CHAPTER I
INTRODUCTION

BACKGROUND

Corrosion is a process that takes place around us everyday. Its aspects are commonly recognized in everyday life ranging from; squeaking hinges, nuts and bolts that cannot be loosened to the brittle red/brown material that eating away pour almost brand new car. These occurrences are the result of a thermodynamically driven process of the metal being converted to a more stable state. Usually this state is a metal oxide, a similar state to the material commonly found in nature from which the metal was refined from in the first place. For this reason the process of corrosion has been described as metallurgy in reverse. The processes of “metals to ore conversion” or corrosion is the basis of significant cost to all developed nations. India loses Rs.2 lakh crore ($45 billion) every year on account of corrosion of infrastructure, industrial equipment and other vital installation said Baldev Raj, Director Indira Gandhi Centre for Atomic Research and Chairman CII Corrosion Management Committee on Corrosion Awareness Day(24.4.11). The latest surveys of world corrosion organisation show that the annual worldwide direct loss of corrosion is $2.2 trillion of a nation’s GDP (www.news.in.msn.com/business/article).

1.1 INTRODUCTION TO CORROSION

Corrosion is the deterioration of materials by chemical interaction with their environment. The term corrosion is sometimes also applied to the degradation of plastics, concrete and wood but generally refers to metals (www.npl.co.uk/upload/pdf/basics-of-corrosion-control.pdf).

Corrosion is the destruction of a metal by a chemical or electrochemical reaction. With a few exceptions all metals corrode in contact with water including moisture in air. Under these conditions the metal atom (M) undergoes oxidation by donating electrons to an electron acceptor (equation 1.1). The charge transfer process is achieved by electrons moving within the conductive metal resulting in the reduction of species (N) (equation 1.2), with the charge balance achieved by an ionic current pathin
the opposite direction. The two sites, connected electronically by the metal and ionically by the electrolyte, are together referred to as a corrosion cell, shown schematically in Figure 1.1. The site of oxidation is referred to as anode and the reduction site as cathode.

Figure 1.1 Schematic representation of electrochemical corrosion cell where a potential difference between the two sites drives the current.

\[ \text{M} \rightarrow \text{M}^{n+} + ne^- \quad (1.1) \]

\[ \text{N} + ne^- \rightarrow \text{N}^{n-} \quad (1.2) \]

A potential difference between the two sites drives the corrosion current. The rate at which a metal corrodes depends on the magnitude of the corrosion current. The current (i.e. the corrosion rate) can be reduced by limiting the production (oxidation at the anode) or consumption (reduction at the cathode) of electrons or by limiting the rate of ionic charge transfer. This can be achieved by the removal of the electrolytic pathways from the metal by the application of a physical barrier such as an insulating coating. Though no coating barrier removes the electrolytic path ways indefinitely, protection using a physical barrier is often employed together with other means of controlling corrosion.

1.2 IMPORTANCE OF CORROSION STUDIES

The importance of corrosion studies is of threefold. The first area of significance is economic, including objective of reducing losses resulting from corrosion of tanks, metal components of machine, ships and bridges and so on. The second area is improving safety of operating equipment which through corrosion may fail with catastrophic consequences. The third objective is conservation, applied primarily to metal resource the
world's supply of which is limited and the wastage of them includes corresponding loses of energy and water reserves associated with the production and fabrication of metal structures.

1.3 IMPORTANCE OF CORROSION PREVENTION

Virtually all metals suffer corrosion, so its effect permeates nearly every aspect of human endeavor and this fact alone makes the study of corrosion a unique one. Nowadays it is necessary to study corrosion than was done earlier due to

- The use of new high tensile strength alloys which are more susceptible to certain types of corrosive attack.
- Increasing pollution of air and water resulting in more corrosive environment.
- Strict safety standards of operating equipment, which may fail in a catastrophic manner due to corrosion.
- Vehicles support equipments in fair to poor overall condition and stored outdoors painted with inadequately often suffer severe corrosion and need attention.
- Unauthorized materials are sometimes used, such as cheap spray paint or industrial cleaning compounds that can damage equipment and violate environmental restrictions.
- Effects of unprevented corrosion of systems are apparent, reducing reliability and increasing maintenance time and cost.
- Adopt technologies that lead to corrosion and make the operating environment not as sustainment system.

