



Corrosion

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Corrosion Inhibition by Turmeric Extract

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ABSTRACT

The inhibition effect of turmeric extract on Cu corrosion in 0.5N HCl acid has been studied by impedance, Polarisation, Cyclic-Voltametry and FTIR techniques between the 303K to 333 K. The inhibition efficiency increased with the concentration of turmeric extract. The corrosion rate increased with the increase in temperature and it reduced when the extract is merged in solution. The adsorption of extract on metal surface is obeying Langmur's and Temkin's isotherm. The thermodynamic data and results of other technique found that the rate of corrosion is reduced.

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Introduction

HCl acid is a major chemical which has manu use in industries and cleaning product, especially in the cloth and removal of scale from boiler. Generally 11N acid destroys the metal and alloys which used in tank and boiler, the data has been published about the resistance of these materials to corrosion by the HCl solution¹⁻⁴.

The most of studies were focused on the inhibition of Cu and Al in HCl acid using organic compounds containing nitrogen, sulphur, and oxygen atoms as corrosion inhibitors⁵⁻⁶. The corrosion inhibition properties of these organic compounds due to the pai electrons and moleculer structure of compound.

The inhibitors and synthetic inhibitors are toxic in nature and harmful for the environment therefore it necessary to develop rnviromentally acceptable and low cost inhibitors in this term turmeric is best inhition product against the corrosion of metal because turmeric have tannins and terpins and other phytochemicals which is known for the mediclinical properties like antiseptic, antibacterial, antioxidant and most likely corrosion inhibition.

So, in this present study and investigation, the corrosion of Cu in 0.5N HCl solution in presence and absence of turmeric extract at different temperature has been studied by electrochemical and spectral technique. It aimed to predict the corrosion rate and inhibition efficiency of inhibitor on the metal.

Specimens

Cu specimens were cut to size of 4.5 x1cm x0.2cm were prepared by polishing with 600 grit silicon carbide paper, rinsed with distilled water and finally dried in a stream of air.

Preparation of plant extract

The extract of turmeric is prepared by the root of Turmeric which dried in air and grained. The 50 gm powder subjected to the soxhlet extraction using 80% methanol, the solvent can be removed by boiled at constent temperature at 55 °C in vacuume evaporator, and finally the residue of Turmeric was collected. All the solution is prepared with AR grade chemicals in double distilled water.

Experimental:

Technique of AC Impedance Method

Corrosive media used were 0.1M KCl and NaF. The pH of solution was adjusted to different range values from pH 2, pH 4to pH 9.5 by adding dilute HCl and NaOH solutions. The N₂ gas was constantly purged to maintain deaerated condition. Metal electrode was than immersed in the sealed cell containing the test solution. A saturated calomel electrode and platinum electrode were used as reference and counter electrodes, respectively. AC measurement was carried out after 1 hour, when a constant potential was attained. The slope, $\Delta E/\Delta I$, at the corrosion potential, is defined as polarization resistance, R_p if we defined the constant B as:

$$B = b_a b_c / (2.3(b_a + b_c)) R_p$$

Were b_a and b_c are the Tafel slopes determined from E Vs $\log_{10} I$ plot.

The corrosion current density is given by:

The electrochemical *impedance* measurements were performed under the response analyzer, Solartron 1250 and 1287electrochemical interface using small amplitude sine wave signals, 10mV, over the 1 kHz frequency range of 1 kHz to 1 MHz with 5 points per decade. This tourniquet is based on the theories that describe the response of a circuit to an alternating current or voltage as a function of frequency.

Potentiometry method

The electrochemical *potentiostatic polarization* measurements were performed under the response analyzer, Solartron 1250 and interface using small amplitude sine wave signals, 10mV, over the 1 kHz frequency range of 1 kHz to 1 MHz with 5 points per decade. This tourniquet is based on the theories that describe the response of a circuit to an alternating current or voltage as a function of frequency at different temperature.

