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PROTECTION OF MILD STEEL FROM CORROSION USING SEED EXTRACT [GREEN INHIBITOR] IN ACID ENVIRONMENT

Mahima Srivastava

Associate Professor, Department of Chemistry, DBS (PG) College, Dehradun - 248001, Uttarakhand, India.

Abstract - *Implementation of Castor seed extract on corrosion of mild steel in acid solution in paste form was investigated using traditional weight loss measurements techniques. Corrosion inhibition efficiency of Castor seed extracts was evaluated using weight loss measurements for effect of various solution concentrations in paste form. Surface analyses via scanning electron microscope (SEM) shows a significant improvement on the surface morphology of the mild steel panels in the presence of optimum concentration of inhibitor. From the results, it is clear that Castor seed has good potential as environment friendly, green, corrosion inhibitor.*

Key Words: mild steel, corrosion, inhibitor, SEM, castor seed.

1. INTRODUCTION

Iron and mild steel are used in large quantities for structural purposes and for fabrication of machine tools. Iron on exposure to moist air, is found to be covered with a reddish – brown coating called rust. The rust consists essentially of hydrated ferric oxide, Fe2O3.3H2O, together with small quantity of ferrous carbonate, FeCO3.Acid solutions are usually used for pickling in order to remove rust from their surface. Results indicate that metal dissolves most rapidly in pure sulfuric acid solution, somewhat more slowly in pure hydrochloric acid and slowest of all in pure phosphoric acid [1]. The dissolution of iron in H2SO4 is slowed down by halide ions [2].

$$Fe + 2HCl = FeCl_2 + H_2$$

The hydrogen molecule, due to slow rate of formation in some cases, penetrates the crystal lattice and deforms it leading to brittleness of metal. Organic, inorganic, or a mixture of both inhibitors can inhibit corrosion by either chemisorption on the metal surface or reacting with metal ions and forming a barrier-type precipitate on its surface [3].

Because of the toxic nature and/or high cost of some chemicals currently in use as inhibitors, it is necessary to develop environmentally acceptable and inexpensive ones. Natural products can be considered as a good source for this purpose. The aqueous extracts from different parts of some plants such as Henna, Lawsoniainermis [4], Rosmarinousofficinalis L. [5], Carica papaya [6], cordialatifolia and curcumin [7], date palm, phoenix dactylifera, henna, lawsoniainermis, corn,Zea mays [8], and NypaFruticansWurmb[9] have been found to be good corrosion inhibitors for many metals and alloys. Leaves extracts are used as common corrosion inhibitors. The anticorrosion activity of Meethineem (Murrayakoenigii),Amla (Emblicaofficianilis), Black Myrobalan (Terminaliachebula), soapberry (Sapindustrifolianus), and Shikakai (Accaciaconicianna) was investigated. Corrosion inhibition has also been studied for the extracts of Beautiful swertia (Swertiaangustifolia). Similar results were also shown by Eucalyptus (Eucalyptus sp.) leaves, Jambolan (Eugenia jambolana), sugar-apple (Annonasquamosa), Babul (Acacia Arabica), Papaya (Carica papaya), Neem (Azadirachtaindica) and Ironweed (Vernoniaamydalina) were used for steel in acid media. Attap palm leaves were studied for the corrosion inhibition of mild steel in HCl media. In addition tothese, the use of herbs such as coriander, hibiscus, anis, black cumin, and garden cress as new type of green inhibitors for acidic corrosion of steel has also been seen [10 - 15].Seeds are of great concern for corrosion inhibition studies. Tobacco (Nicotiana), black pepper (Piper nigrum), acacia gum, and lignin can be good inhibitors for steel in acid medium. Papaya, Poinciana pulcherrima, Fedegoso (Cassia occidentalis), and Datura (Daturastramonmium) seeds are efficient corrosion inhibitors for steel [16 - 18].

In the present work our aim is to use inhibited pickling acid in the paste form so that it can be conveniently applied on large structures as well as on small tools to be pickled / cleaned. As a contribution to the current interest on environment friendly, green, corrosion inhibitors, the present study investigates the inhibiting effect of Castor

seed [Ricinus communis], a green inhibitor which is commonly known as Arandi. It is quite cheap as India is the major producer.

2. EXPERIMENTAL

Mild steel (Fe 99.30%, C 0.076%, Si 0.026%, Mn 0.192%, P 0.012%, Cr 0.050%, Ni 0.050%, Al 0.023%, and Cu 0.135%) panels of size 10 cm * 7.5 cm of pickled cold rolled closed annealed mild steel (18 SWG) cut from a single sheet were used in all experiments. For identification of specimens all were numbered and a suspension hole of about 2 mm diameter near upper edge was made. The specimens were polished to mirror finish with emery paper. They were cleaned with cotton to remove powder and traces of adhered metal, and then they were degreased with sulfur – free toluene followed by cleaning with methanol before experiments.

All the acid and chemicals used in the experiment were of AR grade quality. Distilled water was used for the preparation of solution. In the study, 4N solutions of acid were prepared.

