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CORROSION ADSORPTION AND THERMODYNAMIC PROPERTIES OF WRIGHTIA TINCTORIA LEAVES OF MILD STEEL IN 1.0N HYDROCHLORIC ACID MEDIUM

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ABSTRACT

The adsorptive nature of Wrightia tinctoria leaves extract on mild steel in 1.0 N Hydrochloric acid environment contains various concentrations of inhibitor with different exposure time and temperature has been investigated by using mass loss measurements. The observed result reveals that the percentage of inhibition efficiency increased with increase of inhibitor concentration and temperature. It is exothermic, spontaneous and chemisorptions process. The inhibitor follows Langmuir adsorption isotherm. The corrosion product formed on the metal surface confirmed by the adsorption studies such as Temkin, frumkin flurry huggins Elawady and Frendlich adsorption isotherm.

Keywords: *Mild steel, Green inhibitor, Wrightia tinctoria, Adsorption, Concentration.*

I. INTRODUCTION

Mild steel, also known as plain-carbon steel, is now the most common form of steel because its price is relatively low, while it provides material properties that are acceptable for many applications [1]. However, the challenge is that it has low corrosion resistance especially in acidic environments [2]. Industrial processes such as acid cleaning, pickling, descaling, and drilling operations in oil and gas exploration use acidic solutions extensively and as such iron and steel vessels or surfaces used in these environments are prone to corrosion [3]. The use of many inorganic inhibitors, particularly those containing phosphate, chromate, and other heavy metals, is now being gradually restricted or banned by various environmental regulations because of their toxicity and difficulties faced in their disposal especially in the marine industry, where aquatic life is at threat [4]. Synthetic organic inhibitors have also been extensively applied but their use is now being marred by their toxicity and high cost of manufacturing. This has prompted researchers to explore other areas to produce eco-friendly, cheap, and biodegradable green corrosion inhibitors to replace inorganic and synthetic organic inhibitors. Natural products such as plant extract, amino acids, proteins, and biopolymers have been reported to be efficient corrosion inhibitors [5]. Plant extracts are viewed as rich source of naturally synthesized chemical compounds that can be extracted by simple procedures with low cost . These natural extracts are analogous to the synthetic organic inhibitors and are being proven to work as much as their synthetic counterparts. The heavy loss of metals is a result of its contact with the pollution environment can be minimized to a great extent by the use of corrosion inhibitors, using both organic and inorganic compounds. Some of few studies are Beet root, Saponin, Terminalia bellerica, Oxandra asbeckii, Argemone mexicana, Betanin, Henna, Wheat, Ginger ,Marraya koeningii, Garlic extract, Ananas sativum Sauropus androgynus, mimusops elengi have been found effective corrosion inhibitors for mild steel, copper, brass etc[6-10].

In Continuous of our research work, the present investigation is the corrosion adsorption behaviour of Wrightia Tinctoria leaves on mild steel in Hydrochloric acid environment have been investigated with various periods of contact and temperature using the mass loss measurements. Various adsorption studies is analysed by temkin, frumkin, frendlich, elawady and flurry Huggins adsorption isotherm[11]

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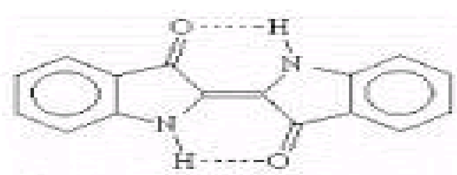
II. MATERIALS AND METHODS

2.1 Preparation of specimen for mass loss measurements:
Rectangular specimens of area $20cm^2$ (5 x 2 x 2 cm) were cut from a parent sheet of copper, Brass, mild steel. The specimens were drilled a hole at one end and numbered by punching before the use of specimen, then the electrodes were pickled with picking solution (Table – 1), washed with water, rubbed with cotton cloth and dried. After pickling the electrodes were mechanically polished with 1/0 to 5/0 emery sheets and degreased with trichloroethylene then kept it in dessicators. These electrodes were used for this investigation[12].