1.4 COST OF CORROSION IN VARIOUS COUNTRIES

Corrosion has a huge economic and environmental impact on virtually all facets of the world’s infrastructure, from highways, bridges and buildings, to oil and gas, chemical processing, and water and wastewater systems.

Enormous losses occur due to corrosion every year in all countries. The losses due to corrosion vary from country to country, depending upon the climatic conditions
prevailing in the country. Losses sustained by industry, by the military and are municipalities’ amount to many billions of dollars annually.

The losses may be direct losses e.g. price of corroded metal and labour cost of replacement or indirect which are most difficult to assess, but brief survey of typical losses of this kind compels the conclusion that they add several billion dollars to the direct losses. Examples of indirect losses are plant downtime, loss of product, loss of efficiency, contamination and over design.

A comprehensive study of corrosion in the U.S., published in 2002, estimated the annual cost of corrosion at US$276 billion (BRL460.5 billion). The annual cost of corrosion in the U.S. today has been estimated at more than US$300 billion (BRL500). Similar costs have been estimated by studies conducted in the United Kingdom, Germany and Japan (www.CorrosionDoctors.org).

The 2009 cost of corrosion in water/wastewater systems alone in the U.S. was estimated to exceed US$50 billion (BRL83 billion) (Koch et al 2002). An earlier study estimated the average annual corrosion-related cost in the U.S. for natural gas, crude oil and hazardous liquids transmission pipelines at US$7 billion (BRL12 billion), which the study divided into the cost of capital (38 percent), operation and maintenance (52 percent), and failures (10 percent) (www.nace.org).

In the Persian Gulf, where the sea is salty and much of the soil has high saline content, the cost of corrosion was estimated in 2006 to be US$10 to 15 billion per year (BRL 17 to 25 billion) (www.CorrosionCost.com).

In China, a study estimated the annual cost of corrosion in 2001 at 498 billion Yuan (BRL102 billion; US$61 billion) (En-Hou Han) China’s GDP that year was 9.6 trillion Yuan (www.PeopleDaily.com). That put China’s cost of corrosion even higher than the industrialized nations at 5.2 percent of GDP.

Using the percentages of GDP for industrialized nations, the cost of corrosion in Latin America and the Caribbean in 2009 is estimated to be BRL 208 to 278 billion (US$125 to 167 billion).
If present construction practices are continued, by 2050 when Brazil could have the world’s fourth largest economy, at BRL19 trillion (US$11.5 trillion), (Goldman Sachs) Brazil’s annual cost of corrosion alone could be more than BRL600 billion (US$360 billion) (Jim’O Neill et al 2009).

This year and in the years to come, the nations of Latin America are expected to make substantial investments in infrastructure. In Brazil alone, infrastructure investment in 2011 is expected to be about BRL99 billion (US$51 billion) (Report 2010).

1.5 CONSEQUENCES OF CORROSION

Corrosion can affect seriously health, safety, depletion of resources, appearance and cleanliness, product life and restoration of corroded objects consequences to our society.

1.5.1 Impact on Safety: Corrosion adversely affects the structural integrity of components and makes them susceptible to failure and accident. Corrosion has also been a significant factor in several accidents involving civil and military aircraft and other transportation vehicles. Corrosion failure involving bridges, ships, airports, stadiums are too numerous recorded in the catalog of engineering disasters (Tullmin et al., 1990).

1.5.2 Impact on Health: Adverse effects on health may be caused by corroding structures, such as a plumbing system affecting the quality of water and escaping of products into the environment from the corroded structures.

1.5.3 Depletion of resources: Corrosion puts a heavy constraint on natural resources of a country because of their wastage by corrosion. The process of depletion outweighs the discovery of new resources which may lead to a future metal crisis similar to the oil shortage in the past.

1.5.4 Appearance and cleanliness: Corrosion behaves like a beast to the beauty. It destroys the aesthetic appeal of the product and damages the product image which is a valuable asset to a corporation. Surface finishing processes, such as electroplating, anodizing, mechanical polishing, electro polishing, painting, coating, etching and texturing all lead to the dual purpose of enhancement of aesthetic value and surface integrity of the product.
1.5.5 Product life: Corrosion seriously shortens the predicted design life, a time span after which replacement is anticipated. The reason for their survival is that the engineers make use of imaginative designs, environmental resistant materials and induction of corrosion free maintenance measures. Distinguished and evocative designs always survive whereas designs of a transitory nature deteriorate to extinction with time.