Clay – soil was collected, washed, dried, powdered and sieved. 100 gm sieved soil was taken in a plastic glass with a hole at the bottom. This glass was put over uninhibited and inhibited acids. Soil soaked acid uniformly and thus pickling paste was prepared. 100 gm soil soaked 31.3 cc acid.

Polished and weighed panels were suspended by a V-shaped hook made of capillary over 100 % humidity for 6 months at room temperature. In 6 months, heavy rust appeared on the panels. Panels were re-weighed to get the amount of rust.

Pickling paste was applied over weighed rusted panels under different conditions. After the experiment, paste was removed by washing with saturated sodium bicarbonate solution. The panels were again washed with water and dried with hot air. The panels were finally weighed to get the amount of rust dissolved. Experiments were conducted in triplicate and mean value is reported in the Table.

The Castor seeds were crushed and powdered. This powder, thus obtained was used as inhibitor. 1 mg of it was added to 100 cc of acid and kept for 24 hours. This acid was used for the preparation of inhibited pickling paste.

The inhibitor efficiency was calculated from the following equation:

$$\%IE = \frac{Wu - W_i}{Wu} * 100$$

Where,

%IE = Inhibitor efficiency
Wu= Wt. loss without inhibitor
W i = Wt. loss with inhibitor

Variables Studied:
1. Concentration of inhibitor
2. Concentration of acid
3. Period of Exposure
4. Coating Thickness
5. Water Content
6. Temperature

3. RESULT AND DISCUSSION

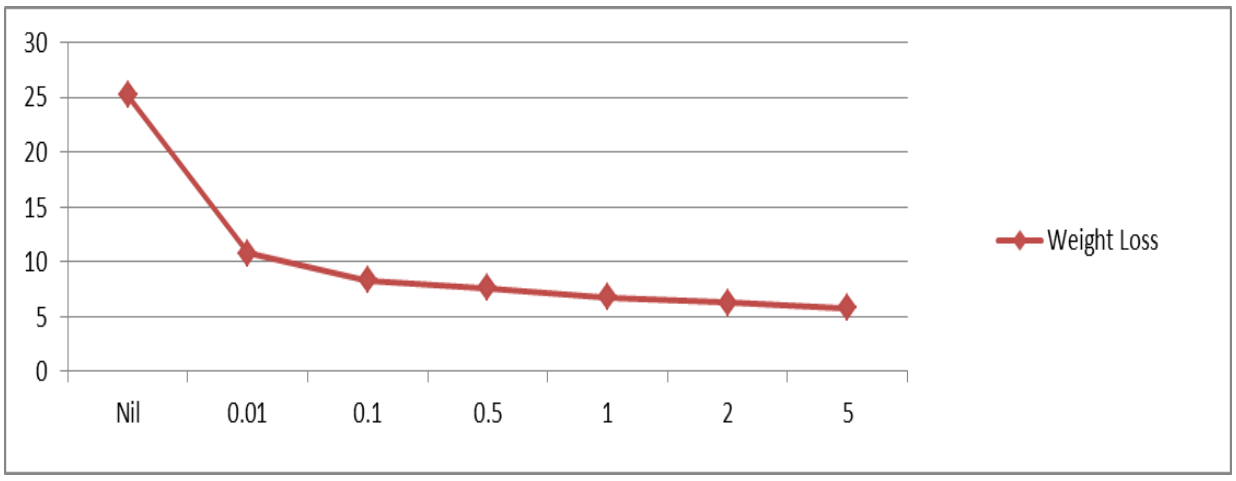
A. Effect of concentration of Castor seed in HCl:

The effect of concentration of concentration of castor seed 0.01% to 5.0% on its inhibitive efficiency for mild steel in paste containing 4N HCl at room temperature is shown in table 1 and figure 1[a and b]. Results show that when 0.01% castor seed was added to paste, weight loss reduced from 25.2 mg/dm^2/hr to 10.8 mg/dm^2/hr, as the concentration of Castor seed was further increased, weight loss continuously decreased. At 5% concentration, the weight loss obtained was 5.8 mg/dm^2/hr. Inhibitor efficiency was 60% which continuously increased with increase in concentration of inhibitor upto 77%.

Table 1 : Effect of concentration of inhibitor(castor seed)on the rate of attack of mild steel by paste [HCl(4N) ;1 hr.;3.0 gm paste/dm^2 = coating thickness]

