SUMMARY AND CONCLUSIONS

The general introduction of this thesis started by definition of corrosion process and its products followed by the classification of metals corrosion and types of corrosion inhibitors. The main part of thesis showed a literature survey of corrosion behavior of C-steel (L-52), nickel and zinc electrodes in aqueous solutions (acidic, neutral and alkaline), respectively. This survey also contained different modern and old subjects about the inhibition process of the above metals in different aqueous media. The introduction talked also about the usage of natural products as corrosion inhibitors for metals and alloys.

Chapter (I) contained the main experimental part which discusses in details the methods of extraction, purification and composition of natural products namely, Lawsonia (L), Ficus (F) and Opuntia (S) extracts. The effect of these extracts on the corrosion behavior of C-steel, nickel and zinc electrodes in different aqueous solutions (0.1M HCl, 3.5% NaCl and 0.1M NaOH), respectively, was studied by using the electrochemical (galvanostatic polarization) technique at room temperature (25 ±2) °C. The inhibition efficiency of different electrodes rearrangement as follows:

The inhibition efficiency of henna extract for C-steel corrosion in different test solutions increases in all the add concentrations in the following order:

$$NaOH < NaCl < HCl$$

The effect of Ficus extract on C-steel in different aqueous media indicates is similar to the behavior of Lawasonia extract and have the following order:

$$NaOH < NaCl < HCl$$

Opuntia extract reveals the same behavior of Lawasonia and Ficus extracts on C-steel in acidic and neutral medium in the following order:

$$NaCl < HCl$$

The inhibition efficiency of Lawsonia extract on nickel corrosion in different aqueous media can be discussed from the data of result tables and have the following order:

$$NaOH < NaCl < HCl$$

Ficus extract has the same behavior of inhibition effect on corrosion of nickel in different aqueous media where the inhibition efficiency increases and have the following order:

$$HCl < NaCl < NaOH$$

The inhibition efficiency of Opuntia extract on the corrosion of nickel have the following order:

$$HCl < NaCl$$

The effect of Lawsonia extract on zinc in different aqueous media has the same behavior of C-steel in the same media. The inhibition efficiency increases with increasing the additive concentration and have the following order:

$$HCl < NaOH < NaCl$$

The influence of Ficus extract on corrosion in different aqueous media has the same behavior of Lawsonia extract on zinc corrosion. The inhibition efficiency increases with increasing the additive concentration and have the following order:

$$HCl < NaCl < NaOH$$

Opuntia extract have good effect on zinc corrosion in acidic and neutral media and the inhibition efficiency have the following order:

$$HCl < NaCl$$

Chapter (II) deals with study the pitting corrosion of the same metals in chapter (I) using potentiodynamic anodic polarization technique in solutions of different concentrations, ranging from 0.1 to 1M, sodium chloride solution. It was found that Cl^- ions cause the destruction of the passivating film and initiation of visible pits. As the chloride ions concentration increases, the pitting potential of C-steel, nickel and zinc is shifted to more active (negative) direction. Straight line relationship between $E_{pitt.}$ and log C_{Cl^-} is obtained satisfying the following equation.

$$E_{pitt.} = a_1 - b_1 \log C_{Cl^-}$$

But in the cases of C-steel and zinc the relation gives broken line at certain range of chloride ion.

The effect of natural extracts of (Lawasonia, Ficus and Opuntia) products on the pitting corrosion of different metals in 0.6M NaCl solution was studied at scanning rate of 1mV/sec. The increasing of the concentration of these extracts cause a shift of the pitting potential to positive direction. This effect denotes increased resistance to pitting attack. A straight line relationship is obtained between $E_{pitt.}$ and log $C_{inh.}$ satisfying the following equation:

$$E_{pitt.} = a_2 + b_2 \log C_{inh.}$$

Inhibition afforded by these extracts decreases in the following order:

$$\text{extract F} > \text{extract L}$$

In the case of C-steel, and the same order in the case of nickel but it differ in the case of zinc in the following order:

extract F > extract L

Chapter (III) is concerned with discussions the inhibition mechanism of Lawsonia, Ficus and Opuntia extracts on the surface of C-steel, nickel and zinc, respectively. The adsorption behavior of all the tested natural extracts on the surface of the different electrodes in different aqueous media (acidic, neutral and alkaline) follows the Langmuir adsorption isotherms. This result revealed that, the inhibition of corrosion process occurs *via* adsorption. In addition, the inhibition process occurs by forming insoluble complexes in the state of Lawasonia and Opuntia, which form a barrier between the surface of the metal and the medium. The complexes are formed as a result of interaction between the metal cations and lawson or opentiol.

The following remarks could be withdrawn from the obtained data:

1- All extracts of the natural products of Lawsonia, Ficus and Opuntia were found to be effective inhibitors on the corrosion of C-steel, nickel and zinc elecrodes in different tested media.

2- The values of inhibition efficiency (IE) generally increases with increasing the concentration of all the tested extracts in different aqueous media. The values for IE of Lawsonia extract have the maximum IE of 95.78 % for C-steel corrosion in acidic medium. Ficus have the maximum inhibition for nickel corrosion of 95.70 % in alkaline medium. Opuntia have the maximum inhibition for C-steel corrosion reaches 97.06 % in acidic medium.

3- The obtained results suggest that the tested natural extracts act as mixed inhibitors.