Cyclic-Voltametry

Voltammograms were obtained using a PAR Model 273 Potentiostat fitted with current interrupt and positive feedback iR compensation. The cell, consisted of a cell body (containing

approximately 200 mL of electrolyte) fitted with a lid. The working electrode was a cement-coated iron wire. Four platinum wire counter-electrodes were held in fritted glass compartments, which were placed in an equidistant configuration around the centrally located working electrode to provide uniform radial current distribution along the length of the working electrode. Electrical contact with the saturated calomel reference electrode was maintained via a luggin capillary shield. The cell was maintained at $25.0 \pm 0.28^\circ\text{C}$ using a recirculating water bath.

Chloride determinations were carried out using static mercury drop polarography. Loss on ignition was determined using either a muffle furnace or a thermogravimetric analyzer.

FTIR Analysis

BRUKER Alpha FTIR modal was used in this analysis, the electrochemical solution is analysed.

Results and discussion

Impedance Analysis

Figure 1.1.1 shows the Nyquist and Bode plots of the metals in deaerated 0.1M KCl at 40°C . In this plot the imaginary component (Z) is taken against the real-component at each frequency. Here, frequency is increased in counter clockwise direction. At high frequencies, impedance was almost entirely created by the solution resistance, R_s , while at low frequencies; the impedance was almost entirely created by the combined polarization resistance and solution R_s , R_p . The $|Z|$ Vs f plot also gave a value of R_s and R_p . The value of $|Z|$ is the high limiting value; R_p is the difference between low frequency limit and high frequency limit.

There was no variation and effect of R_s when the speed of rotation increased; this behavior indicates that the corrosion rate of reaction is strongly controlled by diffusion through a fluid boundary layer of inhibitor. Fig.2 shows the Nyquist and Bode plots of metal in deaerated 0.1M KCl solution at 40°C and pH 9.5. These results also revealed.

The comparison in AC spectrum between pH 4 and pH 9.5 are correlated by Fig.3. The analysis of impedance plot, through fitting results, is indicative that the equivalent circuit at pH 9.5 gave a better fitting of two circuits.

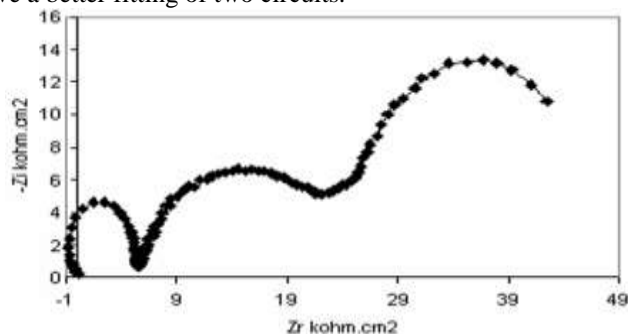


Figure 1.1.1: Nyquist plots of metal in deaerated 0.1M KCl solution at 40°C .

A parallel combination of capacitance and resistance as a series to the circuit of cathodic branch as a charge transfer resistance, with parallel charge transfer resistance-diffusion impedance for the anodic branch, the circuit after solution resistance is attributed to the passive film, which is found by the inhibitor on the metallic surface. This is the entire conclusion summarized in Table 1.1.1, and Table 2. The impedance diagram obtained for the Cu in 0.5 N HCl in the presence of the Bixin inhibitor are depicted in Figure 1.1.1 to 1.1.4. They are perfect semicircles and this was attributed to charge transfer reaction. Impedance parameters derived from the Nyquist plots

are tabulated in Table 1.1.1 to 1.1.2. It can be seen that as the concentration of inhibitor increases, C_{dl} value also decreases in the value of C_{dl} , result of molecules function by adsorption at the metal-solution interface.

All the analysis earlier reported by the El-Etre A Y, *J Colloid Interface Sci.*, (2007), Chetouani A, Hammouti B and Benkaddour M, *Pigment & Resin Technology*, (2004) Pandian Bothi Raja and Mathur Gopalakrishnan Sethuraman (2008) and Ferreria E.S., Giacomelli C., Giacomelli F.C., and Spinelli A., (2004).