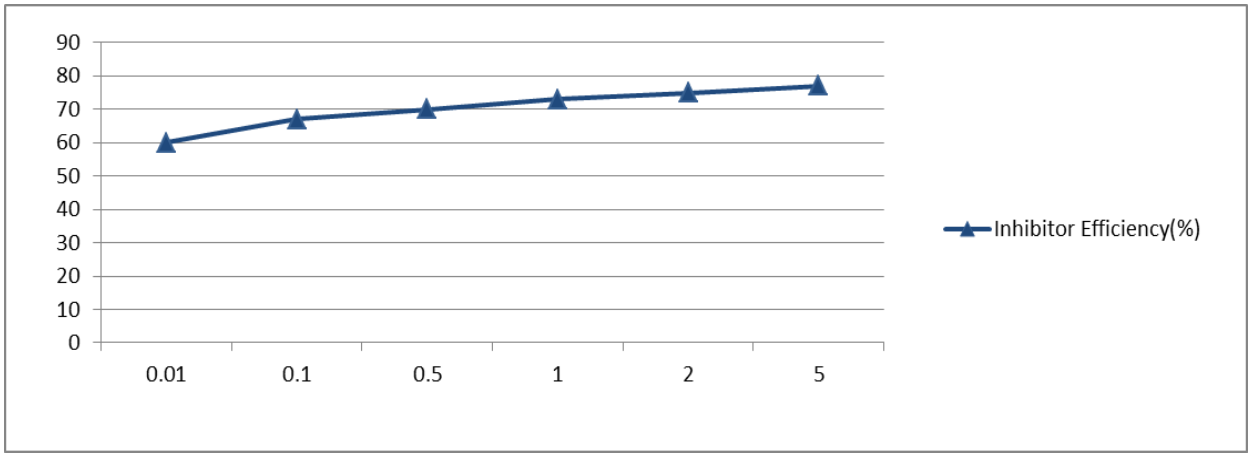
Concentration of inhibitor (%)	Weight loss(mg/dm^2)	Inhibitor Efficiency(%IE)
Nil	25.2	Nil
0.01	10.8	60
0.1	8.3	67
0.5	7.6	70
1	6.8	73
2	6.3	75
5	5.8	77

Figure 1a : Effect of concentration of inhibitor(castor seed)on the rate of attack of mild steel by paste [HCl(4N);RT;1 hr.;3.0 gm paste/dm^2 = coating thickness]



X axis : Concentration of inhibitor (%)
Y axis :weight loss(mg/dm^2)

Figure 1b : Effect of concentration of inhibitor(castor seed)on its inhibitive performance [HCl(4N);RT;1 hr.;3.0 gm paste/dm^2 = coating thickness]



X axis : Concentration of inhibitor (%)
Y axis : inhibitor efficiency(%IE)

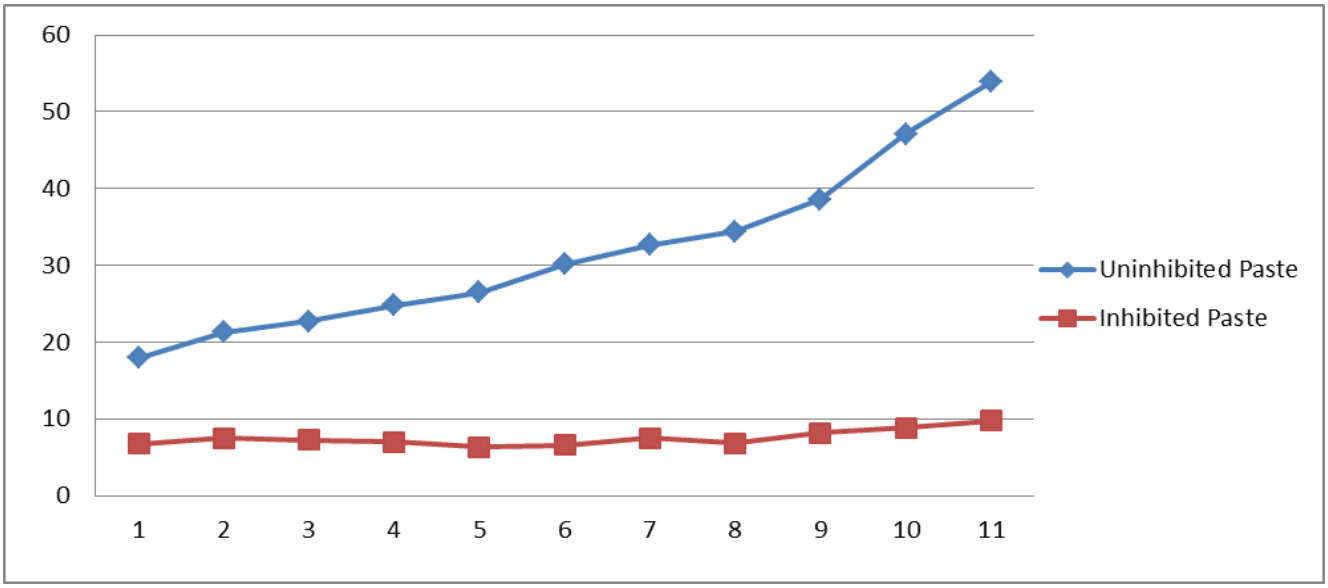
B. Effect of Concentrationof HCl :

Table 2 and figure 2[a and b] shows rate of dissolution of rust and weight loss of mild steel in paste with different concentration of HCI [1N- 11N] in the absence and presence of 1.0% castor seed [CS] at room temperature. the addition of CS reduced the weight loss considerably, weight loss of mild steel specimens in paste with 1N to11N HCI varied from 18 mg/dm^2/hr to 53.9 mg/dm^2/hr ; in inhibited system weight loss obtained ranged from 6.8 mg/dm^2/hr to 9.8 mg/dm^2/hr. The inhibitor efficiency ranged from 62% in 1N to 82% in 11N HCl.

