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Corrosion Inhibition of Mild Steel by using Banana Peel Extract

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Abstract

Corrosion is the deterioration of metal by chemical attack or reaction with its environment. It is a continuous problem, difficult to eliminate completely. The cost of metallic corrosion to the total economy is in billions of rupees per year. The inhibiting action of the banana peel extract as a corrosion inhibitor in controlling corrosion of mild steel in 0.1M HCl solution was studied. Corrosion inhibition was identified by employing weight loss measurements and electrochemical techniques. Five samples of mild steel specimen were taken and they are subjected to varying concentration of banana peel extract solution for analyzing the inhibitory properties. The protective film has been analyzed using FTIR spectroscopic techniques. The results indicated that the corrosion rate is decreasing as the concentration of banana peel increases and simultaneously it enhances the inhibition efficiency of the mild steel.

Key words: Mild steel, Banana peel extract, Corrosion inhibition, Corrosion rate, Weight loss measurements, Electrochemical techniques.

1. Introduction

Mild steel founds its applications in the field of construction in wide range of industries due to its high strength and availability at low cost. The main setback for mild steel is its tendency to corrode easily in an acidic environment. Inorganic acids like HCl and H_2SO_4 are used for drilling, fracturing and acid stimulations at various stages in oil exploration, production and/or descaling operations, which leads to a significant amount of corrosion. Several protective measures are to be taken. One of them is being the use of corrosion inhibitors. Corrosion inhibitors are surface active compounds that are added in small quantities to stop metal dissolution by a corrosive environment. Corrosion inhibitions by organic compounds are widely used in industries. Most organic inhibitors control corrosion by adsorption of inhibitor molecules on the metal surface forming thin films. The use of inhibitors is one the most practical methods for the protection of metals in acidic media. However, most of organic inhibitors are harmful and toxic to the environment. This has led to the need for natural products which are eco-friendly and harmless. Several investigators have reported the use of natural inhibitors, which were extracted from plant leaves or seeds. [1]. Taleb H. Ibrahim et al. investigated about the corrosion of mild steel using Potato Peel Extract in 2M HCl by weight loss and electrochemical techniques. It was observed that the increase in the inhibition efficiency with increasing potato peels extract concentration. A reasonable corrosion inhibition level was obtained at a concentration of 50 ppm at higher temperatures (>70% inhibition efficiency) [2]. S.A.Umoren et al. found that corrosion of mild steel using leaf and stem extracts in 1 M H_2SO_4, there is a significant corrosion inhibition and the inhibition increases with increase in concentration of leaf and stem extracts [3]. Deepa Rani.P et al. identified corrosion inhibitor and reported its inhibiting properties by weight loss measurements at various times and temperature. The inhibition efficiency is markedly higher in a Natural sea water environment with the addition of Emblica officinalis leaves extract compared with those in the inhibitor free solution. The inhibition efficiency increased with increase of inhibitor concentration [4]. M.S.Al-Otaibi et al. tested the Corrosion inhibitory action of some plant extracts on the corrosion of mild steel in acidic media. Using polarization studies, it was found that the extracts of A. Sieberi, T. Auriculatum, C. Tinctorius, L. Shawii and O. Baccatus plants serves as an effective green corrosion inhibitors for mild steel in 0.5M HCl media [5]. A.Anejjar et al. found the Inhibition of carbon steel corrosion in 1M HCl medium by potassium thiocyanate. The inhibition efficiency of potassium thiocyanate (KSCN) depends on temperature and increases with increasing of the KSCN concentration[6]. Aprael S. Yaro et al. demonstrated the Apricot juice as green corrosion inhibitor of mild steel in phosphoric acid. The maximum corrosion inhibition efficiency of apricot juice on mild steel is 75% at 30°C. From Statistical analysis, it was identified that the corrosion rate depends on temperature, inhibitor concentration and the combined effect of these two parameters [7]. DeepaPrabhu et al. studied about the Corrosion behavior of 6063 Aluminium alloy in acidic and in alkaline media. The corrosion rate was increased by the following factors: Increase in the temperature, Increase in concentration of sodium hydroxide medium and phosphoric medium. Sodium hydroxide medium induces more corrosion on 6063 Aluminium alloy than the phosphoric acid medium [8]. Mahmoud N. EL-Haddad et al. tested the use of Hydroxyethylcellulose as an eco-friendly inhibitor for 1018 c-steel corrosion in 3.5% NaCl solution. Corrosion inhibition decreases when the temperature increases for 1018 c-steel in 3.5% sodium chloride solution by hydroxyethylcellulose [9]. E.Uwahl et al. found out the