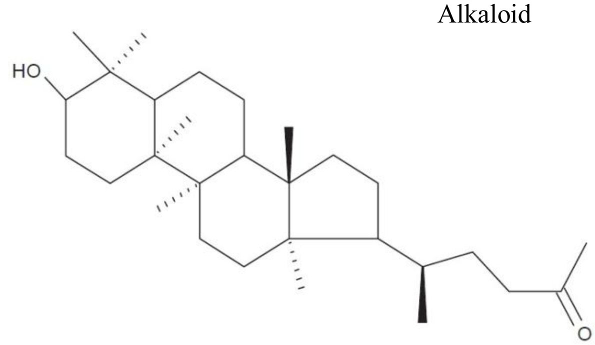
2.2 Preparation of electrolyte:
1.0N Hydrochloric acid of Analar grade reagent was prepared with double distilled water and used for our present investigations.

2.3 Preparation of Inhibitors used:
About 3 Kg of *Wrightia tinctoria* leaves was collected from in and around Western Ghats and then dried under shadow for 5 to 10 days. Then it is grained well and finely powdered, exactly 150g of this fine powder was taken in a 500ml round bottom flask and a required quantity of ethyl alcohol was added to cover the fine powder completely, and left it for 48 hrs. Then the resulting paste was refluxed for about 48 hrs, the extract was collected and the excess of alcohol was removed by the distillation process. The obtained paste was boiled with little amount of activated charcoal to remove impurities, the pure plant extract was collected and stored[13].

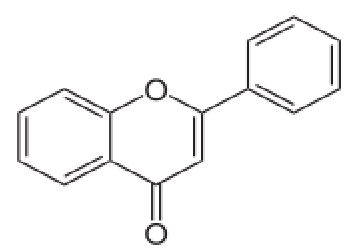
2.3 Properties of *Wrightia tinctoria* leaf:
Wrightia tinctoria belongs to *Appocynaceae family* and it is an annual herbaceous climbing plant with a long history of traditional medicinal uses in many countries, especially in tropical and subtropical regions. The common Names is *veppalai*. The peel extract of this plant is used to regulate thyroid function and glucose metabolism. The phytochemicals present in this plant is flavonoids, alkaloids, saponins, and triterpenes[14]. The structures are shown below



Alkaloid



Wrightial



Flavanoid

Figure: 1 Chemical structure of the main active compounds present in Wrightia tinctoria leaves extract.

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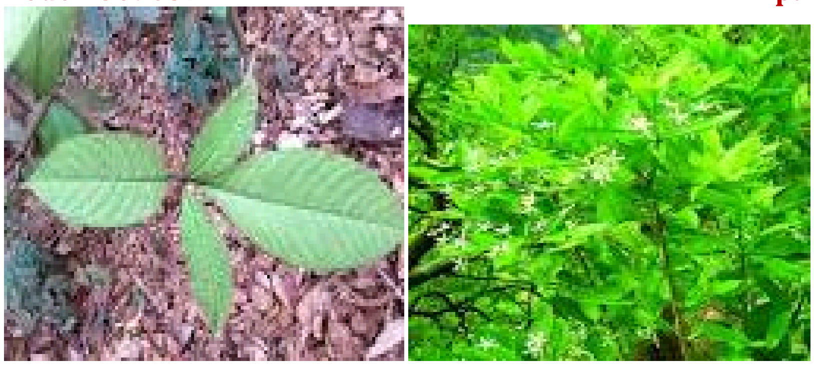

(a) (b)

Figure: 2. (a) & (b) are picture of Wrightia tinctoria leaves and trees

2.5 Non – Electro chemical Studies

In mass loss measurements, all the testing electrodes were immersed completely in exactly 100ml of the test solution in the presence and absence of the inhibitor. The specimens were withdrawn from the test solutions after24 to 360 hrs exposure at room temperature and after one hour at 313K to 333K. The differences in weight of the specimens before and after immersion using LP 120 digital balance with sensitivity of ±1 mg. The tests were performed in triplicate to guarantee the reliability of the results and the mean value of the mass loss is reported.

