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Comparative study of Anticorrosion potential of stem extract from *Calotropis procera* in different solvents

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ABSTRACT
From the studies of corrosion inhibition potential of stem extract of Calotropis procera in methanol and Chloroform were prepared by weight loss method for pig iron in 1M HCl. The experiment was done in the different concentration in ppm solution (200 ppm – 1000 ppm) for the four different time period 2 – 8hrs). Found the results for %IE, Surface coverage(θ) and Corrosion rate (g/cm. h) by using the weight loss method. In the experiment of both extracts (Methanol, hot water and Chloroform) the inhibition efficiency increased with the increasing concentration and decrease with increase in time period, the highest %IE in Methanol extract found 95.0% at 1000 ppm concentration for 2hrs immersion time and minimum 17.0 % at 200 ppm for 8hrs immersion time.For the hot Water extract the percentage inhibition efficiency values are 76% is highest at 1000 ppm for 2hrs and minimum is 25.5% at 200 ppm for 8hrs. In the case of Chloroform, the highest % IE is 78.15 and minimum 9.4 % and same reaction was done for surface coverage but the values of corrosion, rate decrease with increasing concentrations and time.

Keywords*: Calotropis Procera, % Inhibition Efficiency, Corrosion rate, Surface coverage,Stem Extract, Pig Iron Specimen.*

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I. INTRODUCTION

Metalliccorrosion is a process of oxidation where the metal reacts in presence of water and oxygen(**Koch *et al.*, (2016**). Corrosion is a major problem that affects not only business but also human life and environment. The iron, steel, food, oil and petroleum industries are more affected by the corrosive media**(Alaneme and Olusegun, 2012)**.So many types of paints and inorganic chemicals are used to reduce the corrosion but they are limited because its high cost and toxic natureof these chemical are very hazardous for human being, animal and environment also

(Rani and Bharathi, 2011). Green inhibitors are one of the more beneficial thanchemical inhibitors **(Doner *et al.*, 2011).**

Plantextracts having the properties to reduce corrosion of iron (**Kumar and Mohana 2014).** These green inhibitors are very helpful for not only economic system but also for environment and human being due to their low cost, biodegradability, high availability and non-toxic behaviour and less hazardous**.**The efficiency of plant extract as inhibitors are due to containing organic heterocyclic compounds consist of polar functional group like(O, S, N, P), conjugated double and triple bond and π electron in their molecules these hetero atoms present in the ring structure. These double and triple bonds are very important for the adsorption of surface **(Raval, 2012).**Most of the plants containing secondary metabolites like Tannins, terpen, Glycosides, Catechin, Flavanoids, containing the power to reduce corrosion of the metal (**Umoren *et al.*, (2016).**

II. EXPERIMENTAL

The pig iron coupons were collected from the Azad iron and steel industry of Lucknow, up, India.Each coupon was 2.5 cm in width, 5 cm length and 1mm thickness, has the following composition (wt.%): C = 40; Si = 25; Mn = 7.5; P = 15; S = 10; and Fe = 2.5. The coupons were cleaned by using sand paper and hexane anddried by using oven very carefully after that all the strips were stored in a moisture-free desiccator, weighted each coupon before use.

2.1 Preparation of extracts

The stem of Calotropis procera were collectedand ground to fine powder aftershade dried. Extraction was doneby two different methods (Soxhlet method and soaking method). Methanol and Chloroform was used as solvents for Soxhlet method and hot water extract was prepared by using the soaking method. All extracts were brought to dryness on a hot plate to obtain a solid residue.

2.3 Weight loss method

The pig iron samples were immersed in uninhibited and inhibited solutions for (2-8 hrs) in different concentrations of plant extracts (200 ppm – 1000 ppm). The pig iron specimen were prepared as mentioned previously and weighted using a electric balance with a accuracy of 0.1 mg. After each test, the pig iron specimens were taken out and rinsed thoroughly with distilled water, dried and re-weighed accurately (**HassaneLgaz*et al*., 2018)**

After weighing all the iron specimen, loses of weight in iron was calculated to finding the inhibition efficiency of extract material. From the weight loss result, corrosion rates (C_R), degree of surface coverage (θ) and the inhibition efficiency ($\%IE_{inh}$) of the inhibitor was found by using Eqs. (1), (2), (3) respectively (**Al Senani *et al.*, 2015).**

$C_R = W/A.t$ ……..*(1)*

Where, W is weight loss, A is the sectional area and t is the exposure time of the pig ironcoupons.