Inhibitive action of ethanol extracts from Nauclealatifolia on the corrosion of mild steel in H_2SO_4 solutions and their adsorption characteristics. The inhibition efficiency was directly proportional to the concentration and inversely proportional to the temperature [10]. K. K. Alaneme et al. analyzed the Corrosion inhibition and adsorption mechanism studies of Hunteria umbellata seed husk extracts on mild steel immersed in acidic solutions. The effect of corrosion inhibition of mild steel increases with increase in extract concentration of H.umbellata seed husk in 1M HCl and 1M H_2SO_4 and reduces with increase in temperature [11]. I. Adejoro et al. evaluated the Corrosion inhibition potentials of ampicillin for mild steel in hydrochloric acid solution. It is noted that an antibiotic drug Ampicillin behaves as a good inhibitor for mild steel in acid medium. The inhibition efficiency is directly proportional to the concentration of ampicillin and indirectly proportional to the temperature. This gives the highest inhibition efficiency 0f 75.85% in the concentration of 5×10^{-3}M at 30°C [12].

In the present study, the inhibition of corrosion of mild steel in 0.1M HCl aqueous solution by banana peel extract was investigated using weight loss method and electrochemical measurements such as linear polarization resistance (LPR). The inhibitor active components within the banana peel extract were investigated using FTIR.

2. Experimentation

2.1. Preparation of Banana Peel Powder

Banana peel was cut into small sizes of 2 – 3 cm and cleaned with water. To remove the moisture content, the banana peel was exposed to sunlight for 7 days and dried in hot air oven for 2 hours at 100°C. Finally it was heated to 300°C in the furnace for 30 minutes. Then the heated peel was grinded to fine powder.

2.2. Preparation of Extract Solution:

10g of banana peel powder was taken and mixed with 170 ml of distilled water. The banana peel powder was refluxed to make the extract solution for coating. The powdered sample was refluxed in distilled water at 80°C, until 70 ml of extract solution was obtained. The extract solution was poured in Petri Disc. The function of Petri Disc is to transfer the solution from liquid to solid state. The obtained powder was taken and kept open in atmospheric conditions for three days.

2.3. Specimen Preparation:

Mild steel C1018 has the composition of (0.20% of Mn; 0.9% of Ni; 0.022% of P; 0.004% of S; 0.05% of Si and the balance is iron) was chosen for the study. The specimen size for the corrosion inhibition coating was 1.0 cm * 4.0 cm * 0.2 cm and a surface area of 15.9 cm^2. The specimen surface was cleaned and polished with different grades of emery paper. The specimens were degreased using ethanol, followed by immersion in nitric acid solution for two minutes to activate the surface. Afterwards, the surface was washed using doubled-distilled water, followed by rinsing with acetone. Acetone is a polar substance that dissolves almost all organic compounds. Finally specimens were dried and weighed.

2.4. Corrosion Inhibition Process:

20 ml of distilled water was mixed with 2 mg of extract powder to get 200 ppm of extract solution. Similarly the various concentrations of extract solution ranging between 100 - 500 ppm were prepared. The corrosion inhibited specimen was prepared by dip coating method. The mild steel specimen was dipped into the extract solutions in a beaker and covered with aluminium foil for seven days at atmospheric conditions. After the seven days, the inhibited specimen was taken out and gently rinsed with distilled water. Finally, it was dried and weighed. The weight of the specimen increases due to the coating of concentration solution.

2.5 Testing Methods:

2.5.1 Weight Loss Method:

Pre-weighed mild steel specimens were immersed in 250 ml of 0.1M HCl solution. The specimens were left immersed for 24 hours in a temperature of 25°C. Before taking weight-loss measurements, the metal specimens were washed with doubled-distilled water, immersed in 20% H_2SO_4 for 1 minute, washed thoroughly with water and ethanol, and then dried before reading their weights. Inhibition efficiency was calculated using the following relationship,

$$\text{Inhibition Efficiency (\%)} = = \frac{W_0 - W_1}{W_0} \times 100$$

Where, W_0 - Weight of the mild steel specimen without banana peel coating, W_1 - Weight of the mild steel specimen with banana peel coating.