Thermodynamic parameters of adsorption isotherm equation was calculated by the various equation from mass loss measurements

2.6 Adsorption studies

Temkin adsorption isotherm was calculated by the equation
LogC Vs ɵ -- 1
Frendlich adsorption isotherm was calculated by the equation
Log ɵ Vs logc -- 2
Frumkin adsorption isotherm was calculated by the equation
ɵ Vs log[C ɵ /1- ɵ] ----------------------------------3
Flurry Huggins adsorption isotherm was calculated by the equation
Log(1- ɵ)Vs Log ɵ/C ------------------------------------4
Elawady adsorption isotherm was calculated by the equation
Logc Vs log((ɵ/1-ɵ) ------------------------------------5

III. RESULT AND DISCUSSION

3.1 Mass loss measurements

Table-1: The corrosion parameters of mild steel in 1N Hydrochloric acid containing different concentration of WTL extract after 24to 360 hours exposure time

Conc (ppm)	Corrosion rate (mmpy)					Inhibition efficiency (%)				
	24 hrs	72 hrs	120 hrs	240 hrs	360 Hrs	24 Hrs	72 hrs	120 hrs	240 hrs	360 hrs
0	0.1627	0.1394	0.1394	0.1580	0.1549	-	-	-	-	-
10	0.1394	0.1007	0.0743	0.1348	0.1115	14.28	27.77	46.67	14.70	27.99
50	0.1162	0.0542	0.0604	0.1139	0.0991	28.56	61.11	56.67	27.94	35.99

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100	0.1162	0.0542	0.0464	0.1022	0.0774	28.56	61.11	66.67	35.29	50.00
500	0.0929	0.0464	0.0325	0.0929	0.0635	42.85	66.67	76.67	41.17	59.00
1000	0.0697	0.0387	0.0232	0.0813	0.0495	57.14	72.22	83.33	48.53	68.00

3.2 Temperature Studies

The dissolution behavior Mild Steel containing various concentration of WTL extract in 1N Hydrochloric acid with temperature ranges from 313K to 333K is investigated by mass loss method and the values are listed out in Table-2[15-17]. The observed values of corrosion rate decreased from 25.1082 to 3.9057 mmpy with increase of inhibitor concentrations. The percentage of inhibition efficiency gradually is increased from 62.32 to 84.44 % with increase of inhibitor concentration at 313 K. The corrosion resistant behavior of WTL extract on mild steel in 1N Hydrochloric acid at 313 to 333K is shown in Table-2[18,19].

Table-2: The corrosion parameters of mild steel in 1N Hydrochloric acid containing different concentration of WTL extract at 313 to 333 K

Conc. (ppm)	Corrosion rate (mmpy)			Inhibition efficiency (%)		
	313K	323K	333K	313K	323K	333K
0	25.1082	40.1732	50.2165	-	-	-
10	9.4853	21.7605	35.1515	62.32	45.83	30.00
50	7.8114	11.7171	26.7821	68.88	70.83	46.66
100	5.0216	8.9273	17.8547	80.00	77.77	64.44
500	4.4636	7.8114	15.6229	82.22	80.55	68.88
1000	3.9057	6.6955	10.6012	84.44	83.33	78.88

Table 3: Corrosion thermodynamic parameters of Temkin adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Concentration (ppm)	Logc	313 k(ɵ)	323 K(ɵ)	333 k(ɵ)
10	1	0.6232	0.4583	0.3000
50	1.6989	0.6888	0.7083	0.4666
100	2	0.8000	0.7777	0.6444
500	2.6989	0.8222	0.8055	0.6888
1000	3	0.8444	0.8333	0.7888

