ABSTRACT

Corrosion is a natural process driven by energy consideration. Inhibition is a preventive measure against corrosive attack on metallic materials. Hydrochloric, sulphuric and phosphoric acids are most commonly used acids in pickling baths to remove the metal oxides formed on the surface. Inhibitors are used in industrial processes to minimize both the metal loss and acid consumption.

The corrosion inhibitive properties of the fruit peel, flower and bract extract of *Musa acuminata* were studied on mild steel in 1N hydrochloric, sulphuric and phosphoric acid media. The phytochemical components like tannins, flavonoids, saponins, alkaloids and phenols present may be responsible for exhibiting anti-oxidative activity.

The weight loss method was conducted using various concentration of the inhibitors (0.05% - 2.0% v/v). The parameters like inhibitor efficiency, corrosion rate and surface coverage were calculated. The effect of temperature was studied by varying the temperature from 303 K–353 K. The activation energy (E_a), free energy of adsorption (ΔG_{ads}), enthalpy of adsorption (ΔH_{ads}) and entropy of adsorption (ΔS_{ads}) were calculated for inhibited and uninhibited systems.

The results show that there is a decrease in the corrosion rate with increase in the inhibitor concentration from 0.05% to 2.0% at room temperature for all immersion periods which is attributed to the adsorption of

plant constituents on the surface of mild steel which makes a barrier for mass and charge transfers and protects further attack by the acid. The inhibition efficiency increases up to 5 hours and decreases thereafter. The effectiveness of the inhibitor was studied at various temperatures from 303 K – 353 K for various concentrations of plant extracts in the respective acid for one hour, and the results were analysed. The data revealed that the presence of inhibitor leads to a decrease in the corrosion rate. It was observed that the inhibition efficiency increased up to 313 K and decreased thereafter. With increase in temperature, the equilibrium between adsorption and desorption processes shifts, leading to a higher desorption rate than the adsorption until the equilibrium is again established. This explains the lower protection efficiency at higher temperature especially for lower concentration of the inhibitor.

The surface coverage (θ) values evaluated using corrosion rate values from the weight loss method for different inhibitor concentrations were found to obey Langmuir and Temkin adsorption isotherms. The apparent E_a values showed an increase in activation energy for inhibited acid compared to uninhibited acid and increased with increasing inhibitor concentration. This suggested that, the presence of reactive centres on the inhibitor block the active sites on the metal for corrosion resulting in the decrease in corrosion rate. The hindrance to dissolution is due to the formation of Fe-plant extract layer by the interaction of the inhibitor with the mild steel.

The low negative value of free energy of adsorption ΔG_{ads} with increase in temperature indicates the physical adsorption of inhibitor molecule on the metal surface which results from the electrostatic interaction between the charged centres of the molecules and charges on the metal surface. The decrease in the value of ΔG_{ads} shows the spontaneous adsorption of inhibitor on the mild steel surface in the three acids. The negative value of ΔH_{ads} and low value of ΔS_{ads} indicate physisorption by the inhibitor. The negative ΔH_{ads} value also indicates the exothermic nature of adsorption.

The electrodynamic parameters of the inhibitor such as corrosion potential E_{corr}, corrosion current density I_{corr}, anodic and cathodic Tafel slopes b_a and b_c in absence and presence of inhibitors were obtained. I_{corr} values of the inhibited acids are lower than that of the uninhibited acid, which indicates that the increase in corrosion inhibition property is due to increase in adsorption of inhibitor molecules on the electrode surface. Thus, as the concentration of the inhibitor increases, there is a regular decrease in I_{corr}, showing that the extract of *Musa acuminata* in the acid media acts as a very good inhibitor for mild steel. The lower I_{corr} values without causing any significant changes in the corrosion potential E_{corr} suggests that the inhibitor is a mixed type inhibitor and reduces both the values of b_a and b_c.

The impedance parameters were derived from the investigations for various concentrations of the inhibitor. The charge transfer resistance (R_{ct}) was calculated from the difference in impedance at lower and higher frequencies. It was noticed that the double layer capacitance C_{dl} decreases with increase in concentration of the inhibitor. The decrease in the C_{dl} values can result from a decrease in dielectric constant and / or an increase in the thickness of electrical double layer suggesting that the inhibitor molecules function by adsorption at the metal-solution interface. The charge transfer resistance values for the mild steel increases with increase in the concentration of the inhibitor indicating that the increase in concentration of plant extract decreases the corrosion rate. The Nyquist plot for various concentrations of the inhibitor in the acid media shows that the diameter of the Nyquist plot is semicircular in appearance and increases with increase in the concentration of the plant extracts. This suggested that the formed inhibitive film is strengthened by the increase in the concentration of plant extract.

The comparison of the images obtained from scanning electron microscopy (SEM) revealed that the plant extract molecules of the inhibitor are adsorbed on the metal surface, thereby decreasing the corrosion of the metal surface. EDX and FTIR spectra show that the inhibitor layer contains compounds present in the plant extract giving a strong evidence for the interaction between the metal and the functional groups such as OH, NH_2 and C=O leading to the formation of film of large surface coverage which serves as a barrier between the corrosive acid medium and the metal thereby inhibiting corrosion.

An attempt has also been made to study the possible use of plant extract on corrosion protection in industries. The extent of corrosion and protection by inhibitor were assessed by visual observation. It was found that there was large reduction in the evolution of hydrogen and acid mist formation.

From the above study, it can be concluded that the plant extract under study could act as good pickling inhibitor and create an ecofriendly environment in the industry.