as natural waters, cooling water systems and in acidic range such as acid pickling to remove the rolling scale as well as in oil and gas production and refining.

Inhibitors are often easy to apply and provide the advantage of in-situ application without causing any significant disruption to the process. However, there are several considerations when choosing an inhibitor:

• Cost of the inhibitor can be sometimes very high when the material involved is expensive or when the amount demanded is huge.

• Toxicity of the inhibitor can cause jeopardizing effects on human beings, and other living species.

• Availability of the inhibitor will determine the selection of it as if the availability is low, the material is often expensive.

• Environmental friendliness

1.5.1 Types of Inhibitors

There are several types of inhibitors available to the industries now. They are:

(i) Volatile Inhibitors: [46,47]

This type of inhibitors is also known as vapour phase inhibitors. As corrosion can also occur in vapour environment, it is useful to carry corrosion inhibitors into the system, which then need to be, themselves, volatile. When the inhibitor molecules in the vapour come into contact with the surface of a metal, the adsorption of the inhibitor will occur. The moisture then hydrolyses it; hence protective ions may be released. These include species like amines and nitrites for inhibition of ferrous metal.

(ii) Passivating (Anodic) Inhibitors [48]

Passivating inhibitors are anodic inhibitors. They cause the anodic curve of polarization polarization to shift such that less current flows. They have the ability to passivate the metal surface. There are two categories of passivating inhibitors, namely oxidizing anions and non-oxidizing anions. Oxidizing anions such can passivate metal in the absence of oxygen. Typical oxidizing anions are chromate, nitrite and nitrate. Non-oxidizing ones such as phosphate, tungstate and molybdate require oxygen to perform passivation.

This type of inhibitor is the most widely used and possesses higher efficiency than others. However, one major drawbacks of this is that in order to maintain adequate passivation of the metal and thus provide sufficient inhibition, the concentration of the inhibitor must remain significantly above the critical or minimum concentration. If the concentration is below the minimum value, it is likely that the metal, which must be protected in to the first place, will suffer from localized corrosion such as pitting.

(iii) Precipitation Inhibitors [49]

These inhibitors are often film-forming in nature, for instance silicates and phosphates. They are effective at blocking anodic and cathodic sites. They precipitate on the metal surface, forming a protective barrier layer. Hard water is rich in magnesium and calcium. When these salts precipitate on the metal surface, for example at the cathode where the pH is higher, they establish a protection layer on the metal. Film-forming types of inhibitors are often distinguished by two classes. The first one works by slowing down the corrosion without stopping it completely. The second ceases the attack completely.

Therefore, the efficiency of this inhibitor depends on the pH value and saturation index. The saturation index is then in turn determined by the water composition and temperature.

(iv) Cathodic Inhibitors [49,50]

Cathodic inhibitors reduce the rate of cathodic reaction which is the reduction of oxygen in near neutral environments and the evolution of hydrogen in acidic solutions, respectively. These types are deposited in the

cathodic sites, thus increasing the surface impedance and reducing the diffusion rate. The inhibiting action of cathodic inhibitors works by three mechanisms:

• Cathodic poisons

In this case, the cathodic reduction process is suppressed, for example by impeding the hydrogen recombination and discharge. But it may increase the tendency of the metal to be susceptible to hydrogen induced cracking. Hydrogen can be absorbed into the metal during this process. It is essential to keep hydrogen in atomic form. Typical types of cathodic poisons are arsenic and antimony.

• Cathodic precipitates

Compounds such as calcium, magnesium will precipitate as oxides to form a protective layer which acts as a barrier on the metal surface.

• Oxygen scavenger

This mechanism functions by the removal of oxygen in the system to reduce corrosion. The compounds of oxygen scavenger react with oxygen presenting the system to form a product.

(v) Organic Inhibitors [49]

This type of inhibitors too, is formed by the nature of the film. It forms a form a hydrophobic layer on the surface of the metal to prevent dissolution of the metal. The efficiency of this inhibitor depends on the chemical composition and molecular structure of the inhibitor as well as its association with the metal. They are used often when environmental issues are taken into account. It is categorized into

organic anions and cations. Inhibitors like sulphonates and phosphonates fall into the anions category. Chemicals with active groups such as aliphatic and aromatic and positively charged amine groups are organic cations. This type of organic inhibitor is often in the form of liquid or wax-like.

(vi) Inorganic Inhibitors [50]

Common inorganic inhibitors used are crystalline salts, for example, sodium chromate and molybdate. The only active groups of these compounds that reduce corrosion are the negative anions they carry.

(vii) Mixed Inhibitors [47]

Corrosion inhibitors are rarely used as just one compound. The formulation can be can consist of two or more inhibitors which all carry different characters. This is due to three factors:

• A single inhibitor can only inhibit a few numbers of metals. When the environments involve multi-metal system, the inhibitive action may sometimes cause dangerous effects to other metals.

• The advantages of anodic and cathodic inhibitors can be combined and optimized for best performance.

• The addition of halide ions improves the action of the organic inhibitor in acid solutions.

1.6-Literature survey for corrosion inhibition of carbon steel in aqueous solution.

1.6.1-Organic compound as corrosion inhibitior:

Selected triazole derivatives were synthesized and evaluated as corrosion inhibitors for carbon steel in neutral aqueous environment by weight loss, potentiodynamic polarization and AC impedance methods [51]. All the condensed products showed good inhibition efficiency. The effect of changing functional groups of some triazole derivatives on their inhibition efficiency was also studied. 3-salicylalidene amino-1,2,4-triazole phosphonate was found to be the best corrosion inhibitor compare to the other compounds. Surface analysis was performed to determine the mechanism of corrosion inhibition of carbon steel in neutral aqueous media.

The inhibition effect of three amino acids namely, alanine, glycine and leucine against the corrosion of steel in HC1 solutions was investigated by potentiodynamic polarization methods [52]. Corrosion parameters such as corrosion current ,corrosion rate, corrosion potential and polarization resistance (R_p) were determined by extrapolation of the cathodic and anodic Tafel region. The inhibition efficiency depended on the type of amino acid and its concentration. The inhibition effect ranged from 28 to 91%. The amino acids act as a corrosion inhibitor in HC1 solution through adsorption on the surface of steel and adsorption follows Langmuir isotherm.

4-Phenylazo-3-methyl-2-pyrazolon-5-one and three of its derivatives was investigated as corrosion inhibitors for carbon steel in 2 M hydrochloric acid solution using weight loss and galvanostatic [53].The inhibition efficiency increases with increasing inhibitor concentration but decreases with increasing temperature. The synergistic effect of the pyrazolone derivatives and KBr, KSCN and KI were also studied. The apparent activation energy (E_a^*) and some thermodynamic parameters for the corrosion process were also calculated. The galvanostatic polarization data indicated that the inhibitors were of a mixed type, but the cathode is more polarized than the anode. The adsorption of these compounds on C- steel surface was found to obeys Frumkin's adsorption isotherm. The mechanism of inhibition was discussed in the light of the chemical structure of the undertaken inhibitors.

The effect of some aminopyrimidine derivatives on the corrosion of 1018 carbon steel in 0.05M HNO_3 .solution was studied using weight loss and polarization techniques [54]. The percentage inhibition efficiency was found to increase with increasing concentration of inhibitor and with decreasing temperature. The addition of KI to amincpyrimidine derivatives enhanced the inhibition efficiency due to synergistic effect. The inhibitors are adsorbed on the steel surface according to Temkin isotherm. Some thermodynamic functions were computed and discussed. It was found that the aminopyrimidine derivatives provide a good protection to steel against pitting corrosion in chloride containing solutions.