$\theta = Wo / W_{inh}$ ……..*(2)*

The inhibition efficiency (% IE) of *Calotropis procera* stem extracts was evaluated from the following equation.

$$\%IE = \frac{W_o - W_{inh}}{W_o} \times 100 \ldots\ldots\ldots\ldots (3)$$

Where W_o and W_{inh} are the corrosion rates of the pig iron coupons in the absence and presence of inhibitor, respectively(**Ramananda, 2013).**

III. RESULTS AND DISCUSSION

The percentage of inhibition efficiency (%IE) was found by using weight loss method in different solutions Methanol, Chloroform and hot Water extracts of *Calotropis procera* stem. Resultsfound with difference in weight loss of pig iron coupons in presence and absence of *Calotropis procera* stem extract (**Umoren *et al.*, (2016).** Results were calculatedwith the different concentration to find the results of corrosion rate (CR), percentage inhibition efficiency (%IE) and surface coverage in 1 M HCl solution for different time periods (2-8 hrs.) as shown in Table 1, 2 and 3. and Fig. (1 – 12) present the graphical curves of corrosion rate (g/cm.h), percentage inhibition efficiency (%IE) and surface coverage (Ɵ) against exposure time in 1 M HCl solution **(Loto and Loto 2018)**. The reproducibility of the experiment was higher 95%. From the %IE values, corrosion rates were computed accordingly using the formulae.

Table-1: Weight loss of pig iron in 1M HCl in presence of various concentrations of *Calotropis procera* stem extracts for different time periods in methanol.

Concentration of inhibitor in (ppm)	**Immersion time (hrs.)**	**Weight of coupons (g)**		**Weight loss of coupons (g)**	**Corrosion rate (C_R)**	**Surface coverage**	**Inhibition efficiency**
		Before immersion	**After immersion**		**($g/cm^2.h$)**	**(θ)**	**(%IE)**
0	2	23.84	22.82	1.02	0.0408		
200		23.82	23.70	0.12	0.0048	0.88	88.23
400		23.53	23.45	0.08	0.0032	0.94	92.15
600		23.07	23.00	0.07	0.0028	0.95	93.13
800		22.63	22.57	0.06	0.0024	0.94	94.11
1000		22.91	22.86	0.05	0.0020	0.95	95.09
0	4	22.52	22.16	0.36	0.0072		
200		22.81	22.52	0.29	0.0058	0.19	19.4
400		22.92	22.73	0.19	0.0038	0.47	47.2
600		22.53	22.35	0.18	0.0036	0.50	50
800		22.52	22.35	0.17	0.0034	0.52	52.7

1000		22.19	22.03	0.16	0.0032	0.55	55.5
0	6	22.32	21.91	0.41	0.0054		
200		22.47	22.26	0.21	0.0028	0.48	48.7
400		22.71	22.52	0.19	0.0025	0.53	53.6
600		22.11	21.94	0.17	0.0022	0.58	58.5
800		22.95	22.82	0.13	0.0017	0.68	68.2
1000		22.32	22.20	0.12	0.0016	0.70	70.7
0	8	22.55	22.08	0.47	0.0047		
200		22.97	22.58	0.39	0.0039	0.17	17.0
400		22.82	22.58	0.24	0.0024	0.48	48.9
600		22.79	22.56	0.23	0.0023	0.51	51.0
800		22.68	22.46	0.22	0.0022	0.53	53.1
1000		23.40	23.19	0.21	0.0021	0.55	55.3

Table-2: Weight loss of pig iron in 1M HCl in presence of various concentrations of *Calotropis procera* stem extract for different time periods in Chloroform.

Concentration of inhibitor in (ppm)	**Immersion time (hrs)**	**Weight of coupons (g)**		**Weight loss of coupons (g)**	**Corrosion rate (C_R) (g/cm^2.h)**	**Surface coverage (θ)**	**Inhibition efficiency (%IE)**
		before immersion	**after immersion**				
0	2	22.59	22.32	0.27	0.0108	-	-
200		23.66	23.46	0.21	0.0084	0.22	22.2
400		23.64	23.50	0.14	0.0056	0.48	48.0
600		23.54	23.43	0.11	0.0044	0.59	59.1
800		23.04	22.96	0.8	0.0032	0.70	70.
1000		23.83	23.76	0.7	0.0028	0.74	74.0
0	4	22.20	21.88	0.32	0.0064		
200		21.88	21.66	0.22	0.0044	0.31	31.2
400		22.84	22.71	0.13	0.0026	0.59	59.3
600		22.46	22.35	0.11	0.0022	0.65	65.6
800		22.43	22.34	0.09	0.0018	0.71	71.8
1000		22.13	22.06	0.07	0.0014	0.78	78.1
0	6	21.87	21.46	0.41	0.0054		
200		21.40	21.13	0.27	0.0036	0.34	34.15
400		21.80	21.59	0.21	0.0028	0.48	48.7
600		21.98	21.85	0.13	0.0017	0.68	68.3
800		22.29	22.17	0.12	0.0016	0.70	70.7
1000		21.63	21.54	0.9	0.0012	0.78	78.0
0	8	22.23	21.70	0.53	0.0053		
200		22.44	21.96	0.48	0.0048	0.094	9.4
400		22.82	22.44	0.38	0.0038	0.28	28.3
600		22.30	22.06	0.24	0.0024	0.54	54.7
800		22.21	21.99	0.22	0.0022	0.58	58.5
1000		22.52	22.31	0.21	0.0021	0.60	60.3