1.5.6 Restoration of corroded objects: Objects of outstanding significance to natural history need to be preserved. Many historical structures have been lost through the ravages of corrosion. It is a limiting factor preventing the development of economically or even technologically workable systems such as

- Boiling water reactors
- Marine environment
- Nuclear power plants
- Automobiles
- Defense

1.5.7 Boiling water reactors

Systems such as boiling water reactors involving aqueous solutions are affected by transpassive corrosion. Transpassive corrosion involves the dissolution of chromium from the surface of stainless steel and nickel-base alloys. It is suspected that transpassive corrosion affects the initiation of irradiation assisted stress corrosion cracking. This technologically important corrosion process leads to the failure of such applications such as gas turbines, heat exchangers and many others that operate at high temperatures.

1.5.8 Marine environment

Corrosion can cause rapid failure in marine systems. Galvanic corrosion is the most frequent cause of unexpected marine equipment failures in sea water. It has caused failures of ship fittings and deckhouse structures, fasteners, hull plating, propellers shafts, valves, condensers and piping. In sea atmospheres, galvanic corrosion causes many failures and it occurs at any time when two different metals are in electrical contact in sea water. Seawater systems are used by many industries such as shipping, offshore oil, gas production, power plants and coastal industrial plants.
1.5.9 Nuclear power plants

In nuclear power plants the deterioration occurs through corrosion- erosion and cracks. Nuclear power plants have been designed for decades of operation. One of the challenges in their maintenance is related to the phenomena of stress corrosion cracking and corrosion erosion. In nuclear power plants the temperature of the cooling water reaches about 300°C and the pressure up to 120 bar. The pressure bearing components in contact with the cooling water are made up of stainless steel on nickel base alloy. Oxygen in water reacts with the outermost layer of these metals, forming a thin oxide layer that slows down further corrosion. Corrosion products are released from a thin metal oxide layer by the flow of cooling water. These particles become activated and are deposited on the inner surfaces of the pipes. The resulting activity tends to make the maintenance operation of nuclear plants more costly in the long run.

1.5.10 Automobiles

The costs of corrosion are not always apparent. Even though anti-rust coatings on automobiles have made signs of rustles evident, rust may be affecting the less visible parts of the vehicle. Aircrafts that undergo regular anti-corrosion maintenance not only are safer, but maintain their resale value more than the untreated aircraft. Marine craft are also vulnerable to corrosion, particularly those in salt water environment.

1.5.11 Defense

Most Department of Defense equipment and facilities are composed of materials that are susceptible to oxidation, stress, surface wear and other chemical and environmental mechanisms that cause corrosion. Military forces operate world-wide in locations that produce varying corrosion-related effects – locations ranging from aggressive coastal or marine environments wherever forces battle the effects of humidity, temperature, and salt spray to caustic desert settings where wind-blown sand penetrates every crevice and erodes surface materials. The tremendous negative impact is manifested in reduced availability, deteriorating performance and ever-increasing total ownership cost of warfighting systems and infrastructure.
Some important consequences of corrosion are summarized below:

- **Plant shutdowns.** Shutdown of nuclear plants, process plants, power plants and refineries may cause severe problems to industry and consumers.

- **Loss of products,** leaking containers, storage tanks, water and oil transportation lines and fuel tanks cause significant loss of product and may generate severe accidents and hazards. It is well known that at least 25% of water is lost by leakage.

- **Loss of efficiency.** Insulation of heat exchanger tubing’s and pipelines by corrosion products reduces heat transfer and piping capacity.

- **Contamination.** Corrosion products may contaminate chemicals, pharmaceuticals, dyes, packaged goods, etc. with dire consequences to the consumers.

- **Nuclear hazards.** The Chernobyl disaster is a continuing example of transport of radioactive corrosion products in water, fatal to human, animal and biological life.

### 1.6 DESIGN FOR CORROSION PREVENTION

The interaction of a material with its environment results in corrosion. So the significance of corrosion control includes economic, safety and environmental concerns. Various methods are used for corrosion prevention. There are five methods of corrosion prevention or control that are generally used. They are (1) Material Selection, (2) Coatings, (3) Cathodic and Anodic Protection (4) Design and (5) Environmental Change.