Table 2 : Effect of change of concentration of HCl in inhibited paste on the rate of attack of mild steel [RT;1 hr.;3.0 gm paste/dm^2 = coating thickness; castor seed = 1%]

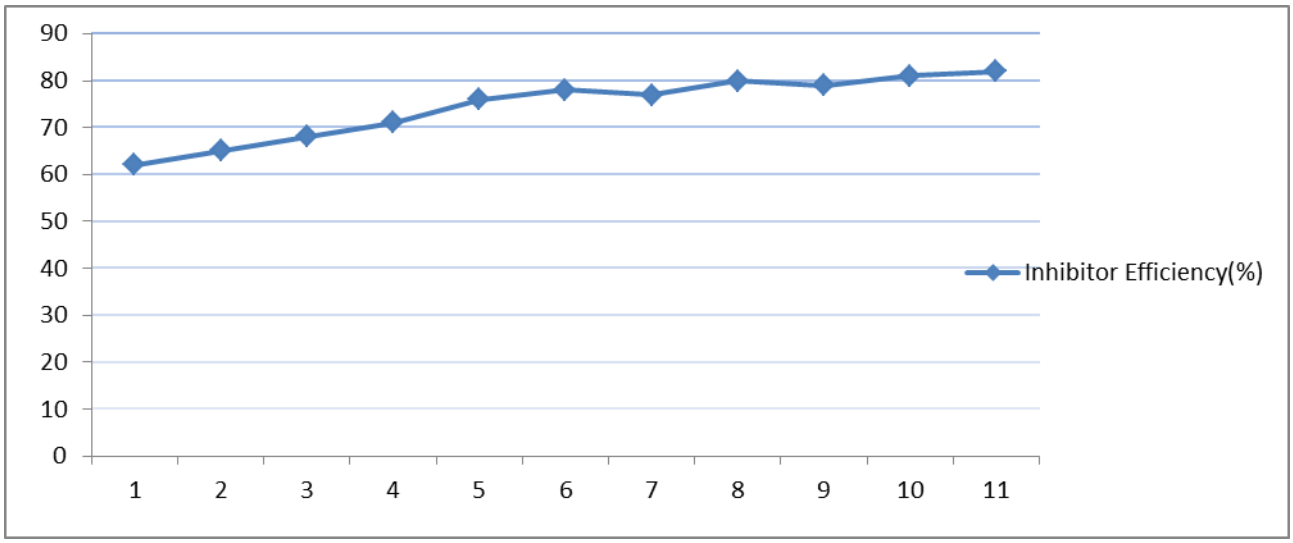
Concentration of acid in pickling paste(N)	Weight loss (mg/dm^2)		Inhibitor Efficiency (%IE)
	Un.	In.	
1	18.0	6.8	62
2	21.3	7.5	65
3	22.7	7.3	68
4	24.8	7.0	71
5	26.5	6.4	76
6	30.2	6.6	78
7	32.7	7.5	77
8	34.4	6.9	80
9	38.6	8.2	79
10	47.1	8.9	81
11	53.9	9.8	82

Figure 2a : Effect of change of concentration of HCl in inhibited paste on the rate of attack of mild steel [RT;1 hr.;3.0 gm paste/dm² = coating thickness; castor seed = 1%]



X axis : Concentration of acid in pickling paste(N)
Y axis :weight loss (mg/dm²/hr)

Figure 2b : Effect of change of concentration of HCl in inhibited paste on inhibitor efficiencyof castor seed [RT;1 hr.;3.0 gm paste/dm² = coating thickness; castor seed = 1%]



X axis : Volume of acid HCl(N)
Y axis : Inhibitor efficiency (%IE)

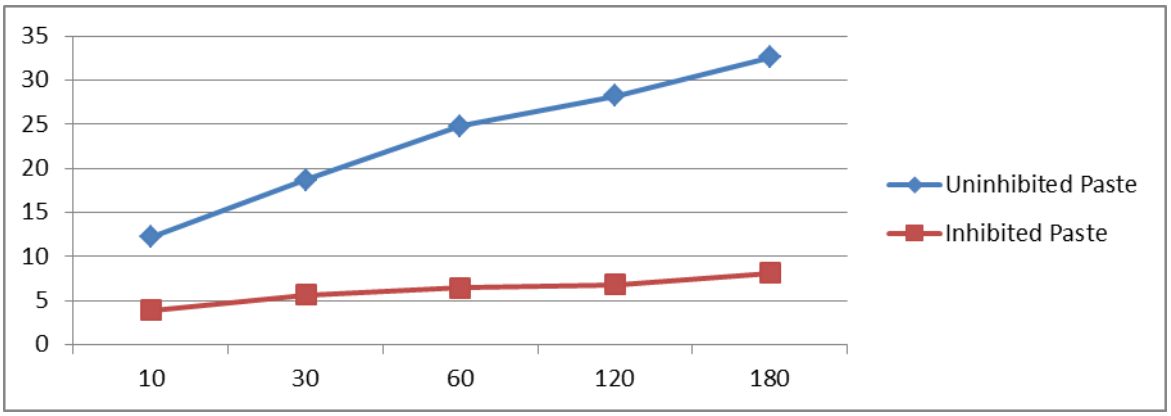
C. Effect of time of application :