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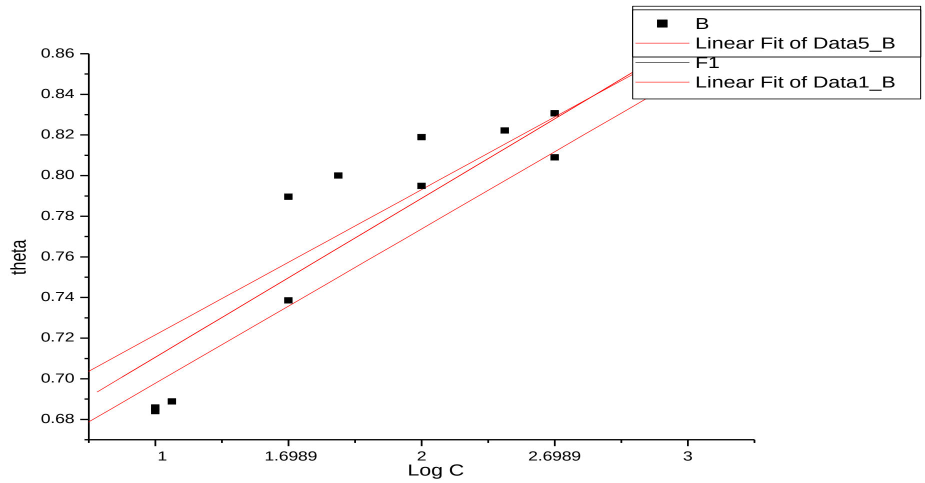

Figure 3: Corrosion thermodynamic parameters of Temkin adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Table4: Corrosion thermodynamic parameters of frendlich adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Concentration (ppm)	Logc	313 k(log ɵ)	323 K(log ɵ)	333 k(logɵ)
10	1	-0.2053	-0.3388	-0.5228
20	1.6989	-0.1619	-0.1497	-0.3310
30	2	-0.0969	-0.1091	-0.1908
40	2.6989	-0.0850	-0.0939	-0.1619
50	3	-0.0734	-0.0791	-0.1030

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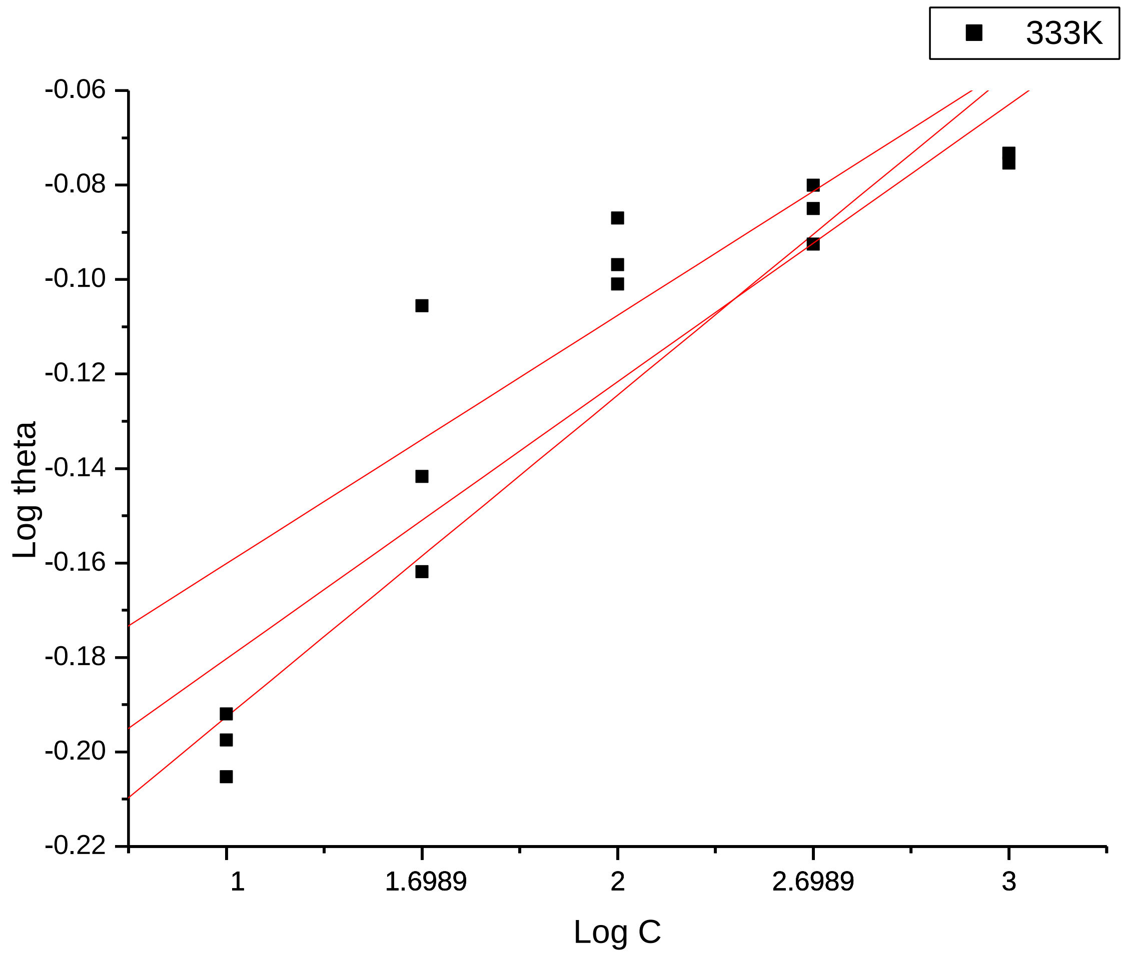