The inhibition efficiency of n- decylamine on the corrosion of low carbon steel in 1N sulphuric acid at different temperatures was investigated potentiokinetically [55]. Various parameters such as

corrosion potential, corrosion current, polarization resistance, transfer coefficient, standard free energy of adsorption, enthalpy and entropy as well as the activation energy were calculated. It has been found that the adsorption of n- decylamine on the steel surface follows Langmuir isotherm. The mechanism of carbon steel dissolution and the hydrogen evolution reaction does not change in the presence of the inhibitor used.

Selected triazole derivatives have been synthesized and evaluated as corrosion inhibitors for carbon steel in neutral aqueous environment by weight loss, potentiodynamic polarization and AC impedance methods [56]. All intensive products showed good inhibition efficiency. The effect of changing functional groups of some triazole derivatives on the efficacy of their inhibition was also reported. 3-salicylalidene amino-1,2,4-triazole phosphonate was found to be the best corrosion inhibitor compare to the other compounds. Surface analysis was performed to determine the mechanism of corrosion inhibition of carbon steel in a neutral aqueous media.

The effect of some pyridine derivatives on the corrosion of carbon steel in 2M HCl solution was studied using electrochemical polarization method (potentiodynamic-Tafel extrapolation) as well as weight loss method [57]. The inhibition efficiency of the tested compounds dependent on the concentration and nature of the inhibitor. Results obtained from both potentiodynamic polarization and weight loss techniques reveal that, these compounds are good inhibitors. The presence of substituent's in pyridine ring plays an important role in the percentage inhibition of the compounds under investigation. The adsorption of these compounds on the carbon steel follows Langmuir adsorption isotherm.

Four azoles compounds, namely, imidazole, benzoimidazole, benzotriazole and benzothiazole were investigated as inhibitors for corrosion of mild steel in 1M HCI solution [58]. Impedance spectroscopy, polarization resistance, gravimetric and polarization methods were used. A suitable structural model is provided for the interface in the presence of inhibitors and the corresponding parameter values are calculated.. The apparent activation energy of the process that occurs in the presence of an inhibitor was determined on the ground of five temperature values in the range from 20°C to 60°C. Using the data obtained by two independent methods comparative investigations were carried out in 1M H_2SO_4 aiming to demonstrate the effect of the acid's anion. The generalization of the data obtained provided to make conclusions concerning the mechanism of the inhibitor's adsorption.

The effect of succinic acids (SA) on the corrosion inhibition of a low C-steel (LCS) was investigated in aerated non-stirred l.0 M HC1 solutions in the pH range (2-8) at 25°C [59]. Weight loss, potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques was applied to study the steel corrosion behavior in the absence and presence of different concentrations of SA under the influence of various experimental conditions. Measurements of open circuit potential as a function of time till steady-state potential (E_{st}) were also established. Surface analysis using energy dispersive X-ray and scanning electron microscope allowed to clarify the mechanistic aspects and evaluate the relative inhibition efficiency. Results obtained showed that SA is a good inhibitor for LCS in HC1 solution. The polarization curves showed that SA behaves mainly as an

anodic type inhibitor. The inhibition efficiency increases with increase in SA concentration. Maximum inhibition efficiency (97.5%) at SA concentration >0.01 M at pH 8. The effect of SA concentration and pH on the potential of zero charge (PZC) of the LCS electrode in 1.0 M HC1 solutions was studied and the mechanism of adsorption is discussed. The results obtained from weight loss, polarization and impedance measurements are in good agreements.

The corrosion behavior of carbon steel in a wide range of concentrations (0.1-1M) of gluconate and tartarate was studied by potentiodynamic and open circuit measurements [60].The results showed a high rate of corrosion with an increase in the concentration of organic acid salt The results indicate that low carbon steel displays typical active to passive transition behavior in absence of chloride ions. The effect of scan rate, temperature and chloride ions on the behavior of carbon steel in gluconate and tartarate solutions was also studied. The corrosion of carbon steel in tartarate was higher than that in gluconate solutions.

Some tertiary amines in the series of l,3-di-amino-propan-2-ol, referred as l,3-di-moipholin-4-yl-propan-2-ol (DMP) and 1,3-bis-diethylamino-propan-2-ol (DEAP), had been synthesized by alkylation reaction [61]. These compounds were examined by MS, IR, HNMR and ^{13}C NMR. The electrochemical performance of these products was investigated by potentiodynamic polarization measurement and electrochemical impedance spectroscopy (EIS) under thin electrolyte layer and their inhibition efficiencies were measured using gravimetric methods. These compounds, retarding the anodic dissolution of iron by forming protective layer on the metal surface. Polarization data indicated that the inhibitive performance of DMP for carbon steel was

improved with the increasing of concentration, while DEAP showed a maximum inhibiting power at 2.5×10^{-2} M was 95%. Adsorption on the carbon steel surface follows the Langmuir isotherm model. A Fourier transform spectrometer (FTIR) was used to analyze adsorbed surface film.

The effect of some synthesized pyrazole compounds on the corrosion of carbon steel in 1M H_2SO_4 solution was investigated [62]. The investigation involved electrochemical polarization methods (potentiodynamic, Tafel extrapolation and the determination of the polarization resistance). A significant decrease in the corrosion rate of carbon steel was observed in the presence of the investigated compounds. The results show that these compounds act as mixed type inhibitors, but the cathode is more preferentially polarized. The relative inhibition efficiency of these compounds depends on both the nature and concentrations of the investigated compounds. Compounds are found to adsorb on the carbon steel surface according to the Langmuir adsorption isotherm.

l,12-bis(l,2,4-triazole) dodecane (dtc12) is an excellent corrosion inhibitor for carbon steel in deaerated 1M HC1 solution [63]. Electrochemical and analytical techniques were used to study the inhibition of corrosion of carbon steel in acidic medium. The corrosion inhibition of carbon steel with dtc12 was attributed to the synergistic effect between chloride anion and quaternary ammonium ion. The protective efficiency of the film was higher than 90%, indicating that corrosion of carbon steel in 1M HCl solution is reduced by dtc12. The effect of dissolved oxygen on the inhibition efficiency was also investigated. The results showed that the inhibition efficiency increases at an early stage and decreases during immersion.

Quinine was tested as a corrosion inhibitor for low carbon steel in 1.0 M HC1 solution [64]. Electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization were used to study the inhibiting effect of quinine in the temperature range (20°-50°C). The corrosion of steel was controlled by a change transfer process at the prevailing conditions. The electrochemical results showed that quinine is an an effective inhibitor of low carbon steel. Efficiency up to 96% was obtained at 20°C. The inhibition efficiency increases with increasing the inhibitor concentration and reaches a near constant value in the concentration range 0.48 mM and above. Application of the Langmuir adsorption isotherm enabled a study of the extent and the mode of adsorption.