Table 3 and figure 3[a and b] shows weight loss of mild steel specimens for 10 minutes to 180 minutes in uninhibited paste varied from 12.2 mg/dm² to 32.6 mg/dm² and in inhibited paste varied from 3.9 mg/dm² to 8.1 mg/dm². The inhibitor efficiency varied from 68% to 75%.

Table 3 : Effect of time of application of inhibited paste on the rate of attack of mild steel[HCl(4N);RT;3.0 gm paste/dm² = coating thickness; castor seed = 1%]

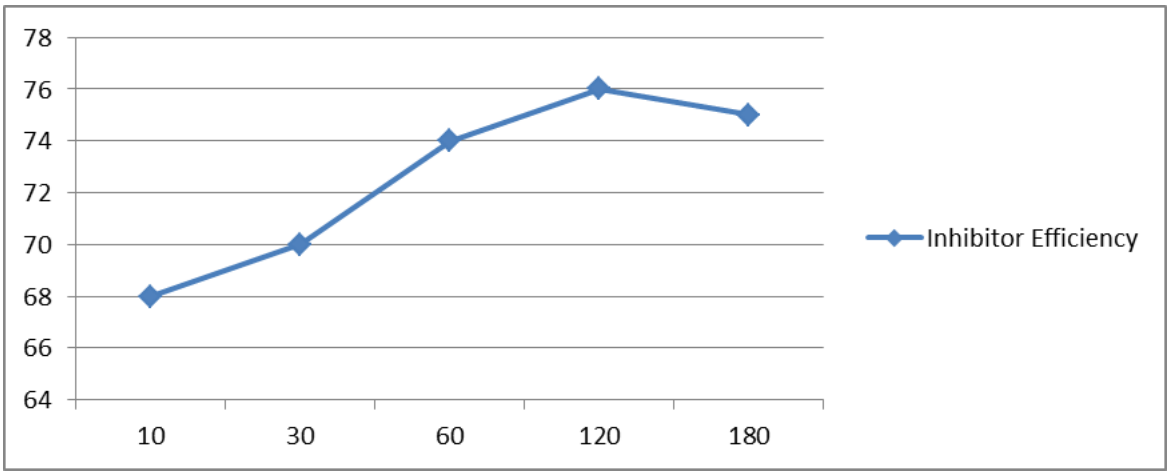
Time of Application (min.)	Weight loss (mg/dm²)		Inhibitor Efficiency (%IE)
	Un.	In.	
10	12.2	3.9	68
30	18.7	5.6	70
60	24.8	6.4	74
120	28.2	6.8	76
180	32.6	8.1	75

Figure 3a : Effect of time of application of paste on the rate of attack of mild steel[HCl(4N);RT;3.0 gm paste/dm² = coating thickness; castor seed = 1%]



X axis : Time of application (min.)
Y axis : weight loss (mg/dm²)

Figure 3b : Effect of time of application of paste on the inhibitive performance of castor seed[HCl(4N);RT;3.0 gm paste/dm² = coating thickness; castor seed = 1%]



X axis : Time of application (min.)
Y axis : Inhibitor Efficiency (%IE)

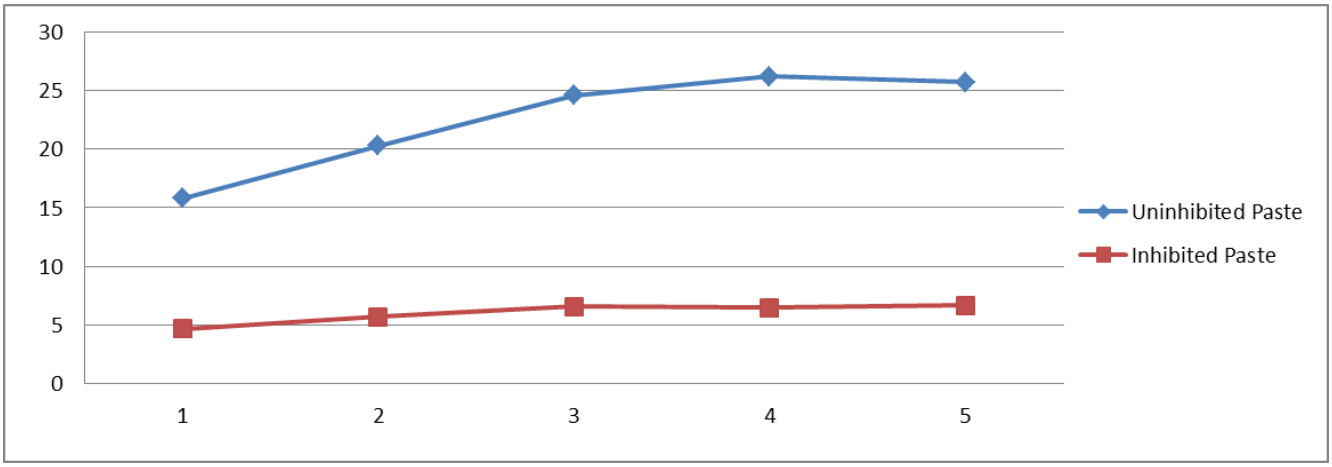
D. Effect of Coating thickness :

