CHAPTER-V

SUMMARY

In the present investigation, the corrosion of mild steel that are used in the many industrial purposes has been studied in the presence and absence of some natural and organic inhibitors. The inhibition efficiency of these inhibitors was assessed by weight loss method and the results obtained were further confirmed by the electrochemical techniques such as open circuit potential, potentiodynamic polarization and electrochemical impedance studies. Due to the bio-degradability, eco-friendliness, cost-effectiveness, less toxicity and easy availability of these inhibitors, the trend of using them have become increasingly important in the recent years.

Therefore for this study three inhibitors have been chosen and they were synthesized as follows.

Inhibitor- (Piper nigrum.L)

The pepper seed has been collected and powdered into grain form. From the powdered substance 20 g of Piper nigrum.L has been dissolved in doubly distilled water and kept for reflux for one hour. The extract is filtered and the filtrate is used for various milli molar concentrations. Piper nigrum.L (Piperidin) acts as a major role for corrosion inhibition of mild steel and was successfully tested as a powerful inhibitor.

Inhibitor- (Adhatoda vasica)

The leaves of the plant Adhatoda vasica (AV) were procured and dried at room temperature (27°C) followed by grinding. The dried material was extracted successively with methanol in Soxhlet extractor for 24 hours at 60°C. The extracted plant material was filtered and methanol filtrate was evaporated to 40°C. The residue was dissolved in hot
water and it was used for the preparation of various milli molar concentration of inhibitor solution. Adhatoda vasica (AV) acts as a major role for corrosion inhibition of mild steel.

Inhibitor- (1,2,3-Benzotriazole)

Inhibitor solution of Benzotriazole was prepared by dissolving 1g of 1,2,3-Benzotriazole in 100ml of test solution. Similarly various milli molar solutions have been prepared. This Inhibitor shows very good result in controlling the rate of corrosion.

The results of weight loss method has been clearly indicate that these three inhibitors namely Piper nigrum.L (PNL), Adhatoda vasica (AV) and 1,2,3 Benzotriazole effectively inhibit at various acid media like Hydrochloric acid, Sulphuric acid and Citric acid at different concentrations like (1M and 2M) at different time intervals and control the rate of corrosion. It could be inferred that the inhibition efficiency increased with increase in concentration of inhibitor and decreased with increasing concentration of various acid media.

Further, the study has been extended to investigated the corrosion behaviour of mild steel using different inhibitors by electrochemical techniques, in which open circuit potential states that the variation of the potential of mild steel electrode immersed in different acid media in the absence and presence of the studied inhibitors as a function of the time of exposure has varied greatly. From the analysis, it is clear that the open circuit potential (OCP) of mild steel electrode for different acid media without inhibitor (blank) tends towards more negative and after the addition of the inhibitor, the value first giving rise to short step, the open circuit potential starts from the active region of the mild steel and attains a stable steady state in the passive region and establish a equilibrium. This behavior represents the breakdown of pre-immersion, air formed oxide film present on the surface. This step is followed by the growth of an oxide film inside the solution until
steady state potential is established. The nobler shift of the OCP can be explained in terms of the formation of a protective layer of the inhibitor on the electrode surface.