Table 1.1.1 Corrosion inhibition parameter for the Cu.

Inhibitor concentration/ppm	E_{corr} mV (-ve)	I_{corr} mA/cm ²	(b_a)	(b_c)	IE %
Termeric					
00	280	12.89	296	768	
50	61	6.56	199	546	49.1
100	52	4.123	199	505	68
200	48	2.68	167	398	79.2
300	29	1.123	156	368	91.2
400	18	1.124	178	340	91.5
600	12	0.224	159	329	98.5

The Nyquist representation of the impedance behavior of Cu in 0.5N HCl solution with and without the turmeric extract shown in Figure 1.1.1 to 1.1.4. The existence of a single semicircle shows the presence of single charge transfer process during corrosion which was unaffected by the presence of inhibitor molecule.

The slightly depressed nature of the semicircle, which has the center below the x-axis, is the characteristics for the solid electrodes and such frequency dispersion has been attributed to roughness and other electrode. The charge transfer resistance (R_{ct}) and the interfacial double layer capacitance values were derived using the equivalent shown in Figure 1.1.1 to 1.1.4. The value of R_{ct} is increased from 32.8 to 458.6 Ωcm^2 . With the decrease in CPE value from 7.78×10^{-5} to $2.1 \times 10^{-5} \mu\text{Fcm}^2$ for the Bixin and similarly for the other inhibitors, variation in these values is similarly shown in Tables 1 and 2. All the data show that the inhibition of Cu corrosion made by using plant extract inhibitors show good results and percent efficiency order of inhibitors can be given as such.

Table 1.1.2 Impedance parameter for Cu

Inhibitor	R_s Ωcm^2	R_{ct} Ωcm^2	CPE μcm^2	%IE
Termeric				
00	1.8	30.3	7.8×10^{-5}	-----
50	1.4	192	4.1×10^{-5}	84.21
100	1.1	240.3	4.4×10^{-5}	87.3
200	0.6	306.1	2.0×10^{-5}	90.16
300	0.4	368.1	2.2×10^{-5}	91.8
400	0.5	628.4	2.52×10^{-5}	95.2
600	0.2	621.2	2.52×10^{-5}	98.2

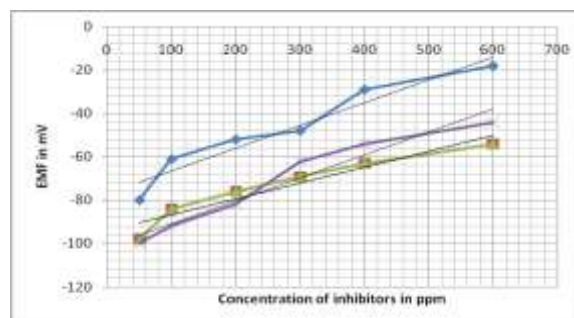


Figure 1.1.2: Change of EMF for Cu in inhibitors

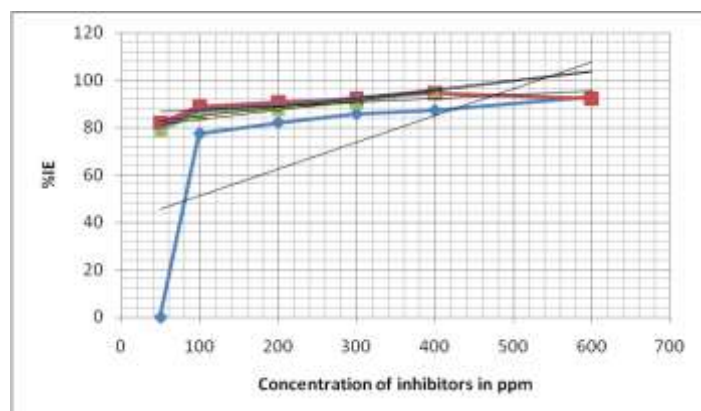


Figure 1.1.3 : Change of %inhibition for Cu with the concentration of inhibitors.

