Summary

The corrosion is a great problem, which faced the world, we can not hide this problem from our live but we can reduce it by several methods as the environment need. This work discusses the corrosion inhibition of carbon steel in 1M HCl solution by novel gemini surfactants.

This work contains three chapters:-

Chapter 1: "Introduction"

Which including that:-

An introduction about surfactant (definition, classification and applications), An introduction about corrosion (definition, forms and inhibition), A literature survey on the previous studies on corrosion inhibition of carbon steel in aqueous solution is given.

Chapter 2: "Materials and experimental techniques"

The experimental part includes complete description of synthesis of inhibitors used, preparation of solution, carbon steel electrode pretreatment, electrolytic cell working procedures, weight loss measurements, and electrochemical measurements. e. g. potentiodynamic polarization and A.C. impedance techiques.

Chapter3: "Results and discussion"

This chapter included the following parts:-

1-Preparation of surfactants

Cationic gemini surfactants were prepared by, a reaction of different alkyl halides (octyl-, decyl-, and dodecyl bromide) with p-N,N-dimethylamino-benzaldehyde to give p-N,N,N-alkyldimethylammonium bromide benzalde- hyde. Then refluxed in ethanol with benzene-1, 4-diamine (p-phenylidenediamine) to produce p-(N,N,N-alkyldimethylammonium bromide)benzylidene)benzene-1,4-diamine.

2- Characterization of the synthesized surfactants

The chemical structures of the prepared surfactants were confirmed by the FTIR and ^{1}HNMR spectra.

All prepared compounds have the same signals. The only difference between the signals of these compounds is the signal intensity of methylene proton.

3-The prepared compounds were tested as corrosion inhibitors using three techniques.

a) Weight loss measurements

The data reveals that, the inhibition efficiencies for all prepared cationic gemini surfactant compounds increase with increasing their concentration. The inhibition efficiencies decrease in the temperature rang (30-40ºC) and increase in the temperature rang (40-60ºC).

b) Potentiodynamic polarization measurements

The data reveals that, all prepared surfactants slightly shifted E_{corr} to more negative potential and also the values of I_{corr} decrease including both anodic and cathodic Tafel slopes β_a, β_c in the presence of the prepared surfactants and this confirms that surfactants act as mixed type inhibitors. The inhibition efficiency increased with inhibitor concentration increment. This fact suggests that the inhibitor compounds may first be adsorbed on the steel surface and cover some sites of the electrode surface.

c) Electrochemical impedance spectroscopy (EIS)

The data reveals that the increase of polarization resistance and decrease of the pseudo capacity with increasing inhibitor concentration indicates that these compounds have the ability to inhibit the corrosion rate of carbon steel in according to adsorption mechanism (formation of a surface film).

The percentage inhibition efficiency increases by increasing the alkyl chain in the surfactant. The values of inhibition efficiency obtained from the weight loss measurements are in good agreement with those obtained from potentiodynamic polarization method and electrochemical impedance spectroscopy (EIS).

The values of activation energy (E_a) were calculated from Arrhenius equation. The data reveals that, the activation energy decrease in the presence of cationic gemini surfactants which indicates that chemical adsorption (strong adsorption of surfactant molecules on the metal surface).

The change in enthalpy and entropy of activation values (ΔH^*, ΔS^*) were calculated from the transition state equation

The adsorption of these cationic gemini surfactants on the carbon steel surface obeys the Langmuir adsorption isotherm.

Thermodynamic parameters for adsorption process such as free energy (ΔG_{ads}) enthalpy (ΔH_{ads}) and entropy (ΔS_{ads}) for the prepared surfactants were determined.

The negative values of ΔG_{ads} indicating that, the adsorption of surfactants on the metal surface is spontaneous process. All prepared surfactants have positive sign of ΔH_{ads} indicating that the adsorption of prepared surfactants on the carbon steel surface in 1M HCl solution is endothermic process. The positive sign of ΔS_{ads} attributed to the increase of disorder due to the adsorption of only one surfactant molecule by desorption of more water molecules.

d) Scanning electron microscope (SEM)

The data reveals that, the surface of carbon steel was strongly damaged in absence of cationic gemini surfactants but in the presence of these compounds the surface is free from pits and it is smooth which indicates a good protective film present on the steel surface and also

confirms the highest efficiency of the prepared surfactants at 5 $x10^{-3}$ M concentration.

e) **Surface tension (γ)**

The data reveals that the values of surface tension decreases as the activity (concentration) of cationic gemini surfactants increases.

The values of effectiveness ($\Pi_{CMC)}$, Maximum surface excess (T_{max}) and the minimum surface area (A_{min}) were calculated. The data reveals that the most effective surfactant is one that gives the greater lowering in surface, by increasing the hydrophobic character of the cationic gemini surfactants shifts Γ_{max} to lower concentrations and the minimum area per molecule at the aqueous solution/air interface increases with increasing length of the hydrophobic part.

Specific conductivity (K) measurements were performed in order to evaluate the CMC and the degree of counter ion dissociation, β. The data reveals that the degree of dissociation increases by increasing carbon chain length.

The values of standard free energy (ΔG_{mic}) were calculated. The data reveals that the standard free energies of micellization for the synthesized surfactants are always negative, indicating that the micellization is a spontaneous process.