The effect of some mercaptotriazole derivatives synthesized in the laboratory containing different hetero atoms and substituent in the organic structure on the corrosion and hydrogen permeation of mild steel in 1.0M HC1 solution was investigated by weight loss and various electrochemical techniques [65]. The obtained results showed that all the mercaptotriazol derivatives work perfectly as corrosion inhibitors for mild steel in 1.0 M HC1 solution. Potentiodynamic polarizations showed that all of these compounds inhibit both the anodic and cathodic process and act as mixed-type inhibitors. Double layer capacitance and charge transfer resistance values were derived from Nyquist plots obtained from AC impedance of these compounds on the metal surface. The inhibition efficiency was mainly dependent on the nature of the investigated compounds. The values of the inhibition efficiency calculated from these techniques are in reasonably good agreement. The extent of reduction of hydrogen permeation current through mild steel surface was studied by the hydrogen electro

permeation technique. The adsorption of these compounds on mild steel surface is found to obey Langmuir adsorption isotherm. The free energy of adsorption for inhibiting process was determined based on Langmuir adsorption isotherm.

The inhibiting effect of three compounds of pyrazolo[*3,4-d*] pyrimidnone derivatives toward the corrosion of carbon steel in 1.0M HCl solution was investigated using galvanostatic and potentiodynamicanodic polarization techniques[66] The rise of the concentration of the inhibitors and decreasing the temperature led to the greater of inhibition efficiency. The inhibiting action of these compounds was explicated on thef basis of its adsorption on the carbon steel surface. The adsorption operation of these compound s was obeyed Langmuir isotherm. There is only one anodic peak during the anodic cyclic voltammogram This peak was elucidated due to the active dissolution of Fe as Fe2+. The percentage inhibition efficiency was computed from the values of peak current density. There is a good convention between the values of the percentage inhibition efficiency gained from the diverse techniques. These compounds inhibit the pitting corrosion of carbon steel by shifting the pitting corrosion potential to more noble direction. The effect of elevation of temperature on the rate of corrosion in devoid of and containing these compounds was studied and some activated thermodynamic parameters were computed.

Seven homologous imidazoline inhibitors, derivatives of cyclopentylic and cyclohexylonaphthenic acids, were synthesized [67]. The effectiveness of these compounds as inhibitors for carbon steel and austenitic stainless steel was tested using the impedance method in 2% NaCl solution in the presence of a hydrocarbon phase. The solution was saturated with hydrogen sulphide. It was found that the inhibitors

and their mixture displayed high inhibition efficiencies, reaching 93% for carbon steel and 94% for the austenitic steel. Inhibitors with the shortest hydrocarbon side chains on the imidazoline ring were found to offer the lowest level of protection, the inhibition efficiency increasing with the length of the side chain. The capacitance measured on the surface was decreased linearly as the coverage of the steel surface by inhibitors increased. The results of impedance measurements with commercial inhibitors have confirmed the conclusions from the tests on the pure chemical species.

The corrosion inhibitor 2,5 - bis (4- dimethyl aminophenyl)-1,3,4-thiodiazole (DAPT) was synthesized and its inhibiting action on the corrosion of mild steel in 1 M HC1 and 0.5 M H_2SO_4 solution at 30°C was investigated by various corrosion monitoring techniques [68]. A preliminary screening of the inhibition efficiency was carried out using weight loss measurements. At constant acid concentration, the inhibition efficiency increases with concentration of DAPT and it founds to be more efficient in 0.5 M H_2SO_4 than in 1 M HC1. Potentiodynamic polarization studies showed that DAPT is a mixed type inhibitor. The effect of temperature on the corrosion behavior of mild steel in 1 M HC1 with addition of DAPT was studied in the temperature range from 25° to 60°C. It was shown that the adsorption is constant with the Langmuir's adsorption isotherm at 30°C. The negative free energy of adsorption in the presence of DAPT suggests chemisorptions of the thiodiazole molecules on the steel surface.

The inhibition ability of benzimidazole and its derivatives against the corrosion of mild steel in 1M HCl solution was studied using galvanostatic polarization and electrochemical impedance spectroscopy [69]. The change of impedance parameters observed by variation of

inhibitors concentration within the range of 50–250 ppm was an indication of their adsorption. The thermodynamic adsorption parameters proposed that these inhibitors retard both cathodic and anodic processes through physical adsorption and blocking the active corrosion sites. The adsorption of these compounds obeyed the Langmuir's adsorption isotherm. The inhibition efficiency was increased with increasing the inhibitor concentration according to the order of 2-mercaptobenzimidazole > 2-methylbenzimidazole > benzimidazole, which is in accordance with the variation of apparent activation energy of corrosion.

The oxo-triazole derivative (DTP) was synthesized and its inhibiting action on the corrosion of mild steel in sulphuric acid was investigated [70]. The results obtained from weight loss, potentiodynamic polarization, electrochemical impedance spectroscopy and scanning electron microscope. The results revealed that DTP was an excellent inhibitor and the inhibition efficiencies obtained from weight loss and electrochemical experiment were in good agreement. Potentiodynamic polarization studies clearly revealed that DTP acted essentially as the mixed-type inhibitor. Thermodynamic and kinetic parameters were obtained from weight loss of the different experimental temperatures, which suggested that at different temperatures (298–333 K) the adsorption of DTP on metal surface obeyed Langmuir adsorption isotherm model.

The inhibitive effect of two Schiff bases namely, 2-[((4-methoxyphenyl) imino) methyl] phenol [SB-1] and 1-[((4-methoxyphenyl) imino) methyl]-2-naphthol [SB-2], on the corrosion of carbon steel in 0.1 M and 1M H_2SO_4 was studied by polarization methods [71]. Corrosion parameters and adsorption isotherms were

determined from current- potential curves. It was found that the percentage inhibition efficiencies and surface coverage increase with an increase in the concentration of inhibitors. The results showed that these compounds act as good corrosion inhibitors especially at high concentrations. The adsorption of used compounds on the steel surface follows Langmuir isotherm.

The effect of azathiones as corrosion inhibitors for the corrosion of carbon steel (0.14%C) in H_2SO_4 and in HC1 was investigated by weight loss and potentiostatic polarization techniques [72]. Potentiostatic data showed that these inhibitors are of mixed type. Azathiones can exist as cations species like other amino compounds. These cationic species are adsorbed on the cathodic sites of the steel and decrease the evolution of hydrogen. The adsorption of azathione molecules on the anodic sites takes place through the lone pair of electrons of nitrogen and sulphur atoms which decreases the anodic dissolution of steel. Azathiones gives better inhibition in 1M HC1 than that of 1 MH_2SO_4. This is explained based on synergistic mechanism, according to which Cl^- ions and azathiones molecules can jointly be adsorbed on the steel surface giving higher efficiency.

The inhibition effect of two compounds of Schiff base namely, N, N-bis (salicylidene) -2- hydroxyl-1,3- propanediamine (LOH) and N,N- bis(2-hydroxyaceto-phenylidene)-2-hydroxyl- 1,3- propanediamine (LACOH) toward the corrosion of mild steel in 2M HCl solution was studided at 303K [73]. It has been determined using weight loss, polarization and electrochemical impedance spectroscopy (EIS) methods. It was found that the corrosion rates decrease, percentage inhibition efficiencies and the degree surface coverage increase with increasing additive concentration. The inhibitors appear

to function through the Langmuir's adsorption isotherm. The results showed that LACOH has the highest inhibition efficiency among the two studied compounds.