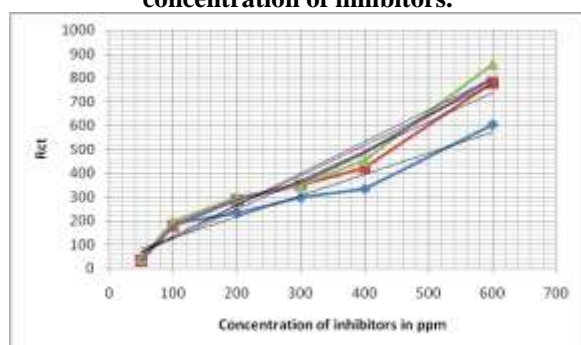


Figure 1.1.4: Change of resistance for Cu with the concentration

Potentiometry method

Polarization measurements were carried out in a conventional three electrode cell. Cu strip coated with the lacquer except for an exposed area of 1.2cm^2 were used as the working electrode. The saturated calomel electrode and Pt electrode were used as reference and counter electrode respectively. The BAS-300 instrument is used for the potential analysis at different temperature. The potential of the electrode measured with respect to SCE, Pt electrode was used as auxiliary electrode.

The potentiometry analysis of corrosion is recent method, in this analysis current density is analysed with the variation of potential for the Turmeric it found that the current density vary between 10^6 to 10^7 mA/cm² and potential -58 and -78 mV respectively.

The potentiogram showing that the turmeric is good inhibition tendency.

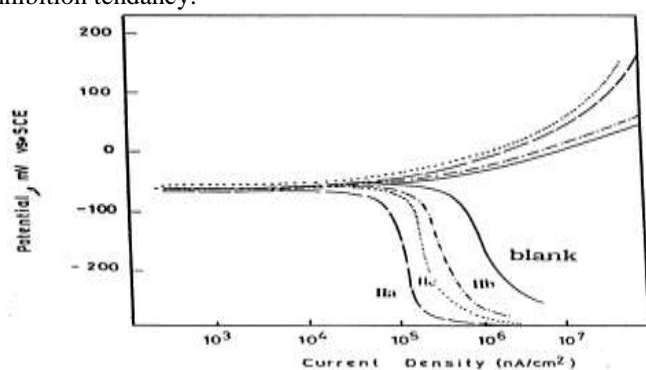


Figure 2.1.1: Potentiogram of Cu inhibition

Cyclic-Voltametry

The Cyclic voltametry measurement of corrosion inhibition determine by the ANOVA modal of instrument and during the analysis it found that the potential change with the Ag/AgCl

electrode between the -50mV to -145mV which reveal the inhibitor adsorbs over the metal surface given a tendency of inhibition.

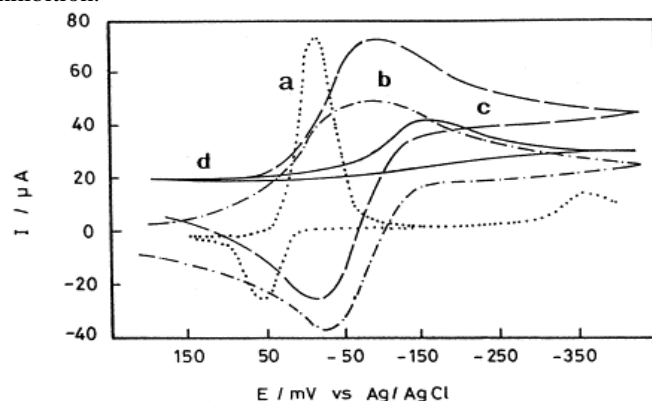


Figure 3.1.1: Cyclic Voltamgram of corrosion inhibition
FTIR Analysis

The peak values obtained from FTIR analysis are shown in figure 6,7, and 8. The broad peaks found in between 3325 cm^{-1} to 3350 cm^{-1} to the presence of suprafacial absorbed water, stretching mode of OH suprafacial of water, the stretching vibration of aliphatic C-H. The peaks at 1632 cm^{-1} to 1635 cm^{-1} found for the C=O stretching. The stretching frequency of C=O and C-O shift between 1732 cm^{-1} to 1735 cm^{-1} , the peaks between 750 cm^{-1} to 500 cm^{-1} is indication of formation of complex between the inhibitor and metal.