Table-3: Corrosion rate, Surface coverage and inhibition efficiency of hot Water extract in 1M HCl in various concentrations at different time intervals

Concentration of inhibitor in (ppm)	Immersion time (hrs)	Weight of coupons (g)		Wt. loss of coupon (g)	Corrosion rate	Surface coverage	Inhibition Efficiency (%IE)
		before immersion	after immersion		($g/cm^2.h$)	(θ)	
0	2	22.30	22.05	0.25	0.010	-	-
200		23.69	23.55	0.14	0.0056	0.44	44
400		23.56	23.44	0.12	0.0048	0.52	52
600		23.39	23.31	0.8	0.0032	0.68	6
800		23.40	23.33	0.7	0.0028	0.72	72
1000		22.93	22.87	0.6	0.0024	0.76	76
0	4	22.79	22.34	0.45	0.0090	-	-
200		22.10	21.89	0.21	0.0042	0.53	53
400		22.43	22.24	0.19	0.0038	0.57	57.7
600		21.97	21.79	0.18	0.0036	0.60	60
800		21.81	21.64	0.17	0.0034	0.62	62.2
1000		22.51	22.35	0.15	0.003	0.64	64.4
0	6	22.94	22.44	0.48	0.0064	-	-
200		22.51	22.16	0.35	0.0046	0.27	27.0
400		22.51	22.24	0.32	0.0042	0.33	33.3
600		22.82	22.57	0.25	0.0033	0.47	47.9
800		22.69	22.46	0.23	0.0030	0.52	52.0
1000		22.72	22.53	0.19	0.0025	0.60	60.4
0	8	22.52	22.05	0.47	0.0047	-	-
200		21.79	21.44	0.35	0.0035	0.25	25.5
400		22.16	22.91	0.25	0.0025	0.46	46.8
600		23.10	22.86	0.24	0.0024	0.48	48.9
800		23.31	23.09	0.22	0.0022	0.53	53.1
1000		22.53	22.34	0.19	0.0019	0.59	59.5

4.1 Graphical analysis for Corrosion rates, inhibition efficiency and Surface coverage

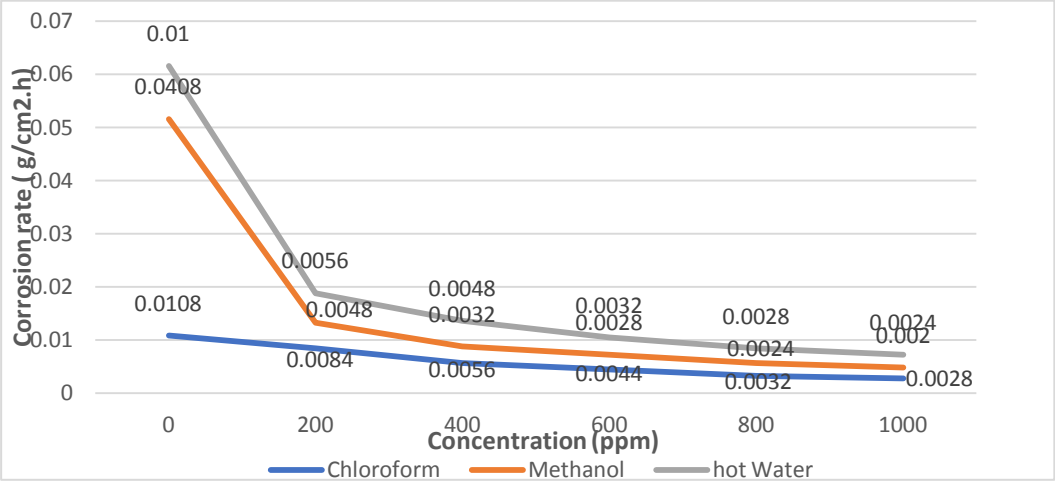

Figure 1: Corrosion rate (C_R) at the different concentration for 2hrs.