Table 4 and figure 4[a and b] show that weight loss of mild steel specimens having paste [uninhibited] thickness 1gm/dm^2 to 5 gm/dm^2 varied from 15.8 mg/dm^2/hr to 25.7 mg/dm^2/hr ; in inhibited paste the weight loss ranged from 4.7 mg/dm^2/hr to 6.7 mg/dm^2/hr. Inhibitor efficiency changed from 70% to 74%.

Table 4 : Effect of coating thickness of inhibited paste on the rate of attack of mild steel[HCl(4N) ;RT; 1 hr.; castor seed = 1%]

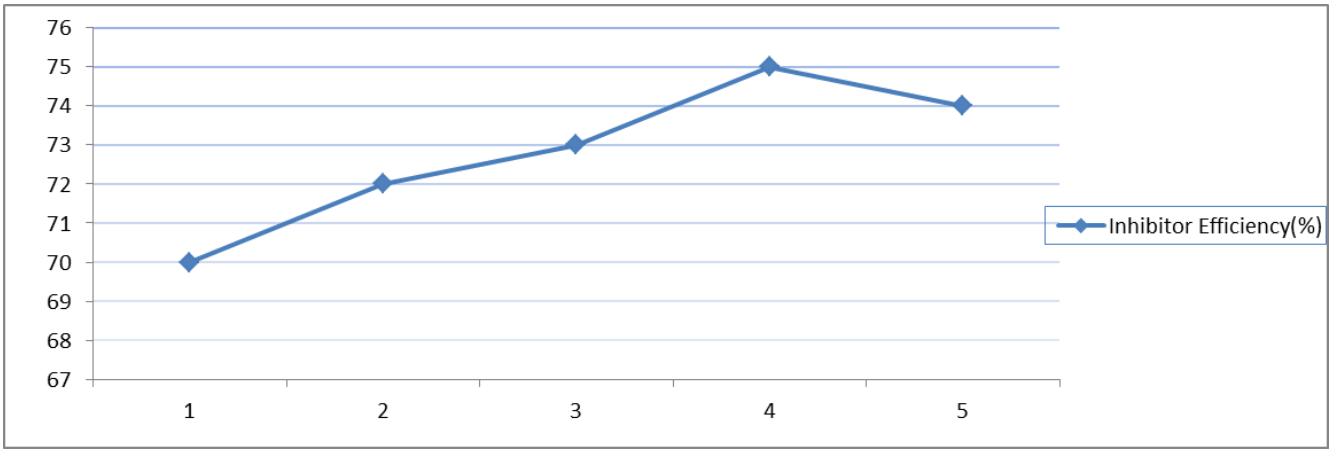
Coating Thickness(gm/dm^2)	**Weight loss (mg/dm^2)**		**Inhibitor Efficiency (%)**
	Un.	In.	
1	15.8	4.7	70
2	20.3	5.7	72
3	24.6	6.6	73
4	26.2	6.5	75
5	25.7	6.7	74

Figure 4a :Effect of time of application of paste on the rate of attack of mild steel[HCl(4N);RT;3.0 gm paste/dm^2 = coating thickness; castor seed = 1%]



X axis :Coating Thickness(gm/dm^2)
Y axis : weight loss (mg/dm^2)

Figure 4b :Effect of time of application of paste on the inhibitive performance of castor seed[HCl(4N);RT;3.0 gm paste/dm2 = coating thickness; castor seed = 1%]



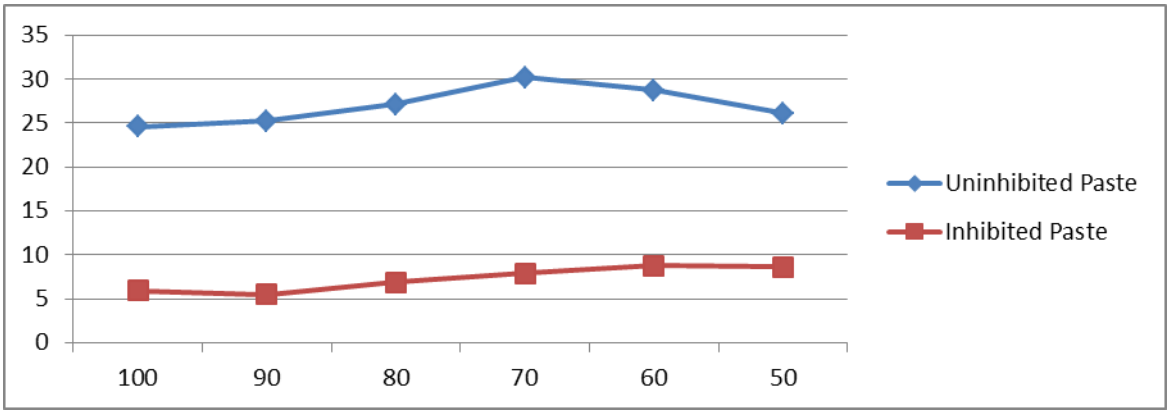
X axis :Coating Thickness(gm/dm²)
Y axis : Inhibitor Efficiency (%IE)