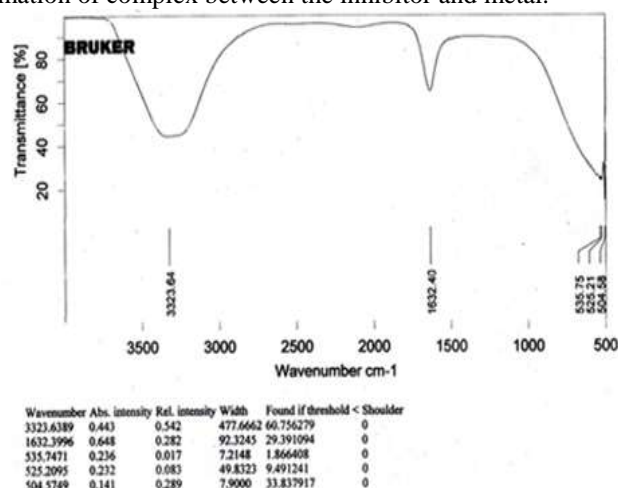


Figure 4.1.1: FTIR spectra of Cu corrosion without inhibitor

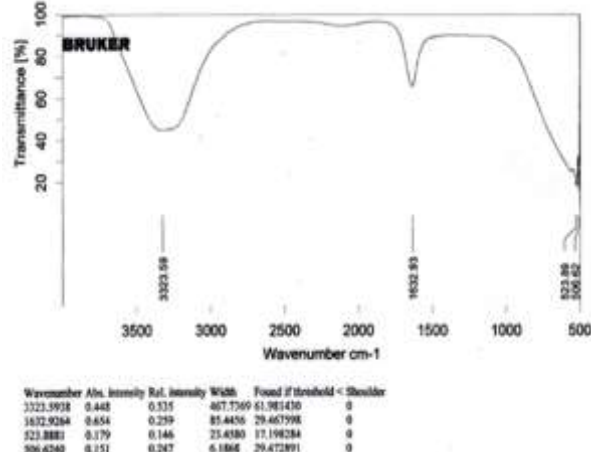


Figure 4.1.2 : FTIR spectra of Cu corrosion with Turmeric inhibitor

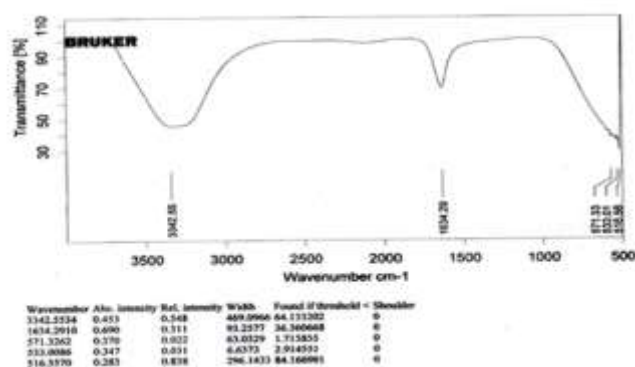


Figure 4.1.3 : FTIR spectra of Cu corrosion with Turmeric inhibitor after 24 Hr

Conclusions

1. The corrosion rate of Cu in 0.5N HCl decreased with the increasing of concentration of inhibitor.
2. The inhibition efficiency increased with respect to the concentration of inhibitor and decreased with rise in temperature.
3. LCR and CR circuit which using for the AC impedance technique reveled that the turmeric shows 98.16% inhibition efficiency.
4. The Potentiometry and polarization measurement shows that the Turmeric is very good corrosion inhibition efficiency.
5. The FTIR peaks and frequency band shows the corrosion efficiency of inhibitor.

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