2.5.2 Corrosion Rate

Corrosion rate (CR) was calculated by assuming uniform corrosion over the entire surface of the specimens. Corrosion rate determination (the rate at which a given metal &/or alloy) in a specific environment is of fundamental importance in corrosion Engineering. The corrosion rate in millimetre per year (mm/y) was calculated from the weight loss method, using this formula,

$$\mathrm{CR} = \frac{W}{(\mathrm{D}\times\mathrm{A}\times\mathrm{t})} \times \mathrm{K}$$

Where, W – weight loss in grams, K – constant (87.6), D – metal density in (g/cm^3), A – Specimen area ($inch^2$), T – time (hrs).

2.5.3 Electrochemical Corrosion Test

Electrochemical corrosion testing measures and/or controls the potential and current of oxidation/reduction reactions. The cell was filled with 600 ml of 2M HCl. The Gill AC Potentiostat supplied by ACM Instruments was used for the electrochemical measurement test. The electrochemical test was performed on inhibited specimens of banana peel extract concentrations ranging from 100 to 500 ppm. For the linear polarization resistance (LPR) test, the start potential was 10 mV, and the finish potential was -10 mV with respect to the open circuit potential. In actual practice, the polarization curve becomes linear on a semi logarithmic plot, at approximately 50 mV more active than the corrosion potential. This region of linearity is referred to as the Tafel region. To determine the corrosion rate from such polarization measurements, the Tafel region is extrapolated to the corrosion potential. At the corrosion potential, the anodic and cathodic reaction rate is equal and this point corresponds to the corrosion rate of the system expressed in terms of current density.

2.5.4 FTIR Spectroscopy

A Small portion of Banana peel extract was left to air dry overnight followed by complete drying in a vacuum oven. A KBr pellet was made from the dry extract and characterized by a Bomem MB-3000 FT-IR equipped with ZnSe optics and a DTGS detector. Spectrum was obtained at 4 cm^{-1} resolution and 200 scans. The FTIR spectrum of the natural banana peel sample was determined to identify carboxyl and hydroxyl groups present in it.

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3. Results and Discussion

3.1 Characterization of Banana Peel Powder:

FTIR spectroscopy of banana peel powder was obtained by using (Perkin Elmer System 2000) spectrometer under ambient conditions. The C=C stretching frequency has decreased from 1638 cm^{-1} to 1626 cm^{-1} , ring "O" stretching frequency has shifted from 1051 cm^{-1} to 1105 cm^{-1} , NH stretching frequency has decreased from 3435 cm^{-1} to 3412 cm^{-1} .

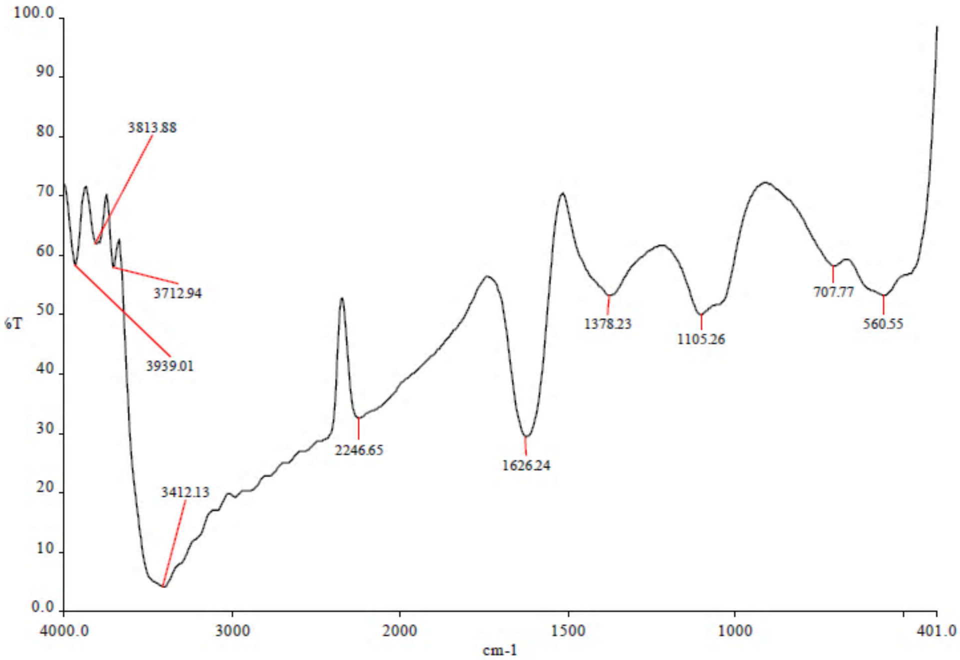

Figure. 1 FTIR image of Banana Peel Powder

Figure. 1 indicates that the Nitrogen atom of NH group has coordinated with Fe^{2+} formed on the metal surface resulting in the formation of Fe^{2-} BPE complex on the metal surface.