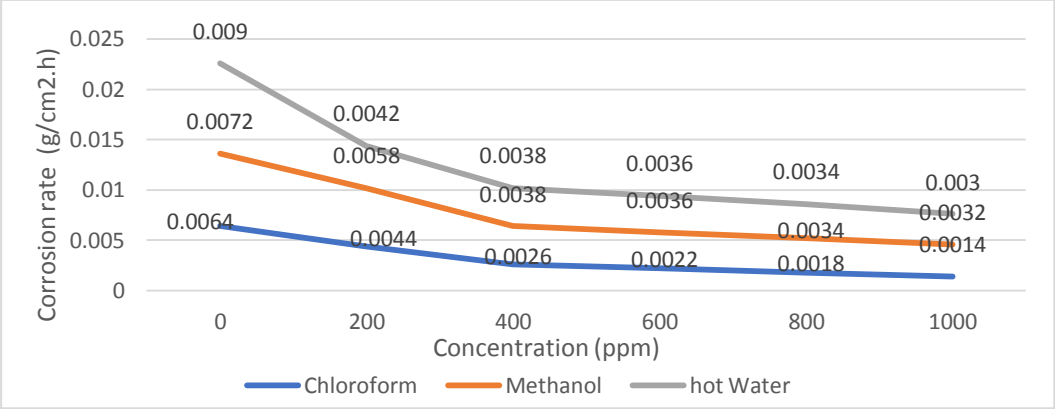

Figure 2: Corrosion rate (C_R) at the different concentration for 4hrs.

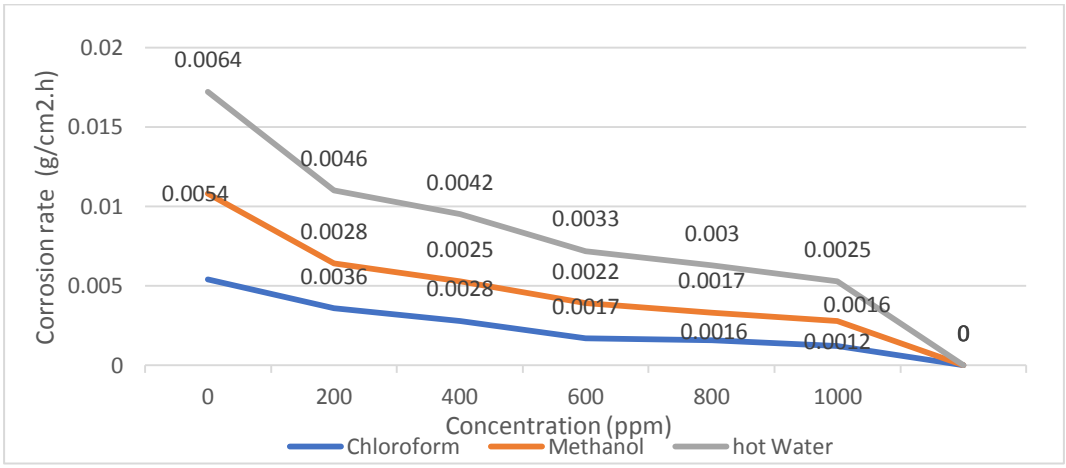

Figure 3 : Corrosion rate (C_R) at the different concentration at for 6hrs.

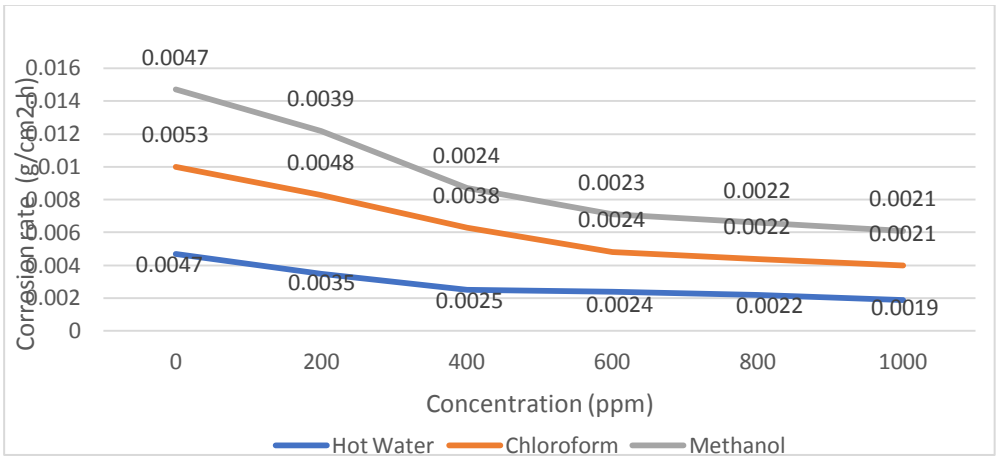

Figure 4: Corrosion rate (C_R) at different concentrations for 8hrs.