Figure -4: Corrosion thermodynamic parameters of frendlich adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Table 5: Corrosion thermodynamic parameters of frumkin adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Concentration (ppm)	ɵ (313K)	ɵ (323K)	ɵ (333K)	log[C ɵ /1- ɵ]	L og[C ɵ /1- ɵ]	log[C ɵ /1- ɵ]
10	0.6232	0.4583	0.3000	1.218	0.9273	0.6320
20	0.6888	0.7083	0.4666	2.040	2.0843	1.6407
30	0.8000	0.7777	0.6444	2.602	2.5421	2.2580
40	0.8222	0.8055	0.6888	3.364	3.3162	3.0440
50	0.8444	0.8333	0.7888	3.734	3.6980	3.512

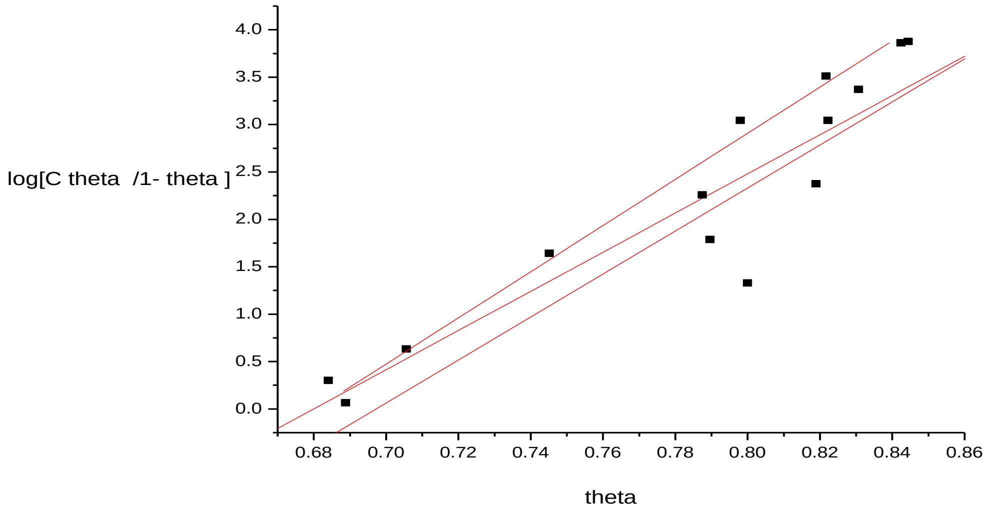

Figure 5: Corrosion thermodynamic parameters of frumkin adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Table 6: Corrosion thermodynamic