#### 1.6.1 Material Selection

Corrosion problems are of primary concern in material selection. It is important to realize that, for example, the use of a stainless steel instead of mild steel will not always diminish corrosion problems, because the modes and rates of corrosion are not constant for a given material, but rather they are dependent upon the environment to which it is exposed.

The same point can be made in relation to other forms of corrosion; thus molybdenum additions to ferrite steels are beneficial with respect to stress corrosion cracking resistance in carbonate environments, but are detrimental in hydroxide solutions, and so on. The general point to be grasped is that in specifying the operating conditions for a component or structure it is vital that the environmental conditions be defined with
Corrosion control is almost always an economic situation. In the case of steel being corroded it is possible to stop the corrosion if only noble metal such as platinum is used. But platinum is too expensive. It is this type of economic consideration has to be taken into consideration. The material which is best for the job is to be selected. This includes cost and strength as well as corrosion resistance considerations.

1.6.2 Coatings

In addition to paints there are other types of coating such as metallic coatings, electro-plating, galvanizing, etc. Coatings are frequently used for cosmetic purposes. They generally have two purposes. One is cosmetic; the other purpose is corrosion protection. The latter purpose is of particular interest to engineers. The corrosion engineer has a wide range of coatings from which he has to select the desired one.

Protective coatings are the most widely used corrosion control technique. Essentially, protective coatings are a means for separating the surfaces that are susceptible to corrosion from the factors in the environment which cause corrosion to occur. However, these protective coatings can never provide 100 percent protection to the surface. If localized corrosion at a coating defect is likely to cause rapid catastrophic failure, additional corrosion control measures must be taken. Coatings are particularly useful when used in combination with other methods of corrosion control such as cathodic protection or galvanic corrosion.

1.6.3 Cathodic and Anodic Control: Cathodic protection is used extensively worldwide as a corrosion control method. Anodic protection is used to a lesser extent, but nevertheless has some very interesting possibilities with respect to corrosion protection. Cathodic protection results when we impress a negative potential onto the material we want to protect. Anodic protection is possible in very specific cases when we impress a positive potential. However this must be done with quite stringent controls.
1.6.4 Design: Simple design of a material to be bigger and thicker can cause corrosion. Normally design is simply a common sense approach such as how to drain tanks, where to locate a plant, and how to install various parts of a plant, etc. The design of the material should be in such a way it prevents corrosion.

1.6.5 Environmental Change: The environment can be changed for the corroding material enclosed. This can be achieved possibly by changing temperature or concentration of solutions. The other way is to add inhibitors to provide some control over the corrosion. An everyday example of a corrosion inhibitor of which almost everyone is aware, is the inhibitor put into automobile-engine cooling radiator.

Looking ahead at the future, it has been identified as the highest priority technology to meet upcoming corrosion challenges. They are

- Better methods to predict, detect, and manage corrosion
- Improved corrosion preventive compounds
- Materials to prevent degradation of advanced composites
- Improved, environmentally acceptable thin film formation or surface treatment technologies.

1.7 CORROSION INHIBITOR

The use of inhibitors is one of the most effective and practical methods of protection of corrosion of metals in acid medium. A corrosion inhibitor is a chemical additive which when added to a corrosive aqueous environment reduces the rate of metal wastage. Some of the mechanisms of its effect are formation of a passive layer, that is, a thin film on the surface of the material that stops access of the corrosive substance to the metal, inhibiting either the oxidation or reduction part of the redox corrosion system (anodic and cathodic inhibitors), or scavenging the dissolved oxygen.

Two processes are involved in the action of inhibitor on the metal surface.

- The first step involves the transport of the inhibitor on the metal surface.
- The second step involves the chemical interaction between the inhibitor and the metal surface and the formation of surface film.
When a corrosion inhibitor is added to a system, adsorption of the inhibitor molecule at the metal solution interface occurs and this is accompanied by a change in potential difference between the metal electrode and the solution due to the nonuniform distribution of electric charge at the interface.

1.8 CLASSIFICATION OF INHIBITORS

A qualitative classification of inhibitors is presented below.