The inhibition effect of 1-methyl-4[4'(-X)-styryl] pyridinium iodides (X:H, CH_3 and OCH_3) toward the corrosion of mild steel in 1.5 M HCl [74] was studied by hydrogen evolution and weight loss measurements. It was found that the studied compounds exhibit a very good performance as inhibitors for mild steel corrosion in 1.5 M HCl. Results show that the inhibition efficiency increases with decreasing temperature and increasing concentration of inhibitors. Good agreement between the results obtained from hydrogen evolution and weight loss measurements was appeared. It has been determined that the adsorption for the studied inhibitors on mild steel complies with the Langmuir adsorption isotherm at all studied temperatures. The kinetic and thermodynamic parameters for mild steel corrosion and inhibitor adsorption, respectively, were determined and discussed. On the bases of thermodynamic adsorption parameters, comprehensive adsorption (physisorption and chemisorptions) for the studied inhibitors on mild steel surface was suggested. A good correlation between the substituent type and the inhibition efficiency of inhibitors through the application of Hammet relationship was obtained. Results show that with increasing the donor property of the substituent, the inhibition efficiency of the inhibitor is increased in the sequence: $H < CH_3 < OCH_3$.

4-Phenylazo-3-methyl-2-pyrazolon-5-one and three of its derivatives was investigated as corrosion inhibitors for carbon steel in 2 M HCl solution using weight loss and galvanostatic polarization techniques [75]. The inhibition efficiency increases with the increase in the inhibitor

concentration but decrease with a rise in temperature. The conjoint effect of the pyrazolone derivatives and KBr, KSCN and KI has also been studied. The apparent activation energy (E_a*) and some thermodynamic parameters for the corrosion process have also been calculated. The galvanostatic polarization data indicated that the inhibitors were of mixed type, but the cathode is more polarized than the anode. The adsorption of these compounds on C- steel surface has been found to obeys Frumkin's adsorption isotherm. The mechanism of inhibition was discussed in the light of the chemical structure of the undertaken inhibitors.

5-Amino-3-methyl-1-phenyl-1*H*-pyrazole-4-carbonitrile (**1**) was used as a precursor for preparation of 3-methyl-1-phenyl-1,5-dihydro-pyrazolo[3,4-d]pyrimidin-4-one (**2**) and its derivatives **3–10**. The produced compounds were separated, purified,and characterized by FT-IR, 1HNMR, 13C NMR, and mass spectroscopy [76] The surface properties were studied by measuring the surface tension. The surface tension, critical micelle concentration (CMC), and surface activities were determined. The surface parameters such as surface excess concentration (*Γ*max), the area per molecule at interface (*A*min), and the effectiveness of surface tension reduction (*π*CMC) were determined from the adsorption isotherms of the prepared compounds. Furthermore, the corrosion inhibition performance of the prepared compounds was evaluated by chemical methods (weight loss) at different inhibitor concentrations and different temperatures. The corrosion inhibition efficiency increased with increase in inhibitor concentration,but decreased with increase in temperature. Thermodynamic activation parameters were computed and discussed to reach the mechanism of the corrosion inhibition process.

Electrochemical techniques was used for investigating of carbon steel by thiomorpholin-4-ylmethyl-phosphonie acid (TMPA) and

morpholin-4-methyl-phosphonic acid (MPA) in natural sea water [77]. The free corrosion potential was observed to shift in the noble direction which indicated that the phosphoric acids tested inhibit the corrosion of carbon steel in seawater. Potentiodynamic polarization curves shows clearly the fact that the addition of these molecules is associated with corrosion current density decrease and a corresponding reduction of the corrosion rate. The phosphonic acids tested as corrosion inhibitors of carbon steel in natural sea water are effective even with small concentration. Fourier transform infrared spectroscopy was used to obtained information on bonding mechanism between the metallic surface and the inhibitors. The morphology of the metal surface in the uninhibited and inhibited solution was examined using the scanning electron microscope coupled with an energy dispersive X-ray analysis system.

New compounds of alkylamides derived from amino acids were tested as corrosion inhibitors for carbon steel in aqueous solution of HCl. The chemical synthesis of these amides performed by aminolysis of amino acids methyl esters resulted in good yields [78]. Electrochemical measurements were performed using polarization scans and weight loss measurements. Polarization scans indicated that these compounds act as mixed corrosion inhibitors with an efficiency of 80-90% when dissolved in the testing solution at ≥ 50 ppm, whereas gravimetric results displayed a similar tendency. Microtox testing indicated a correlation with the molecular structure of inhibitors. Apparently, a long aliphatic chain (C >I2) promoted not only higher corrosion efficiency, but also a higher toxicity. The higher efficiency of dodecyl amine of tyrosine was apparently derived from its longer aliphatic chain, with some contribution from its phenyl ring,

which reinforces the molecular interactions of *n* type bonding to the d orbital metal favouring film formation.

Some Azole derivatives were used as inhibitors for corrosion irradiated and non-irradiated carbon steel in 0.5 M HNO_3 solution using weight loss and potentiodynamic polarization measurement [79] the inhibition efficiency increased with increase in the concentration of the inhibitors but decreased with an increase in temperature. The inhibition was explained in term of adsorption of these compounds on the steel surface. The inhibition efficiency increased in the case of irradiated carbon steel than for the non irradiated one. The ɣ-radiation improved the passive film and increases it's resistance to the nucleation of pits. This phenomenon is termed a photo inhibition effect.

The use of new biocide, antimicrobial corrosion inhibitor namely, 8-hydroxy-N-(2-(quinolin-8-yloxy)acetyl)-quinoline-5-sulfonohydraz- -ide (HQS) to inhibit the corrosion of mild steel in salty water environment were studied using weight loss, electrochemical measurements, and microorganism tests [80]. The results obtained study show that, the new inhibitor can decrease corrosion and microbial growth under the conditions tested. The mass loss for the protected mild steel coupons shows lower corrosion rate compared to the unprotected once. Cyclic polarization test reveals that, the biocide minimizes the pitting area (hysteresis). The nature of protective film formed on mild steel was studied by scanning electron microscopy (SEM). SEM images revealed that, the corrosion inhibition by the HQS on the mild steel surface significantly improved in the presence of biocide.

N-3-hydroxyl-2-naphthoyl hydrazone derivatives were used as inhibitors for corrosion of carbon steel in 0.5 M H_2SO_4 solution using

weight loss and polarization measurements [81].The inhibiting action of these compound, depends primarily on their concentration and molecular size. These compounds acted as mixed type inhibitors and function via adsorption on carbon steel surface, which follows Frumkin adsorption isotherm. The addition of KI, KBr and KSCN to these compounds had a synergistic effect in enhancing the efficiency of corrosion inhibitors.

The inhibiting effect of N-[4-(diethylamino)benzylidine]-3-{[8-(trifluoromethyl)-quinolin-4-yl]thio}propano hydrazide (DEQTPH) toward the corrosion for carbon steel in HCl and H_2SO_4 solutions using weight loss method, electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization method [82]. The corrosion inhibition efficiencies measured by all the above three techniques were in good agreement with each other. The carbon steel samples were also analyzed by scanning electron microscopy (SEM). The results showed that DEQTPH is an excellent inhibitor for mild steel in acid media. The inhibition efficiency in different acid media was found to be in the order, 0.5M H_2SO_4 > 1.0M HCl > 2.0M HCl > 1.0M H_2SO_4. The inhibition was assumed to occur via adsorption of the inhibitor molecule on the carbon steel surface. It acts as an anodic inhibitor. In the 30–60 °C temperature range, the DEQTPH adsorption follows Langmuir isotherm model. The protection efficiency increased with increasing inhibitor concentration in the range 0.2×10^{-4} to 10.5×10^{-4}M and slightly increased with increasing temperature.