E. Effect of Water Content :

Table 5 and figure 5[a and b] show the effect of water content of paste [100% - 50%] on the inhibition of corrosion of mild steel by 1.0% castor seed in the paste containing 4N HCl.In uninhibited paste the weight loss of mild steel specimens varied from 24.6 mg/dm²/hr to 26.1 mg/dm²/hr in the range of 100% water to 50% water. In inhibited system, the weight loss varied from 5.9 mg/dm²/hr to 8.6 mg/dm²/hr for the same range of water content. It is seen that the decrease in water content does not hamper the effectiveness of the inhibitor. The inhibitor efficiency varied from 76% at 100% water content to 67% at 50% water content.

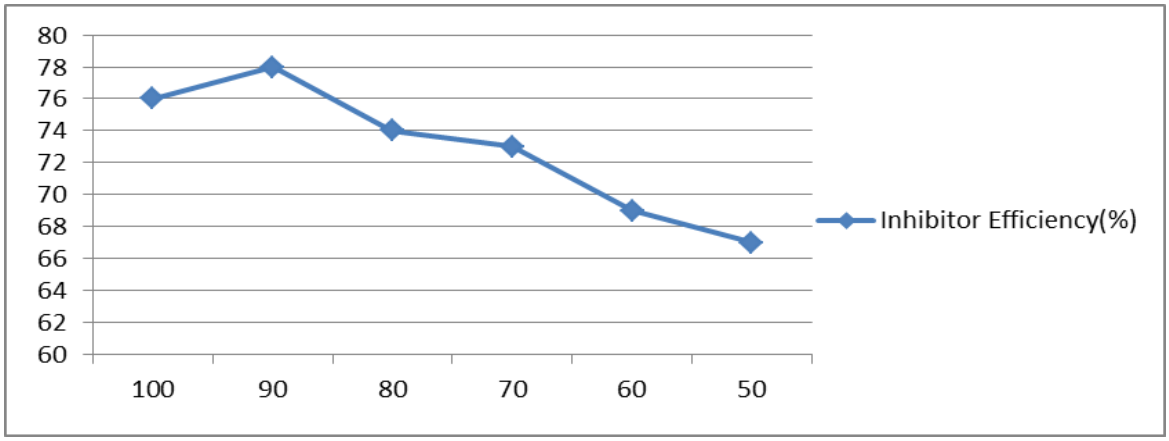
Table 5 : Effect of water content of inhibited paste on the rate of attack of mild steel[HCl(4N) ;RT;3.0 gm paste/dm² = coating thickness; 1 hr; castor seed = 1%]

Water Content(%)	Weight loss (mg/dm2)		Inhibitor Efficiency (%)
	Un.	In.	
100	24.6	5.9	76
90	25.2	5.5	78
80	27.1	6.9	74
70	30.2	7.9	73
60	28.7	8.8	69



X axis :Water Content(%)

Y axis : weight loss (mg/dm2)



X axis :Water Content(%)
Y axis : Inhibitor Efficiency (%IE)

F. Effect of temperature :

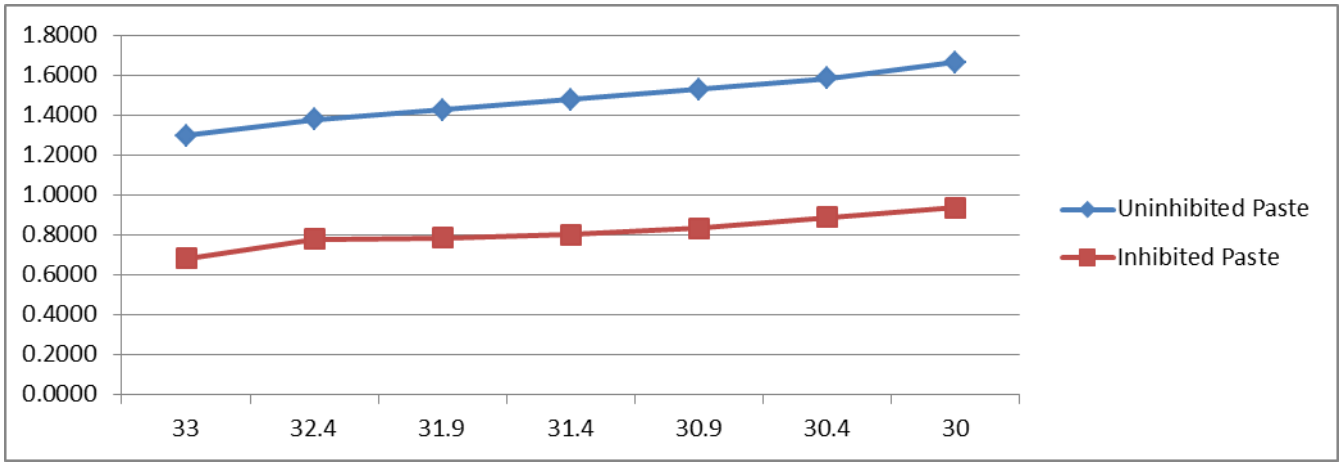
Table 6 and figure 6[a and b] show the effect of temperature (30°C-60°C) on attack of mild steel due to paste containing 4N HCl with and without 1.0% Castor seed. In uninhibited paste, the weight loss of mild steel specimens varied from 19.8 mg/dm^2/hr to 46.2 mg/dm^2/hr in a temperature range of 30°C to 60°C. In inhibited paste, the weight loss varied from 4.8 mg/dm^2/hr to 8.6 mg/dm^2/hr respectively at the same temperature range. The inhibitor efficiency varied from 76% at 30°C to 81% at 60°C.