(Uhlig, 2000)

![Diagram of Inhibitor Classifications](image)

**Figure 1.2 Classifications of Inhibitors**

1.8.1 Environmental Conditioners

Corrosion can be controlled by removing the corrosive species in the medium. Inhibitors that decrease corrosivity of the medium by scavenging the aggressive
substances are called environmental conditioners or scavengers. In near – neutral and alkaline solutions, reduction of oxygen is a common cathodic reaction. In such situations, corrosion can be controlled by decreasing the oxygen content using suitable scavengers.

1.8.2 Interface inhibitors (Liquid phase)

1.8.2.a Anodic Inhibitors

Anodic inhibitors are used in near neutral solutions where sparingly soluble corrosion products such as oxides, hydroxides or salts are formed. They facilitate the formation of passive films that inhibit the anodic metal dissolution reaction. Anodic inhibitors are often called passive inhibitors.

When the concentration of an anodic inhibitor is not sufficient, corrosion may be accelerated, rather than inhibited. The critical concentration above which inhibitors are effective depends on the nature and concentration of the aggressive ions. In general, an anodic inhibitor increases the anodic polarization and moves the corrosion potential in the positive direction, (for example, ortho phosphates, silicates etc.). But a few of them have some undesirable property in low concentrations. For example they cause stimulation of corrosion such as pitting. Hence, anodic inhibitors are usually not desirable.

1.8.2.b Cathodic Inhibitors

Cathodic inhibitors control corrosion by either decreasing the reduction rate (cathodic poison) or by precipitating selectively on the cathodic areas (cathodic precipitators). Cathodic poisons are either adsorbed on the metal surface or reduced at the cathode to form a metallic layer. In near-neutral and alkaline solutions, inorganic anions, such as phosphates, silicates and borates form protective films that decrease the cathodic reaction rate by limiting the diffusion of oxygen to the metal surface.

In acid solution cathodic poisons cause hydrogen blisters and hydrogen embrittlement due to hydrogen evolution. The hydrogen gas instead of leaving the surface, diffuses into steel causing hydrogen damage such as hydrogen-induced cracking, sulfide stress cracking etc.

The cathodic precipitators increase the alkalinity at cathodic sites and precipitate insoluble compounds on the metal surface. The most widely used cathodic precipitators
are the carbonates of calcium and magnesium. This type of inhibitor shifts the corrosion potential in the negative direction. Here cations migrate towards cathode surface where they are precipitated chemically or electrochemically and thus block the surfaces. For example, the action of As\(^{3+}\) and Sb\(^{3+}\) on dissolution of iron in acids.

1.8.2.c Mixed Inhibitor

Mixed inhibitors protect the metal in three possible ways namely, physical adsorption, chemical adsorption and film formation. The effectiveness of mixed inhibitor is related to the extent to which they get adsorbed and cover the metal surface. Adsorption depends on the structure of the inhibitor, surface charge of the metal and the type of the electrolyte.

This type of inhibitors retard both the electrode processes. The potential change is small and the direction is determined by the relative size of the anodic and cathodic sites. It has the advantage over other inhibitors in that they control both the partial corrosion reactions and hence they are very safe to apply. Depending on the environment, inhibitors are also classified in to acid, base and neutral inhibitors.

This may be classified further in to;

(a) Inorganic inhibitors and (b) Organic inhibitors

1.8.3.a Inorganic inhibitors

To improve the inhibition, one of the methods is to add salts of metals in the corrosive medium. In this case, the protection is due to the reduction of electropositive ions and deposition on the metal surface thus lowering the over voltage of main cathodic depolarization reaction (Tamashov and Cheenova, 1967). The effect of inorganic anions has been studied with organic compounds for mild steel in various acid solutions and these are found to be effective inhibitors.

In neutral solutions, the interaction of inhibitors with oxide covered metal surfaces and prevention of oxygen reduction at the cathodic sites take place. Such inhibitors protect the surface layers from aggressiveness. The first step involves the displacement of pre-adsorbed water molecules by the inhibitor followed by chemical or electrochemical reactions at the surface. Hence, the inhibitors which block the cathodic
reduction of oxygen to the surface of the metal are cathodic inhibitors. For example, phosphates, silicates, borates etc. the anodic inhibitors, which prevent anodic dissolution by the formation of the passivating on the metal surface for example, chromates and nitrites. A high surface coverage was observed in presence of benzoate anions, favouring the establishment of passive state (Azambuja, 1999).