3.1 Percentage inhibition efficiency

The values for corrosion rates, drastically decreased with increase in the concentration of the extract in comparison to the blank and found the lowest corrosion rate at highest concentration of extract (1000ppm). Lowest corrosion rate at 1000 ppm concentration for 2hrs in methanol extract was 0.0020 (table 1). At the same concentration for the time periods 4hr, 6hr and at 8hr the lowest values are 0.0032, 0.0016 and 0.0021. Similarly in Chloroform extract, the corrosion rate continuously decreased with increasing concentration and time periods. The lowest value(0.0028) found for Chloroform extract at 1000 ppmfor 2hrs. The values for the time periods of 4hr, 6hr and 8hrs were 0.0014, 0.0012 and 0.0021 respectively. In the case of hot Water extract, the highest corrosion rate value (0.0056) obtained at 200 ppm concentration of extractfor 2hrs immersion time and the lowest corrosion rate (0.0019) found at 1000 ppm concentration of extract for maximum (8hrs) immersion

time. Corrosion rate continuously decreased with the both conditions increasing time periods and concentration of extract.

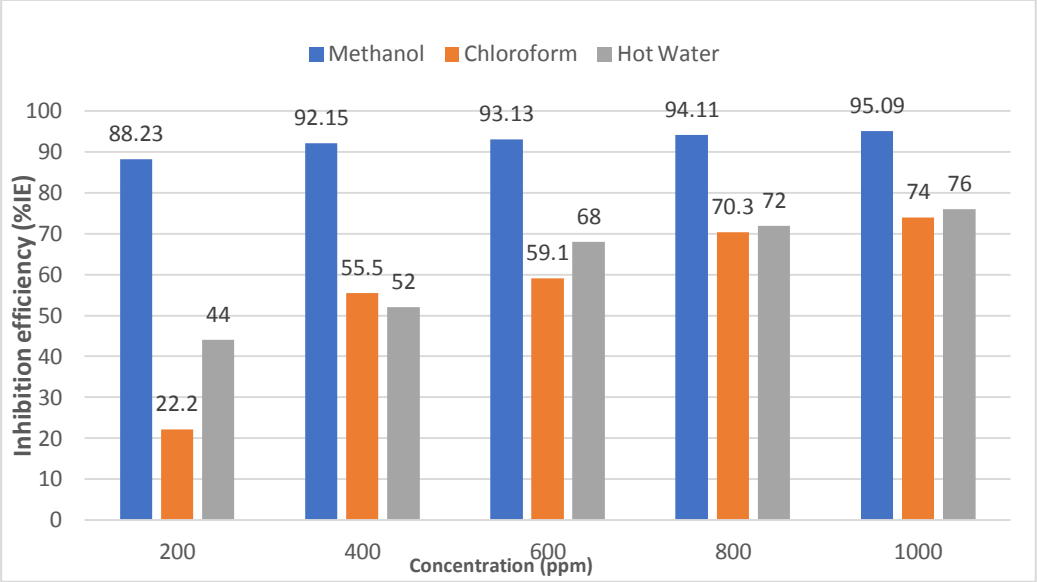

Figure 5: Inhibition efficiency (%IE) at the different concentration for 2hrs.

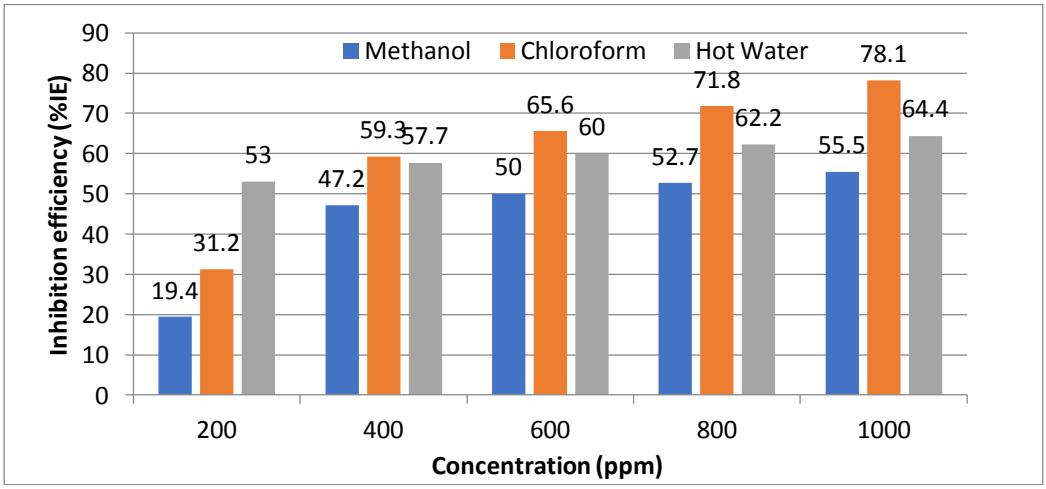

Figure 6:Inhibition efficiency (%IE) at the different concentration for 4hrs.