Tris-hydroxymethyl-(2-hydroxybenzylidenamino)-methane (THHM) was synthesized. The effect of THHM on the corrosion of cold rolled steel (CRS) in 0.1M HCl solution was studied using Tafel polarization measurements and electrochemical impedance

spectroscopy (EIS) [83]. Polarization curve results clearly reveal the fact that THHM is a good cathodic type inhibitor. EIS results confirm its corrosion inhibition ability. The inhibition efficiency increases with increasing THHM concentration but decreases with immersion time. Atomic force microscopy (AFM) reveals that a protective film forms on the surface of the inhibited sample. The adsorption of this inhibitor is found to follow the Langmuir adsorption isotherm. THHM adsorbs on the sample probably by chemisorption's.

The corrosion behavior of mild steel (SS400) and stainless steels (types 430 and 304) in H_2SO_4 and CH_3COOH solutions containing KF was investigated with corrosion tests, electrochemical measurement, surface analysis and solution pH analysis [84]. The corrosion rate of SS400 steel in 0.01 M aqueous solution containing KF decreased with increasing the concentration of KF. The SS400 and type 430 stainless steels were corroded in boiling 50% aqueous CH_3COOH and non-aqueous CH_3COOH solution containing high concentration of KF. The corrosion rate of these two steels was decreased. This is due to decrease in corrosive ions such as H^+ in CH_3COOH by contrast, type 304 steel was scarcely corroded in the boiling 50% aqueous and non-aqueous CH_3COOH solutions containing KF because of the formation of a stable oxide film.

The inhibiting effect of imidazole derivative 1,7-dimethyl-2ˉ-propyl-1 H, 3ˉ-2,5ˉ-bibenzo imidazole (DPBI) against mild steel corrosion in 1M HCl solution was evaluated using the conventional mass loss method, potentiodynamic polarization, linear polarization, and electrochemical impedance spectroscopy [85]. The mass loss results showed that DPBI is an excellent corrosion inhibitors, electrochemical impedance spectroscopy showed that the change in the

impedance parameters, charge transfer resistance, and double layer capacitance with change in the concentration of the inhibitor is due to the adsorption of the molecule leading to the formation of protective layer on the surface of mild steel. The inhibition action of this compound was assumed to occur via adsorption on the steel surface through the active centers of the molecule.

1.6.2-Inorganic as corrosion inhibitor:

The effect of the sodium salts of molybdate, tungstate and monovanadate as well as some derivatives of Neville-Winter acid azo dyes on the corrosion of carbon steel in 3.5 percent NaCl solution was studied [86]. Open circuit potential measurements and potentiostatic polarization techniques was used. It was found that all the compounds have inhibition effects on carbon steel dissolution. The inhibition efficiency increased with increase in inhibitor concentration. The process of inhibition was attributed to the formation of an adsorbed film on the metal surface which protects the metal against the corrosive medium. The adsorption of these compounds on the steel/chloride interface was found to follow Freundlich adsorption isotherm.

The corrosion of carbon steel in three kinds of artificial potable waters containing different concentrations of aggressive anions, e.g. Cl^- and SO_4^{-2} open to air in the temperature range from 5°C to 60°C were conducted using weight loss and electrochemical methods [87]. The corrosion rate was increased with increasing the concentration of aggressive anions and with increasing temperature. At lower concentration of aggressive anions and temperatures, the corrosion rate

was lower and the corrosion potential was higher, at intermediate concentrations and temperatures, the corrosion rate increased logarithmically with decreasing potential, and at higher concentrations and temperatures, the corrosion rate was higher and the potential was lower. The corrosion behavior in potable water can be determined by the balance between inhibitive action of oxygen (passive film formation) and aggressive action of Cl^- and SO_4^{-2} ions.

The corrosion resistance of carbon steel in caustic-containing sulfide solutions was found to depends on the formation of a stable passive film on the surface of the metal [88]. The effects of rising temperature up to 170°C and the concentrations of sulfide and hydroxide on the corrosion rate to determine environmental limits for the reliable operation of carbon steel. The results indicate that, carbon steel can exhibit high corrosion rates with increased hydroxide or sulfide concentrations at temperatures above 100 ° C and change the open circuit potential to values below -1.00V(SCE).

Potential-time curves are constructed for the steel electrode in naturally aerated $Ca(OH)_2$ solutions simulating the corrosion behavior in concrete. Cl^- and SO_4^{-2} ions cause the destruction of passivity and initiation of pitting corrosion [89]. The rate of oxide film growth by $Ca(OH)_2$ and oxide film destruction by Cl^- and SO_4^{2-} ions follows a direct logarithmic law as evident from the linear relationships between the open-circuit potential and the logarithm of immersion time. Chromate, phosphate, nitrite, tungstate and molybdate ions inhibit the pitting corrosion of steel. The rate of oxide film healing and thickening increases with their concentrations. In presence of constant inhibitor concentration, the efficiency of pitting inhibition increases in the order: (weak) $CrO_4^{2-} < HPO_4^{2-} < NO^{2-} < WO_4^{2-} < MoO_4^{2-}$ (strong).

The inhibition effect of [Cu^{+2} cation + 3,5-dimethylpyrazole] mixture of different molar ratios on the corrosion of carbon steel in a 0.5 M H_2SO_4 solution was investigated using both weight loss and galvanostatic polarization techniques [90]. The inhibiting solutions were analyzed using UV- visible spectrophotometric before and after polarization measurements. The results revealed a complex formation between the two components, which was much more effective than the inhibiting action of each additive separately. The inhibition mechanism was explained depending on the results derived from both corrosion and UV-visible spectrophotometric measurements as well as conductometric measurement

The effect of Ni^{2+},imidazol and mixtures of them on the corrosion behavior of carbon steel in 0.5M H_2SO_4 solution was studied using galvanostatic, potentiodynamic anodic polarization and weight loss techniques[91].Ni^{2+}cation,imidazole and mixtures of them provide a good protection to carbon steel against pitting corrosion in chloride containing solutions. The inhibiting solutions were analyzed using UV-vis spectrophotometry. The inhibition was explained in the basis of formation of a complex between the two components[92]. The inhibition mechanism was discussed in terms of the results derived from corrosion and UV-vis spectrophotometric measurements as well as conductometric investigation.

1.6.3- Drugs as corrosion inhibitors:

The inhibiting effect of four sulfa drugs compounds (e.g. sulfa-guanidine, sulfamethoxazole and sulfadiazine) on mild steel corrosion in 1.0M HC1 were evaluated using both galvanostatic polarization and weight loss techniques [93]. All the examined sulfa drugs compounds reduce the corrosion of mild steel. Among the compound studied;

sulfadiazine exhibits the best inhibition efficiency and sulfaguanidine the lowest. The inhibition efficiency goes through a maximum for sulfaguanidine while it increases continuously with concentration to a limit with sulfadiazine, sulfamethoxazole and sulfamethazine, respectively. Galvanostatic polarization measurements indicate that all the examined compounds are a mixed inhibitor type with predominant cathodic effectiveness. Moreover, the results revelead a better performance for these compounds as corrosion inhibitors in HCl.