1.8.3.b Organic inhibitors

Organic compounds containing oxygen, nitrogen, sulphur, multiple bonds have been reported as good corrosion inhibitors. Many organic inhibitors such as amines, aldehydes, alkaloids and nitro and nitroso compounds have been studied and tried as corrosion inhibitors (Khalad (2004), Abd El-Maksoud (2004), Chetouani et al (2002 & 2003). Organic inhibitors can be anodic,cathodic or mixed type based on its reaction at the metal surface and shift of potential. These are effective depending upon its size, carbon chain length, aromaticity, conjugation and nature of bonding atoms (Schmitt and Bedbur, 1985).

Metals, which form amphoteric oxide, are prone to corrosion in alkaline solutions. Many organic compounds are used as inhibitors for metals in basic solutions such as tannin, geletins, agar – agar etc. Compounds such as thiourea, substituted phenols, naphthol β – diketone etc., have been used as effective inhibitors in basic solutions due to the formation of metal complexes.

1.8.6 Interface inhibitors (Vapour phase)

A vapour phase inhibitor is an individual chemical or combination of chemicals having high vapor pressure that can prevent atmospheric corrosion of metallic materials. (eg dicyclohexylammonium nitrate, benzotriazole, phenylthiourea etc). They get readily vapourised and form protective layer on the metal surface. They are be capable of establishing a stable bond with the metal surface in a given environment of a certain range of acidity and pressure and create an impenetrable layer for corroding ions.

1.9 REQUISITES OF A GOOD INHIBITOR

A good inhibitor should possess the following requirements for effective protection. It should be effective at low inhibitor concentration. It should minimize the permeation of hydrogen into the metal. It should inhibit the metal dissolution. There must
be limited pickling. It should be effective at high temperature. It should have good surfactant and foaming properties. It should possess chemical and thermal stability.

The most important requirement is that the inhibitor should minimize the metal dissolution.

1.10 INHIBITING ACTION OF AN INHIBITOR

Inhibitors decrease or prevent the reaction of the metal with the media. They reduce the corrosion rate by

1. Adsorption of ions/ molecules onto metal surface
2. Increasing or decreasing the anodic and/ or cathodic reaction
3. Decreasing the diffusion rate for reactants to the surface of the metal and
4. Decreasing the electrical resistance of the metal surface.

Organic inhibitors generally have heteroatoms. O, N, and S are found to have higher basicity and electron density and thus act as corrosion inhibitors. O, N and S are the active centers for the process of adsorption on the metal surface. The inhibiting efficiency follows the order O<N<S<P. The inhibitor gets adsorbed on the metal surface by displacing water molecules on the surface and forming a compact barrier. Availability of nonbonded (lone pair) and π-electrons in inhibitor molecules facilitate electron transfer from the inhibitor to the metal. A coordinate covalent bond involving transfer of electrons from inhibitor to the metal surface may be formed. The electron density in the metal at the point of attachment changes resulting in the retardation of the cathodic or anodic reactions. (Quraishi et al 2000). Demonstrated that the inhibiting efficiency increases the electron density at the functional group and it can be varied by introducing different substituents in the ring leading to variation of the molecular structure. The strength of the physisorption/ chemisorptions bond depends upon the electron density on the donor atom of the functional group and also the polarizability of the group. When a hydrogen atom attached to the carbon in the ring is replaced by a substituent group (-NH₂, -NO₂, -CHO or –COOH) it improves inhibition (Khalad et al 2003).

Inhibition increases with carbon number in the chain to about 10 carbons, but with higher members little increase or decrease in the inhibiting ability has been noticed.
This is attributed to the decreasing solubility in aqueous solution with increasing length of the hydrocarbon chain. However, the presence of hydrophilic functional groups in the molecule would increase the solubility of the inhibitors. The other factors that contribute to the action of inhibitor are size of the molecule, bonding – aromatic/conjugation and cross linking ability.

1.1 SELECTION OF AN INHIBITOR

The selection of an inhibitor is based on the metal and the environment. It begins with the choice of physical properties. The variables like temperature, pressure as well as mechanical properties affect the corrosion environment. The cost, toxicity and availability are of considerable importance in the selection and utilization of inhibitor.

It is widely accepted that inhibitors especially the organic compounds work by an adsorption mechanism. The resultant film of chemisorbed inhibitor is then responsible for protection either by physically blocking the surface from the corrosion environment or by retarding the electrochemical processes. Numerous additives have been used in the past for the control of corrosion and the scale formation of these organic compounds has been successfully used as inhibitors. But these inhibitors suffer certain disadvantages like high cost, difficulty in disposal management, creating environmental pollution etc.