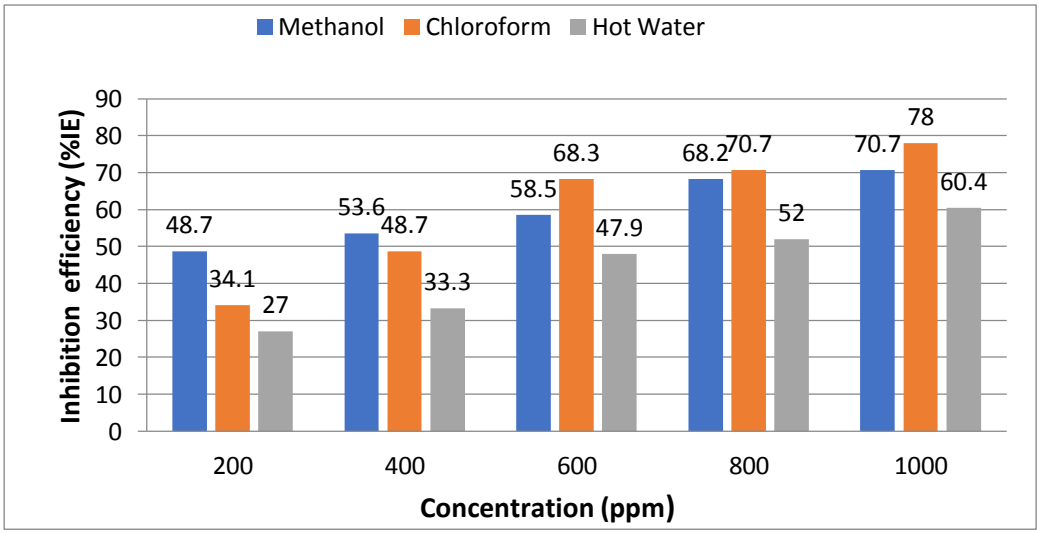

Figure 7: Inhibition efficiency (%IE) at the different concentration for 6hrs.

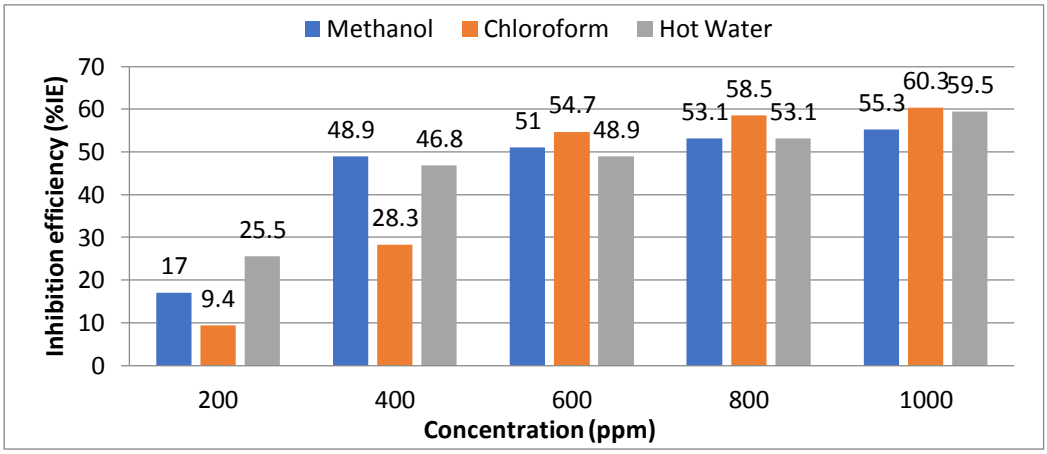

Figure 8: Inhibition efficiency (%IE) at the different concentration for 8hrs.

From the weight loss measurement at different concentrations (200 ppm– 1000ppm) of *Calotropis Procera*stem in methanol extract the maximum value of IE% is 95.09% at 1000ppm for 2hrs immersion time and found the minimum value of IE% is 17.0% at 200ppm concentration for 8hrs as summarised in the table 1.

Similarly for the Chloroform extract of *Calotropisprocera was* found the maximum value 78.1% at 1000ppm for 4hrs immersion time and the minimum IE% obtained 9.4% at 200ppm concentration for 8hrs immersion time as showed in the table 2.