The corrosion inhibition of carbon steel in 1M HCl solution by cefotaxime was studied using Tafel polarization, electrochemical impedance spectroscopy (EIS) and weight loss measurement [94]. The inhibitor showed 95.8 % inhibition efficiency at optimum concentration 300 ppm. Results obtained revealed that inhibition occurs through adsorption of the cefotaxime on the steel surface without modifying the mechanism of corrosion process. Potentiodynamic polarization studies suggest that it is a mixed type of inhibitor. Electrochemical impedance spectroscopy techniques were also used to investigate the mechanism of corrosion   inhibition.

The inhibition efficiencies of ampicillin and flucloxacillin expired drugs on mild steel (MS) corrosion in 1.0 M sulfuric acid medium was examined at 20oC using weight loss (WL), and electrochemical potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS) techniques [95] Examined expired drugs are set to be efficient inhibitors for MS corrosion in sulfuric acid medium. The experimental outcomes of weight loss technique displayed that the inhibition performances of the investigated expired drugs augmented with increasing concentrations of such drugs and reduced by raising the temperature. The observed high inhibition efficiencies of the

studied expired drugs may be owing to powerful adsorption of the drug species on MS surface resulting in formation of protective layers. Adsorption of the tested expired drugs on the MS surface was set to accord with Langmuir adsorption isotherm. The assessed thermodynamic parameters supported the mechanism of physical adsorption of the inhibitors.

1.6.4-Surfactant as corrosion inhibitors:

The adsorption behavior of dodecylamine and its effect on the wettability and corrosion of carbon steel in hydrochloric acid solution were studied [96]. Polarization data indicated that the inhibitions of carbon steel corrosion are due to geometric blocking effect of adsorbed dodecylamine molecules on the metal surface which leads to the formation of monolayer on the metal. Phase images measured by tapping mode atomic force microscopy (AFM) reveal different properties of the surface with and without various concentrations of dodecylamine. AFM force- distance curves indicate that sample surface exhibits adhesion characteristic after the adsorption of dodecylamine. Contact angle measurements show that dodecylamine reduces surface wettability obviously.

The corrosion behavior of carbon steel in 1M HCl solution in absence and presence of three compounds of ethoxylated fatty amide was studied using weight loss and galvanostatic polarization techniques [97]. The percentage inhibition efficiency was found to increase with increasing the additive concentration, number of ethylene oxide unit and with decreasing temperature. The inhibition action of

these compounds was explained in term of adsorption on the steel surface through ethylene oxide unit while the hydrocarbon parts protrude brush-like into the solution. The adsorption process follows Langmuir adsorption isotherm.

Novel cationic Gemini surfactants compounds were synthesized,characterizied and tested as corrosion inhibitors for carbon steel in 1M HCl solution [98].The corrosion inhibition efficiency was measured by using electrochemical impedance spectroscopy, potentiodynamic polarization and weight loss methods. The obtained results showed that, the synthesized compounds are excellent inhibitors for carbon steel in 1M HCl solution. The inhibition efficiency decreased in the temperature range 30-40°C and then increased in the temperature range 40-60°C.The prepared inhibitors act as mixed inhibitors. Thermodynamic and activation parameters were discussed. Adsorption of the synthesized inhibitors was found to follow Langmuir's adsorption isotherm. Mixed physical and chemical adsorption mechanism is proposed. The morphology of carbon steel samples was investigated by scanning electron microscopy (SEM).

The inhibiting power of three synthesized amino acids based-surfactant molecules, namely, sodium N-dodecylasparagines (AS), sodium N-dodecylhistidine (HS) and sodium N-dodecyltryptophan (TS) on the dissolution ofcarbon steel was inspected in 0.5 M NaCl and 05 M NaOH solutions at 25 °C [99] The methods employed in this work were weight-loss (WL), potentiodynamic polarization (PP) and electrochemical impedance spectroscopy(EIS). The chemical structures of the synthesized surfactants were confirmed by FT-IR and 1HNMR. The inhibition efficiencies were found to increase as the surfactants concentrations increase, while decreasing with increasing the

concentration of the corrosive media (NaCl & NaOH) and temperature. Results obtained from the different techniques revealed that the inhibition efficiency of the compound TS was higher than those of both AS and HS. The inhibition efficiencies of the synthesized surfactants were declined in terms of strong adsorption of surfactants on the surface of carbon steel and forming a protective film and such adsorptionwas found to obey Langmuirisotherm. Both thermodynamic and kinetic parameters were evaluated which support the mechanism ofphysical adsorption of the inhibitors. The tested surfactants were found to act as mixed-type inhibitors with anodicpredominance. The surfacemorphology of the carbon steel surface was examined by scanning electron microscopy(SEM). The inhibitory mechanism of carbon steel corrosion was suggested. Results obtained from allemployed methods are consistent with each other.

1.6.5-Natural compound as corrosion inhibitor:

Synthetic organic inhibitors are in most times toxic materials, and considered as source of pollution and their synthesis costs a lot of money. Therefore, natural products act as easy and cheap way to forbidden or retarding the electrochemical corrosion reaction. They can be gained or extracted by simple aqueous media from many wastes of agriculture plants and seeds without any over much cost with the comparison of synthetic organic materials. So, the use natural occurring substance as corrosion inhibitors for metals and alloys is very effective.

Rosemary oil was used as corrosion inhibitor for carbon steel in $0.5M$ H_2SO_4 solution using weight loss, potentiodynamic polarization and electrochemical impedance spectroscopy [100].The inhibition efficiency increases with an increase in the concentration of oil and a decrease of the

temperature. The inhibiting effect of this oil is due to its adsorption on the surface of the steel with formation of a complex with charge transfer between the phenol groups in the inhibitor molecule and the surface of steel. The adsorption process obeys Langmuir's isotherm.

The inhibitive action of natural honey on the corrosion of C- steel, used in manufacturer of petroleum pipelines in high saline water was evaluated [101].The inhibition efficiency was calculated using weight loss measurements and potentiostatic polarization technique. It was found that, natural honey exhibited a very good performance as inhibitor for steel corrosion in high saline water. The inhibition efficiency increases with an increase in natural honey concentration. After some time, the inhibition efficiency decreased due to the growth of fungi in the medium. The adsorption of honey on the C- steel was found to follow the Langmuir adsorption isotherm.

The inhibitive effect of the aqueous extract of the root of shirsh el zallouh (Ferula harmonis) toward the corrosion of C-steel in HCl solution was investigated [102]. The inhibition efficiency was measured using weight loss and potentiostatic polarization techniques. The electrochemical behavior of the extract was investigated 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. The inhibitive effect of the tested extract was discussed in view of adsorption of its components on the steel surface. The adsorption of the extract components on the C-steel surface obeys Langmuir isotherm. The inhibition efficiency decreases as the temperature is increased. The presence of extract increases the activation energy of the corrosion process of C-steel. The curves   of cyclic

voltammetry technique showed that the adsorbed molecules reduce the charge density on the steel surface.