The adsorption characteristics of these materials are mainly due to the presence of hydroxyl groups and carboxyl functions present on pectin substances. The characterization results showed that banana peel act as a bio-sorbent having very high specific surface area, potential binding sites and functional groups.

3.2. SEM Image of Banana Peel Powder:

The banana peel powder structure was observed using scanning electron microscopy as shown in Figure. 2. The peel has an irregular and porous surface. The many pores on its surface support the adsorption process.

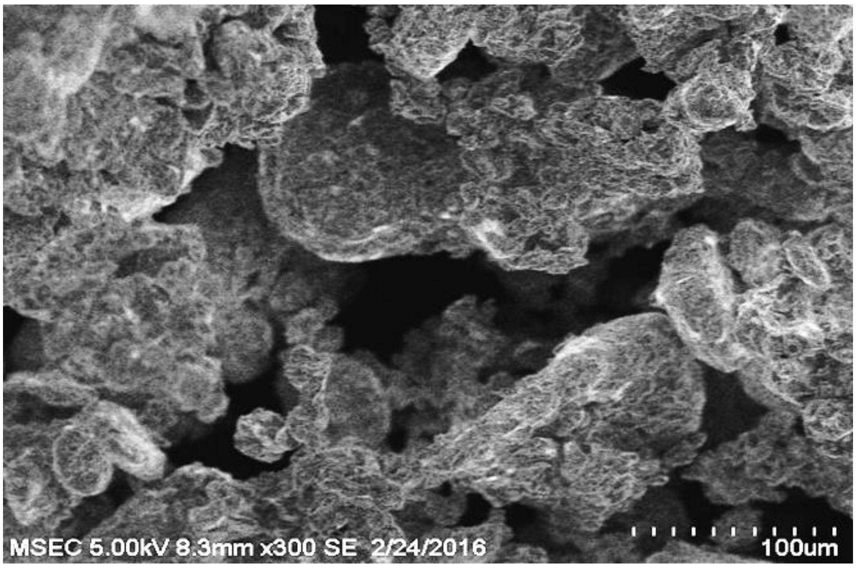

Figure. 2 SEM image of Banana Peel Powder

3.3 Weight Loss Measurements:

In the specimens, the banana peel extract concentration was varied from 100 ppm up to 500 ppm. Graph for the Inhibition efficiency of mild steel versus the concentration of extraction solution was plotted, as shown in Figure. 3. The inhibition efficiency of mild steel increases with the increase in extract solution concentrations.

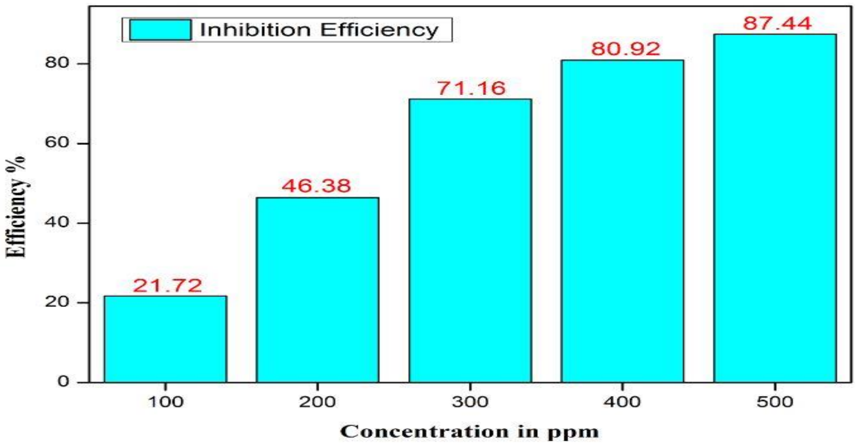

Figure. 3 Inhibition Efficiency Vs Extract Solution Concentrations

3.4 Corrosion Rate:

The Corrosion rate was calculated using weight loss method. Relationship between Corrosion rate and the concentration of extract solutions was plotted as shown in Figure. 4. It infers that the corrosion rate of mild steel decreases as the banana peel concentration goes on increasing from 100 – 500 ppm.