In the case of hot water found the heist value of percentage inhibition efficiency got 76 at 1000 ppm concentration for 2hrs immersion time and the minimum value was 25.5% at 200 ppm concentration of extract for 8hrs immersion time (**Verma *et al.*, 2018)**

So, it observed that IE% increases with increasing concentration of inhibitor (**Qurashi et al., 2009)**. The maximum efficiency of Methanol, hot Water and Chloroform got 95.09%, 76% and 78.1% and 1000ppm

4.2 Surface coverage

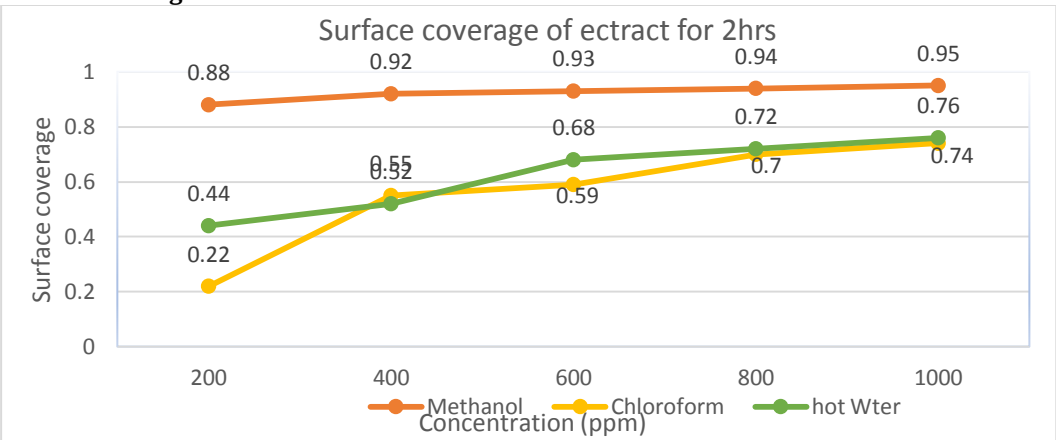

Figure 9: Surface coverage (θ) at the different concentration for 2hrs.

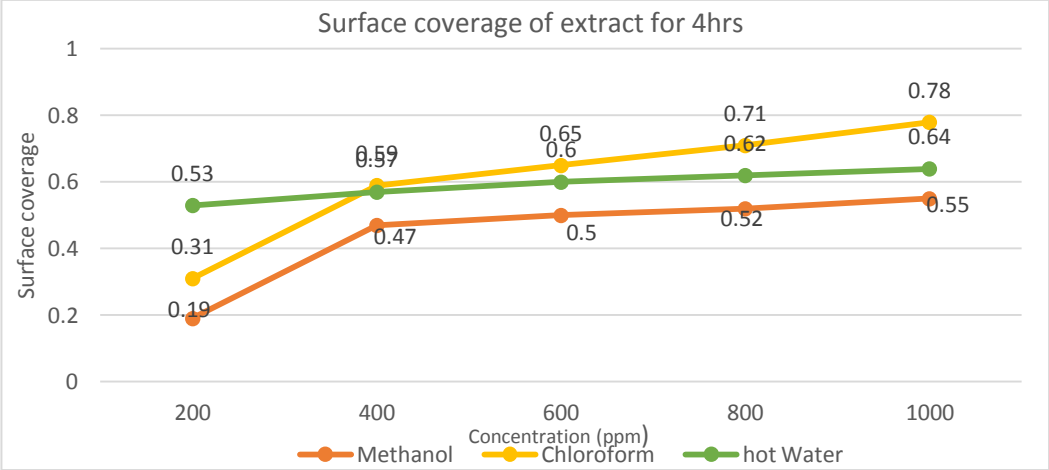

Figure10: Surface coverage (θ) at the different concentration for 4hrs.

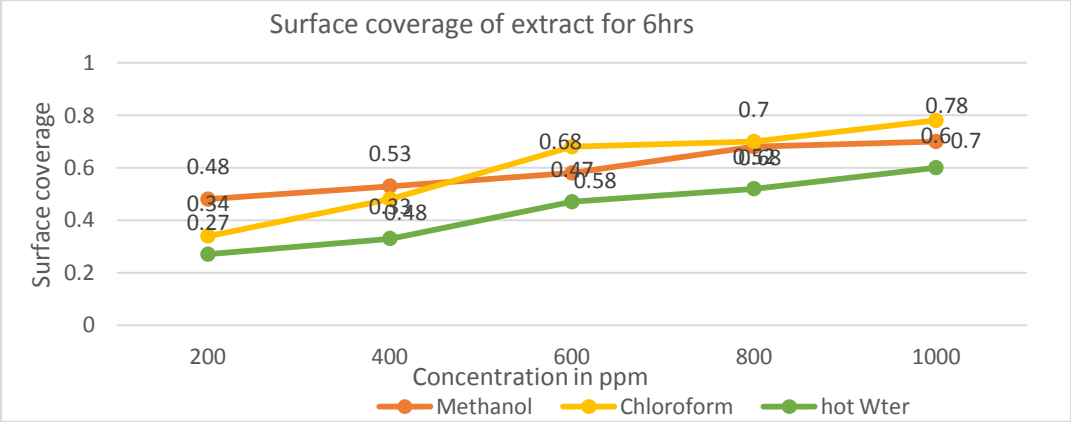

Figure 11: Surface coverage (θ) at the different concentration for 6hrs.