Saleh et al. [103].was studied the inhibitive effects of aqueous extracts of opuntia ficus indica and Aleo eru (leaves) and of orange, mango and pomegranate (fruit-peels) on the corrosion of mild steel, aluminum, zinc and copper in HCl and H_2SO_4 solutions using weight loss and polarization measurements. The extracts reduce the dissolution reactions to an extent dependent on the metal used, the concentration of the additive and the type, concentration and temperature of the attacking acid. The additives provide adequate protection to steel in 5% HCl at 25°C and in 10% HCl at 25°C and 40°C. In the presence of a sufficient concentration of the extracts in 5% HCl at 25°C, the inhibitory efficiency towards steel decreases in the order: Mango (82%), Orange and Aloe eru (80%), Opuntia ficus (75%), pomegranate (65%).These order of efficiency differs for the different metals, but extract of mango peels is Still the most effective for Al (82%) and Zn (80%). The most effective extract for Cu is that of pomegranate fruit- shells (73%). The extracts are generally more effective in HCl than in H_2SO_4 pomegranate measurements prove that all the extracts increase the polarization of steel and Zn, while orange and aloe have no effect on the anodic reaction of Al and only pomegranate has any effect on the anodic polarization of Cu. The results indicate that the extracts generally act as mixed inhibitors.

The effect of extracts of chamomile (chamaemelum mixtum L.), halfabar (cymbopogen proximus), black cumin (Nigella sativa L.), and kidney bean (phaseolus vulgaris L.)plants on the corrosion of carbon steel in aqueous 1M H_2SO_4 solution were investigated by electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization techniques [104] EIS measurements showed that the dissolution process

of steel occurs under activation control. Potentiodynamic polarization curves indicate that the plant extracts behave as mixed-type inhibitors. The corrosion rates of steel and the inhibition efficiencies of the extracts were calculated. The results obtained show that the extract solution of the plant could serve as an effective inhibitor for the corrosion of steel in 1M H_2SO_4 solution. Inhibition was found to increase with increasing concentration of the plant extract up to a critical concentration. The inhibitive actions of plant extracts are discussed based on adsorption of stable complex at the steel surface. Theoretical fitting of different isotherms, Langmuir, Flory-Huggins, and the kinetic-thermodynamic model, were tested to clarify the nature of adsorption.

The effect of eugenol (Eug)and its derivative acetyleugenol (AcEug)extracted from the nail of giroflier on the corrosion of steel in molar hydrochloric acid was studied using weight loss measurements, electrochemical polarization and EIS methods [105]. The naturally substances reduce the corrosion rate. It was found that the inhibition efficiency increased with the content of acetylogenol to 91% at 0.1737 g/l. Eugenol compounds act as mixed type inhibitors. The effect of temperature on the corrosion behavior of steel indicates that the inhibition efficiency of the natural substance increases with increasing temperature.. The adsorption of natural product on the steel is found to follow the Langmuir isotherm

Natural oil extracted from pennyroyal Mint (Mentha pulegium, PM) was examined as corrosion inhibitor of steel in 1.0M HCl solution using weight loss measurements, electrochemical polarization and EIS methods [106]. The naturally oil was found to reduce the corrosion rate of steel. The inhibition efficiency was found to increase with oil content to attain 80% at 2.76 g; PM oil acts as a cathodic inhibitor. The increase in

temperature leads to an increase in the inhibition efficiency of the natural substance. The adsorption isotherm of natural product on the steel has been determined.

The inhibitive effect of the extract of khillah (Ammi visnaga) seeds, on the corrosion of SX 316 steel in HCl solution was determined using weight loss measurements as well as potentiostatic technique [107]. 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 inhibitive effect of khillah extract was discussed based on the adsorption of its components on the steel surface. Negative values were calculated for the energy of adsorption indicating the spontaneity of the adsorption process. The formation of insoluble complexes as a result of interaction between iron cations and khellin, which present in the extract, was also discussed.

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 potentiostatic polarization technique [108].It was found that the extract acts as a good corrosion inhibitor for the three tested electrodes in all tested media. The inhibition efficiency increases as the added concentration of extract is increased. The degree of inhibition depends on the nature of metal and the type of the medium. 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 inhibitive action of the extract is discussed in view of adsorption of lawsonia molecules on the metal surface. It was found that this adsorption follows Langmuir adsorption isotherm in all tested systems. The formation of complex between metal cations and laws one is also proposed as

assitional inhibition mechanism of C-steel and nickel corrosion. Also, vanillin [109] was investigated for the corrosion of mild steel in acid media.Berberine an alkaloid isolated from Captis was studied for its anticorrosion effect for mild steel corrosion in H_2SO_4 medium by Yan Li et al[110].

The inhibitive action of the extent of ficus nitida leaves toward general and pitting corrosion of C-steel, nickel and zinc in different aqueous media was investigated [111]. Weight loss measurements, potentiodynamic polarization techniques were used. It is found that the presence of ficus extract in the corrosive media (acidic, neutral or alkaline) decreases the corrosion rates of the three tested metals. The inhibition efficiency increases as the extract concentration is increased. The inhibition efficiency depends on the type of corroded metal and on the corrosive solution. It was also found that the presence of ficus extract in the chloride containing solution shifts, the pitting potential of the tested metals toward the noble direction. The inhibitive action of the ficus extract is discussed in view of adsorption of its components, the poly aromatic compounds, friendeln, epifriedelanol and nit idol, on the metal surface. It was found that such adsorption follows Langmuir adsorption isotherm. The calculated values of the free energy of adsorption indicated that the adsorption process is spontaneous.

The inhibitory effect of henna extract (Lawsonia inermis) and its main constituents (lawsone, gallic acid, α-D-Glucose and tannic acid) on corrosion of mild steel in 1M HCl solution was investigated by electrochemical techniques and surface analysis (SEM/EDS) [112]. Polarization measurements indicate that all the screening compounds act as a mixed inhibitor and inhibition efficiency increases with inhibitor concentration. Maximum inhibition efficiency (92.06%) is

obtained at 1.2 g/l Henna. Inhibition efficiency increases in the order: lawsone>henna extract>gallic acid>α-D-Glucose> tannic acid. Also, the mechanism of inhibition and parameters of thermodynamics is discussed

The inhibitor effect of the naturally occurring biological molecule caffeic acid toward the corrosion of mild steel in 0.1 M H_2SO_4 solution was investigated using weight loss, potentiodynamic polarization, electrochemical impedance and Raman spectroscopy [113]. The different techniques confirmed the adsorption of caffeic acid onto the mild steel surface and consequently the inhibition of the corrosion process. Caffeic acid acts by reducing the available cathodic reaction area and modifying the activation energy of the anodic reaction. A mechanism is proposed to explain the inhibitory action of the corrosion inhibitor.

The inhibitive and adsorption prosperities of ethanol extract of phyllanthus amarus for the corrosion of mild steel in H_2SO_4 were investigated using gravimetric, thermometric and gasometric methods [114]. Ethanol extract of phyllanthus amarus leaves is a good adsorption inhibitor for the corrosion of mild steel in H_2SO_4. Thermodynamic consideration indicates that the adsorption of the extract is exothermic and spontaneous. Also, the adsorption characteristic of the inhibitor is consistent with the assumptions of Langmuir adsorption isotherm. From the results and findings of the study, physical adsorption mechanism is proposed for the adsorption of ethanol extract of phyllanthus amarus on mild steel surface.

The inhibitive action of lupine (Lupinous albs L.) extract on the corrosion of carbon steel in aqueous solution of 1M H_2SO_4 and 2M

HCL solutions was investigated by potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) techniques [115]. Potentiodynamic polarization curves indicate that the lupine extract acts as a mixed- type inhibtor. EIS measurements showed that the corrosion process is under activation control. The inhibition efficiency of extract obtained from impedance and polarization measurements was in good agreement and it was found to increase with the increase in the extract concentration .The obtained results showed that, the lupine extract could serve as an effective inhibitor for the corrosion of steel in the acidic medium and the extract was more effective in case of HCl solution. Theoretical fitting of the corrosion data to the kinetic.