parameters of flurry huggins adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Concentration (ppm)	Log(1- ɵ) (313K)	Log(1- ɵ) (323K)	Log(1- ɵ) (333K)	log ɵ/C (313K)	log ɵ/C (323K)	log ɵ/C (333K)
10	-0.4238	-0.2662	-0.1549	-1.205	-1.338	-1.522
20	-0.5069	-0.5350	-0.2729	-1.861	-1.848	-2.030
30	-0.6989	-0.6530	-0.4490	-2.096	-2.109	-2.190
40	-0.7500	-0.7111	-0.5069	-2.783	-2.792	-2.860
50	-0.8079	-0.7780	-0.675	-3.073	-3.079	-3.103

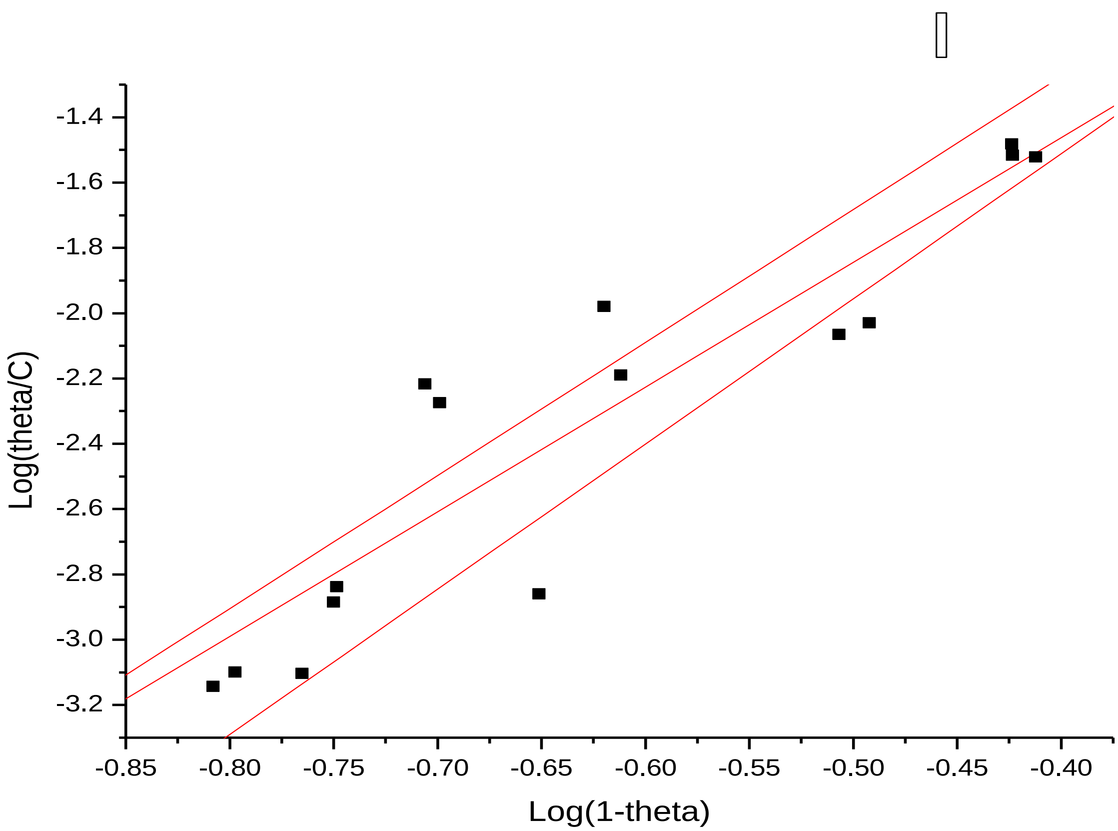

Figure 6: Corrosion thermodynamic parameters of flurry huggins adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Table 7: Corrosion thermodynamic parameters of elawady adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