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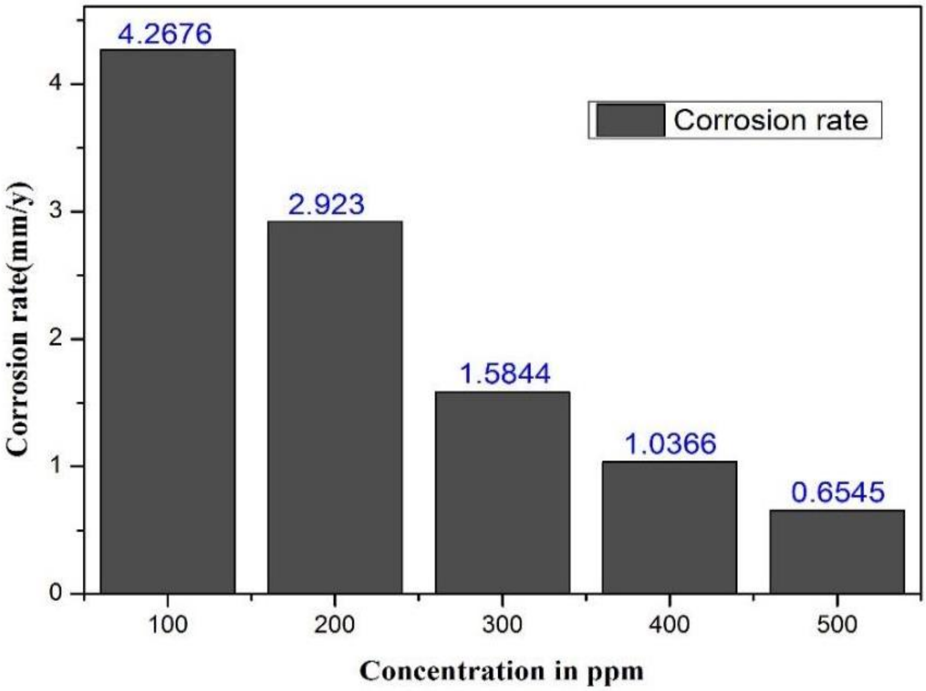

Figure. 4 Concentration of Extract solution Vs Corrosion rate

3.5 Comparison of Inhibition Efficiency and Corrosion Rate

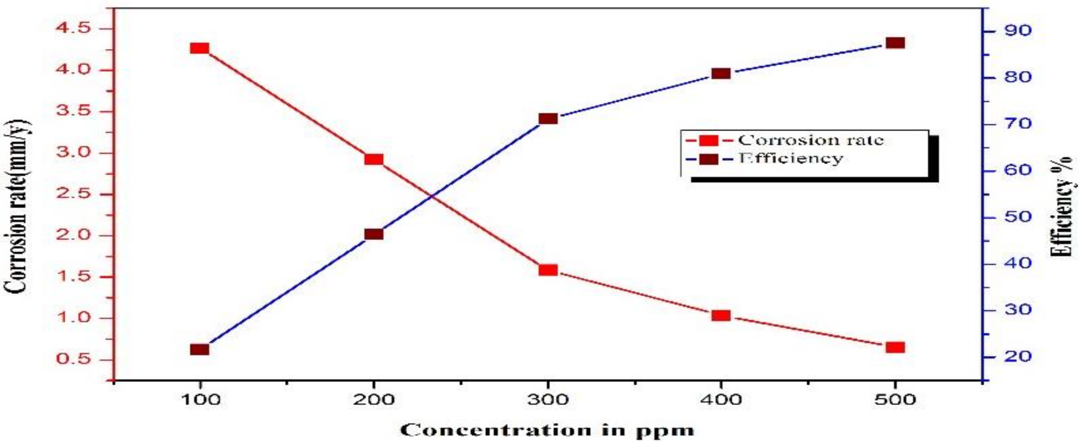

Figure. 5 Concentration of Extract solution Vs Corrosion rate and Inhibition Efficiency

The inhibition efficiencies were calculated. Plot of Concentration of Extract Solution versus the Corrosion Rate and Inhibition Efficiency was created as shown in Figure. 5. The plot infers that the corrosion rate reduces as the concentration of extract solution increases from 100 – 500 ppm and the Inhibition efficiency increases with the concentration of extract solution increases from 100 – 500 ppm. Concentration of extract solution is directly proportional to the Inhibition efficiency and inversely proportional to the Corrosion rate, up to 500 ppm.