The corrosion of mild steel in different acid media in the absence and presence of various studied inhibitors like Piper nigrum L (PNL), Adhatoda vasica (AV) and 1,2,3 Benzotriazole were also investigated by EIS measurement at open circuit potential condition. Nyquist plots for mild steel obtained at the interface of electrode and electrolyte in the absence and presence of optimum concentration of inhibitors. All the plots obtained show only one semicircle and they was fitted using one time constant equivalent model (Randle’s model) with capacitance(C) and charge transfer resistance (Rct). The double layer capacitance (Cdl) value for all different acid media indicates that the homogeneity of the surface of the mild steel roughened due to corrosion. The double layer capacitance Cdl values decreased on the effective addition of different inhibitors at the optimum concentration. The Nyquist plot obtained with different acid media shows only one capacitive loop and the diameter of the semicircle increases on the increasing the electrostatic attraction of the inhibitor which suggested that the formed inhibitive film was strengthened by the addition of the inhibitors. All the systems studied indicate that the reduction of charge accumulated in the double layer due to formation of adsorbed inhibitor layer. The inhibiting efficiencies show that the inhibitory action may be due to the adsorption of the inhibitors on mild steel surface. This study revealed that the strong electrostatic attraction of the studied inhibitors on the metal surface thereby resulting in the high inhibition efficiency. Generally on the metal side, electrons control the charge distribution whereas on the solution side it is controlled by ions. Since ions are much larger than the electrons, the equivalent ions to the charge on the metal will occupy quite a large volume on the solution side of the double layer. The capacitance of the electrical
double layer ($C_{dl}$) decreases in the presence of the inhibitors. Decrease in the ($C_{dl}$) which can result from a decrease in local dielectric constant and / or an increase in the thickness of the electrical double layer, suggests that the inhibitor molecule may act by adsorption at the metal/solution interface.

It is revealed from the Potentiodynamic Polarization studies, the ($E_{con}$) values were shifted slightly towards negative side in presence of inhibitors suggesting that the inhibitors inhibit the corrosion of mild steel in acids solution by controlling cathodic reactions by blocking the active sites on the metal surface. It is evident that, the inhibitors bring about considerable polarization of the cathode. It was, therefore, inferred that the inhibitive action is of mixed type. The non-constancy of Tafel slopes for different inhibitor at optimum concentration reveals that the inhibitor action due to the interference in the mechanism of the corrosion processes at cathode. The inhibition efficiencies were determined from the values of corrosion current density and the inhibition efficiency values were found to show good agreement with those obtained from weight loss measurements.

It has also been studied from the adsorption isotherm that the interaction of inhibitor and the mild steel surface playing a major role in the inhibition of mild steel corrosion. Generally, inhibitors can function either by physical (electrostatic) adsorption or chemisorption with the metal. In order to obtain more information about the interaction between the inhibitor molecules and the metal surface, different adsorption isotherms were tested with the studied inhibitors at different acid media. All the studied inhibitors obey Langmuir adsorption isotherm, which is based on the assumption that all adsorption sites are equivalent and that molecular binding, occurs independently from the fact whether the nearby sites are occupied or not, was verified for all the studied inhibitors.
The inhibition of mild steel corrosion has been further investigated by FT-IR spectrophotometer. Since extracts contained organic compounds and these organic compounds were adsorbed on the metal surface providing protection against corrosion. So, FT-IR analyses of metal surface can be useful for predicting whether organic inhibitors are adsorbed or not adsorbed on the metal surface. FT-IR spectra supports the fact that corrosion inhibition of mild steel in acid medium is due to the adsorption of inhibitor molecules on the mild steel surface, which provides new bonding information on the steel surface and inhibits after immersion in an acid media in the presence of different studied inhibitors. From the spectral analysis it is revealed that the inhibition is due to the adsorption of corresponding organic molecule.

The studied mild steel specimens were used for surface morphological examination which was immersed in different acid medium without and with various milli molar concentrations of inhibitors Piper nigrum.L (PNL), Adhatoda vasica (AV) and 1,2,3 Benzotriazole for 48 hrs. From the micrographs it can be seen that a number of pits occurred due to the attack of aggressive medium on the mild steel surface. The micrographs show a characteristic inclusion, which is fairly an oxide inclusion.

The micrograph also revealed that the surface is severely damaged in absence of the inhibitor. The micrograph of inhibited mild steel surface shows a reduced number of pits and also less damage on the mild steel surface. From this micrograph, it is obvious that all the studied inhibitors exhibit a good protective film on mild steel surface. This is attributed to the involvement of the compounds in the interaction with the active sites of metal surface. This results in enhanced surface coverage of the metal so that there is a decrease in the contact between metal and the aggressive medium.