Concentration (ppm)	Logc	log((ɵ/1-ɵ)) (313K)	log((ɵ/1-ɵ)) (323K)	log((ɵ/1-ɵ)) (333K)
10	1	-0.5450	-0.6253	-0.746
20	1.6989	-0.5202	-0.5134	-0.620
30	2	-0.4845	-0.5136	-0.536
40	2.6989	-0.4780	-0.4829	-0.5202
50	3	-0.4720	-0.4750	-0.4878

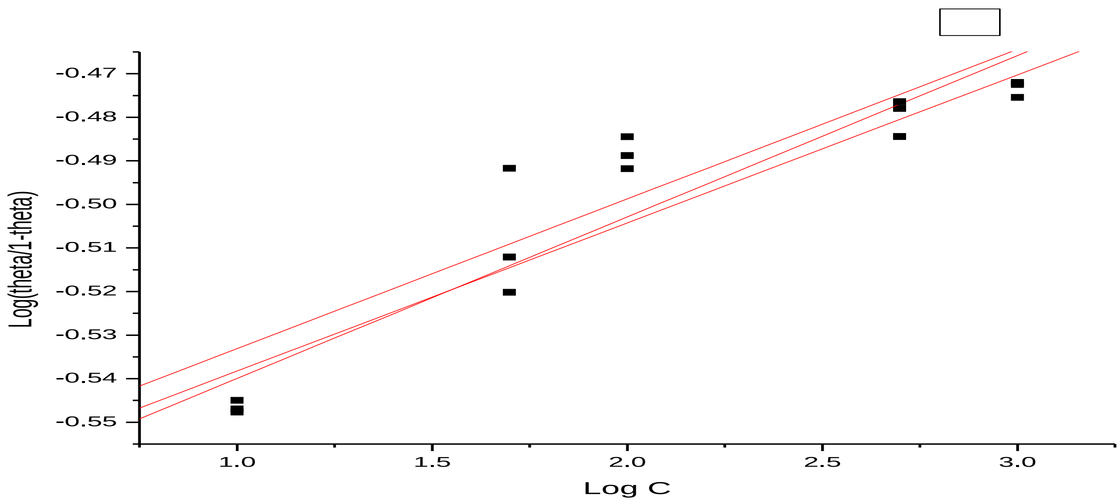

Figure 7: Corrosion thermodynamic parameters of elawady adsorption isotherm of Wrightia tinctoria leaves on mild steel in 1.0N Hydrochloric acid

IV. CONCLUSION

Various adsorption isotherm mechanism has been plotted temkin adsorption isotherm has been increased from 0.3000 to 0.8444, frendlinch adsorption isotherm shows a negative value -0.0734 to -0.5229 from 313k to 333K. Fremkin adsorption isotherm shows from 0.6320 to 3.6980 from 313K to 333 K . Flurry huggins adsorption isotherm shows that the result obtained from -1.205 to -3.103 from 313 k to 333 K. Elwady adsorption isotherm decreases with negative value from -0.746 to -0.4720. The observed values of corrosion rate decreased from 25.1082 to 3.9057 mmpy with increase of inhibitor concentrations. The percentage of inhibition efficiency gradually is increased from 62.32 to 84.44 % with increase of inhibitor concentration at 313 K. It reveals that the percentage of inhibition efficiency increased with increase of inhibitor concentration and temperature. It is exothermic, spontaneous and chemisorptions process. The inhibitor follows Langmuir adsorption isotherm.

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