Galvanostatic and potintiodynamic anodic polarization methods were used to study the inhibiting effect of parsley, lettuce and radish oils on the corrosion of carbon steel (L-52) used in Egyptian manufacturing pipelines in 0.5M NaOH solution [116].The inhibition efficiency increases with an increase in the concentration of these oils. This is due to the adsorption of the basic component of these oils on the surface of the steel. The adsorption process is described by a Langmuir isotherm. It was found that incorporation of chloride ion in the 0.5M solution of NaOH accelerates pitting corrosion of the steel as a result of moving the pitting potential toward more negative values. The investigated oils added to the solution containing chloride ions protect steel from pitting corrosion by shifting the pitting potential to more positive direction.

1.6.6-Polymer as corrosion inhibitor:

Guar gum was tested as corrosion inhibitor for carbon steel in 1M H_2SO_4 solution using weight loss, Tafel polarization techniques [117]. The result showed that, the inhibition efficiency increases with the increasing of guar gum concentration, which act as an inhibitor of the mixed type. The inhibition action of guar gum was discussed in terms of its horizontal adsorption on the metal surface. 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 behavior was explained on the basis of the formation of passivatable active and continuously propagated pits.

Biodegradation and environmental toxicity of products used in the oil industry are of great importance and the corrosion inhibitor cannot be an exception [118]. Chitosan and some derivatives were evaluated as corrosion inhibitors at acidic pH, mainly due to the solubility of the polymer . An eco-friendly corrosion inhibitor with water solubility in all pH range must be ideal and can work under the high salinity of the oilfield environment. Thus, the performance of water-soluble carboxymethyl chitosan (CMC) is presented here as a corrosion inhibitor of carbon steel in the presence of 3.5% NaCl without any acid or base addition. CMC showed good properties as corrosion inhibitor in media containing Cl^-, and behaved as an anodic inhibitor. CMC exhibited inhibitory efficiency of about 80% and 67%, according to Tafel curve and electrochemical impedance, respectively, which are attributed to chemisorption mechanism ($\Delta G_{ads} \approx -45$ kJ/mol).

The inhibition efficiency of the antibacterial cephalosporin e.g. cefotaxime, cefalexin, cefradine and cefazolin toward the corrosion of

iron in 1.0 M HCl was investigated using electrochemical techniques. [119] The results of these techniques indicated that the inhibition efficiency increased with the concentration of inhibitor but decreased with temperature. Potentiodynamic studies proved that the inhibitors act as mixed mode of inhibition and the inhibitor molecules adsorb on the metal-solution interface. The adsorption of the inhibitors on iron surface obeys the Langmuir adsorption isotherm equation. All impedance spectra in EIS tests exhibit one capacitive loop which indicates that the corrosion reaction is controlled by charge transfer process. Inhibition efficiencies obtained from Tafel polarization, charge transfer resistance (Rct) is consistent.

The corrosion inhibition efficiency of aniline, formaldehyde and piperazine based polymer (ADPD) on N80 steel in 3.5% NaCl solution saturated with carbon dioxide was investigated using electrochemical impedance spectroscopy (EIS), potentiodynamic polarization, weight loss, scanning electrochemical microscopy (SECM), scanning electron microscopy (SEM) measurements, density functional theory (DFT) and molecular dynamics simulation (MD) [120]. The adsorption of polymer onto N80 steel surface follows Langmuir adsorption isotherm model. Potentiodynamic polarization study confirmed that inhibitor is mixed type with cathodic predominance. SECM study reveals the current values decreases with the increasing concentration of polymer. SEM study supports the smooth metal surface texture. DFT and MD calculations are in agreement with the experimental findings.

A new class of corrosion inhibitors, namely, polyamino-enzoquinone (PAQ) has been synthesized and its inhibiting action on the corrosion of mild steel in 1M H_2SO_4 and 1M HCl solutions has been investigated by various corrosion monitoring techniques[121]. A preliminary screening of the inhibition efficiency of the polymer was carried out by self corrosion studies. PAQ is found to behave better in 1M H_2SO_4 than 1M HCl solution . Potentiodynamic polarization studies clearly reveal the fact that PAQ is a mixed-type inhibitor. PAQ is able to reduce considerably the permeation current through the steel surface in both the acids. Changes in impedance parameters (R_{ct} and C_{dl}) are indicative of adsorption of PAQ on the metal surface leading to the formation of a protective film which grows with increasing exposure time. The adsorption of this polymer is also found to obey Temkin's adsorption isotherm in both acids thereby indicating that the main process of inhibition is by adsorption. UV spectral studies were also carried out to establish the actual mechanism of inhibition of corrosion

The corrosion inhibition of mild steel in H_2SO_4 in the presence of gum arabic (GA) (naturally occurring polymer) and polyethylene glycol (PEG) (synthetic polymer) was studied using weight loss, hydrogen evolution and thermometric methods at 30–60 °C[122]. PEG was found to be a better inhibitor for mild steel corrosion in acidic medium than GA. The effect of addition of halides (KCl, KBr and KI) was also studied. Results obtained showed that inhibition efficiency increased with increase in GA and PEG concentration, addition of halides and with increase in temperature. Increase in inhibition efficiency and degree of surface coverage was found to follow the trend $Cl^- < Br^- < I^-$ which indicates that the radii and electronegativity of the halide ions play a significant role in the adsorption process. GA and PEG alone and in combination with

halides were found to obey Temkin adsorption isotherm. Phenomenon of chemical adsorption is proposed from the trend of inhibition efficiency with temperature and values ΔG^{o}_{ads} were obtained. The synergism parameter evaluated is found to be greater than unity indicating that the enhanced inhibition efficiency caused by the addition of halides is only due to synergism

Aim of the Present Work

Carbon steel is used as an essential part in the manufacturing of a lot of things in our life. The choice of carbon steel is due to its availability and low cost. Carbon steel surface server corrosion in aggressive media like HCl .Corrosion inhibitors are widely used in industry to reduce the corrosion of carbon steel .Many studied have been carried out to find asuitable compound to use as corrosion inhibitors . Among of these compounds the organic polymer compounds successively used as corrosion inhibitors .The present study aims to examine some polymer compounds e.g polyvinyle alcohol ,synperonic, maltodextrine ,alginic acid, pectin and chitosan to be used as corrosion inhibitors for carbon steel.

Thus ,the present work involves the following :

1) Investigation of the inhibiting effect of some polymer compounds towards the corrosion of carbon steel in 1M HCl.

2) Determination of the inhibition efficiencies of these compounds using different techniques e.g.

     a .Weight loss measurements.

     b. Galvanostatic polarization technique.

     c. potentiodynamic anodic polarization at 1 m V sec^{-1}.

     d. Electrochemical impedance spectroscopy (EIS).

3) Studying the effect of increasing temperature on the rate of corrosion.

4) Study the initiation of the pitting corrosion of carbon steel in chloride containing solutions and its inhibition by the examined polymer compounds.

5) Explanation the mechanism of the inhibition of polymer compounds

6) Finally, the arrangement of polymer compounds according to their percentage inhibition efficiency from the results obtained by all methods used.