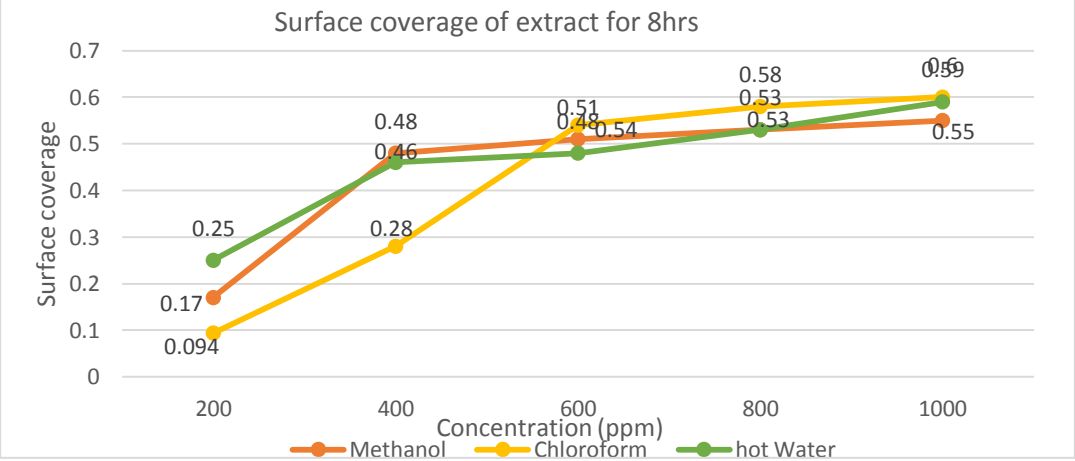

Figure 12: Surface coverage (θ) at the different concentration for 8hrs

From the results obtained the surface coverage against different concentrations of inhibitor, it is found that the surface coverage increased with increasing concentrations of inhibitors from 200 ppm – 1000 ppm for each time intervals.

For Methanol extract the surface coverage value found for 2hr. immersion time of coupons minimum 0.88 and maximum is 0.95 for 200ppm and 1000ppm respectively. Similarly surface coverage value found for 4 hrs immersion time of coupons minimum 0.19 and maximum is 0.55 for 200ppm and 1000ppm respectively. For 6hr. the surface coverage values found at immersion of coupons are found minimum 0.48 and maximum is 0.70 for 200ppm and 1000ppm respectively. The surface coverage values found for 8hr. immersion time of coupons are minimum 0.17 and maximum is 0.55 for 200ppm and 1000ppm respectively.

The results showed that the plant extracts are effective for corrosion. The reason of decreasein percentage inhibition efficiency with increasing time and concentration due to the Chelate formationbetween the metal and inhibitor by the reason of incomplete adsorption on the metal surface**(Shriver *et al*., 1994)**.

On comparing the results of *Calotropis procera* stem extract for pig iron in different solvents in different ppm concentrations and time intervals. It was found that the better percentage of inhibition efficiency was observed in methanol. In the case of methanol, themaximum efficiency 95.09% and minimum efficiency is found in the case of Chloroform 9.4%(**Ramananda, 2013)**

It was found that the methanolic extracts of *Calotropis procera* stem contain many organic compounds such as flavonoids, steroids, tannins, Catechin, triterpenes, Glycosides, Alkaloids and phenolic compounds (**Oyewole *et al*., 2021**). Most of these constituents are known to have good inhibitive action for corrosion.Thus, it is concluded that the plant extracts are good inhibitor for metals due to their low cost and less hazardous nature for the environment**(Popov *et al*.,2015)**. It was found that the plant extracts contained O_2 OR π- electrons and also contained a mixture of hetero atoms in their molecule **(Al-Otaibi*et al*., 2014)**

The plant extracts inhibitors having organic compounds containing some hetero-atoms such as O, N and S with (double and triple bonds). The efficiency of these organic corrosion inhibitors is related to the presence of polar functional groups with S, O and N atoms in the molecule. The process of adsorption of organic compound as corrosion inhibitors on the metal surface in acidic medium is due to the functional group containing hetero atoms like nitrogen, sulfur and oxygen (**Ivanov, 1986).**

The results proves that *Calotropis procera* stem extract is a promising inhibitor for the pig iron in 1M HCl at various immersion time periods.

IV. CONCLUSION

The stem extracts of *Calotropis procera* has showed promising corrosion inhibition properties for pig iron in 1 M HCl. On comparing the percentage inhibition efficiencies of the plant extracts was found at lowest time 2hrs. and at highest concentration 1000 ppm. it was found that the plant of the present study could serve as effective green corrosion inhibitors for Pig Iron in acidic media. Further investigations to assess the corrosion morphology and to isolate and confirm the organic constituents are responsible for the inhibition of pig iron corrosion in acidic media.

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