The use of polymers as corrosion inhibitors has attracted considerable attention recently. Polymers are used as corrosion inhibitors because, through their functional groups they form complexes with metal ions and on the metal surface these complexes occupy a large surface area, thereby blanketing the surface to protect the metal from corrosive agents present in the solution (Rajendran et al., 2005).

The inhibitive power of these polymers is related structurally to the cyclic rings and heteroatom’s (oxygen and nitrogen) which are the major active centers for adsorption. Also, polymers are effective at low concentration; these are thermally and chemically stable and possess good surfactant characteristics. The use of polymer has been advocated because of the toxic nature and environmentally unfriendliness of inorganic and organic corrosion inhibitors.
Polyaniline (PANI) and substituted PANI are unstable and insoluble in water. If PANI is made as water soluble composite, it will be a more effective corrosion inhibitor. Poly ethyleneglycol (PG) is water soluble and its solution is considered as green reaction media. From the information on the nature of PANI, it has been proposed to incorporate PG into aniline and its derivatives separately to formulate different new water soluble polymer composites.

The presence of PG in aniline and its derivatives on metal surface will lengthen the diffusion path of corrosive media so as to improve the barrier properties. In addition PG, will improve the thermal stability of polymer composites. Consequently, the service life of the polymer film on mild steel can be significantly improved by incorporating PG.

### 1.12 SELECTION OF SAMPLES

Mild steel being a low steel alloy softer than cast iron but having high tensile strength can be easily machined. Due to low cost and easy availability, mild steel is a material of choice to fabricate machineries in industries. Therefore it finds a variety of applications like motor car bodies, machines, gears, pipes, tanks etc. and in most of the chemical industries.

The corrosion of mild steel is of fundamental academic and industrial concern that has received a considerable amount of attention. Mild steel has been extensively used under different conditions in chemical and allied industries in handling alkalies, acid and salt solutions. It suffers severe corrosion in these aggressive environment from which is to be protected. Hence the study of corrosion inhibition of mild steel (MS) in aqueous aggressive media is the subject of pronounced technological significance. Thus the investigation has been carried out with mild steel.

### 1.13 SELECTION OF AGGRESSIVE MEDIA

Equipments in power plants, chemical plants, paper mills, sugar plants, pipelines, air conditioners in large buildings, boilers, vessels, reactors etc in industrial environments require scale removal and acid cleaning treatments. Among the commercially available acids HCl is used in nearly all industries. It is the most important pickling acid. It is used before coatings for the removal of oxide in the form of undesirable scales and rust. Large scale
continuous treatments such as metal stripping, wire pickling and economic advantages in the regeneration of depleted pickling solution are factors of increasing economic and ecological importance. These are the main reasons why hydrochloric acid has been chosen as the medium. So, diluted AR grade (Aldrich) HCl was used as corrodent.

1.14 SELECTION OF MEDIA AND POLYMER

In the present study, the polymerization of polyethylene glycol with aniline derivatives was carried out in oxalic acid media with the aim of obtaining polymer composites, since the earlier reports were promising for the organic dibasic acids especially oxalic acid. The polymerization of all the monomeric aniline derivatives, results in high values of the polymer growth rate.

1.15 OBJECTIVES

The following polymer composites were synthesized and subjected to detailed corrosion investigation

1. Pol (ethylene glycol-aniline) composite
2. Pol (ethylene glycol-anthranilic acid) composite
3. Pol (ethylene glycol-methoxy aniline) composite
4. Pol (ethylene glycol-ethoxy aniline) composite
5. Pol (ethylene glycol-o-toludine) composite
6. Pol (ethylene glycol-sulphanilic acid) composite

The present study is aimed to investigate the protection performance of the above six polymer composites on mild steel in 1M HCl medium with the following objectives

1. Synthesis and characterization of the polymer composites
2. Proposing possible structure of the polymer composites
3. Evaluation of the inhibitive action of the polymer composites as inhibitors on the mild steel in 1M HCl medium
4. Comparing the corrosion inhibition efficiency of polymer composites based on the polymer structure and
5. Proposal of a possible mechanism for corrosion inhibition studies.