3. 6 TAFEL Potential Graph:

Corrosion inhibition property of the uncoated and coated mild steel was studied from the electrochemical polarization studies. The electrochemical polarization studies were tested by measuring the electrode potential of un-coated and coated mild steel specimen by immersing in 3.5% NaCl solution for about one hour.

Uncoated mild steel specimen exhibits E_{corr} value at -0.6741V versus Ag/AgCl. It shows that the mild steel corrosion potential is higher negative potential. For the coated steel specimens, the corrosion potential shifts (E_{corr} value at -0.5852V versus Ag/Agcl) to positive side. Tafel potential graph was plotted for the un-coated mild steel and coated mild steel specimens of extract solution concentrations varying from 100 - 500 ppm as shown in Figure. 6.

The shifting of magnitudes in Tafel plot describes about the substantiate corrosion protecting ability of the coated specimen, when compared with the uncoated specimen. These results clearly infer the fact that the banana peel extract possess excellent corrosion protecting ability.

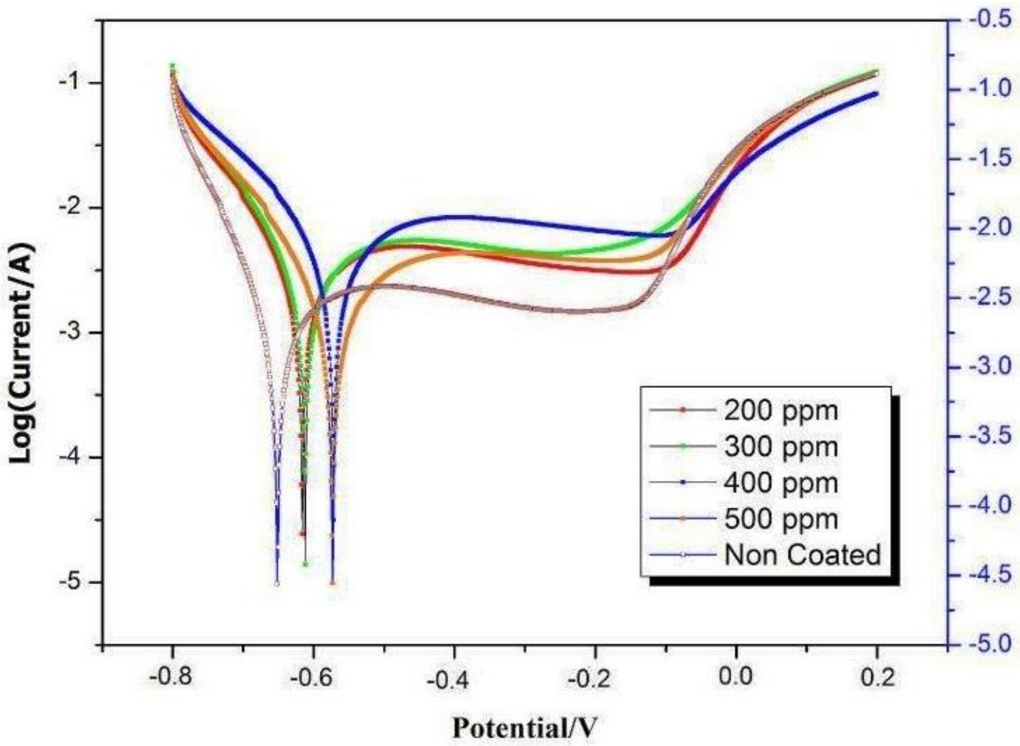

Figure. 6 Tafel Potential Graph for uncoated and coated specimens

4. Conclusions

Mild steel was coated with banana peel extract powder for corrosion inhibition. The inhibition efficiency of mild steel in 0.1M HCL increases with the increasing in concentration of banana peel inhibitor. Inhibition efficiency up to 87% was achieved. Comparison of the analysis of corrosion inhibition has been carried out by using both weight loss and electrochemical method. The results indicated that the corrosion rate decreases, as the concentration of banana peel inhibitor increases and simultaneously it enhances the inhibition efficiency of the mild steel.

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