Arrhenius plots have been drawn showing the dependence of log corrosion rate on 1/T for uninhibited paste and inhibited paste. The linear nature of both the curves indicates that they obey the Arrhenius Equation.

Table 6 : Effect of Temperature on the rate of attack of mild steel [HCl(4N);1 hr.;3.0 gm paste/dm^2 = coating thickness; castor seed = 1%]{also shows the values of 1/T and log weight loss to obtain Arrhenius plot}

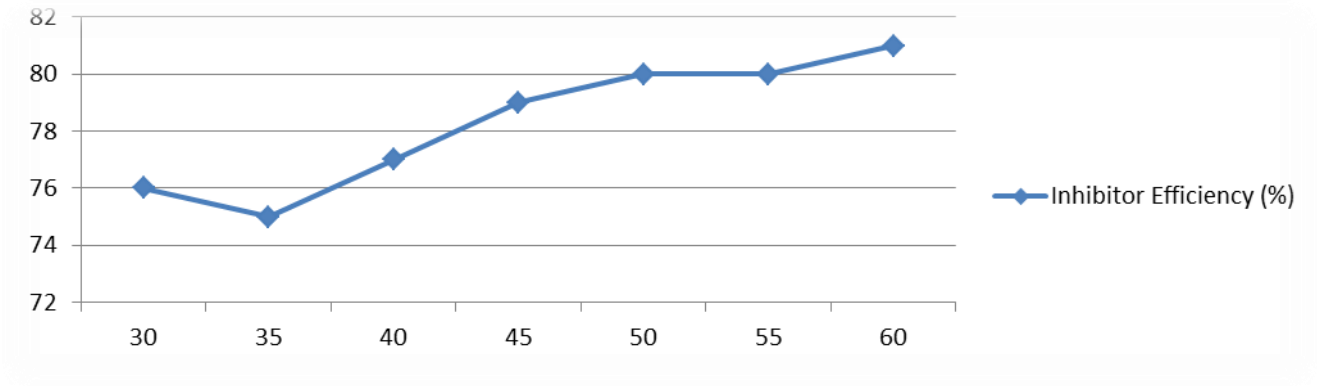
Temperature (°C)	1/T * 10^4	Weight loss (mg/dm^2)				Inhibitor Efficiency (%IE)
		Un.	log Weight loss	In.	log Weight loss	
30	33	19.8	1.2967	4.8	0.6812	76
35	32.4	23.9	1.3784	6	0.7782	75
40	31.9	26.7	1.4265	6.1	0.7853	77
45	31.4	30.1	1.4786	6.3	0.7993	79
50	30.9	33.8	1.5289	6.8	0.8325	80
55	30.4	38.4	1.5843	7.7	0.8865	80
60	30	46.2	1.6646	8.6	0.9345	81

Figure 6a : Effect of Temperature on the rate of attack of mild steel [HCl(4N);1 hr.;3.0 gm paste/dm^2 = coating thickness; castor seed = 1%] [Arrhenius Plot]



X axis : 1/T * 104
Y axis : log weight loss

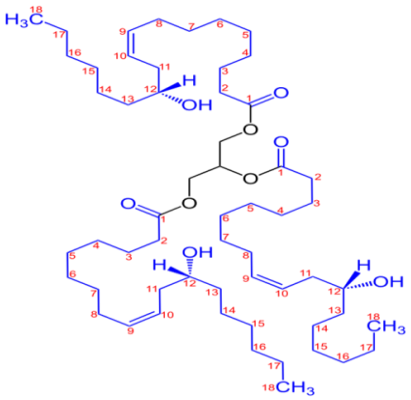
Figure 6b : Effect of Temperature on inhibitive performance of castor seed [HCl(4N);1 hr.;3.0 gm paste/dm^2 = coating thickness; castor seed = 1%]

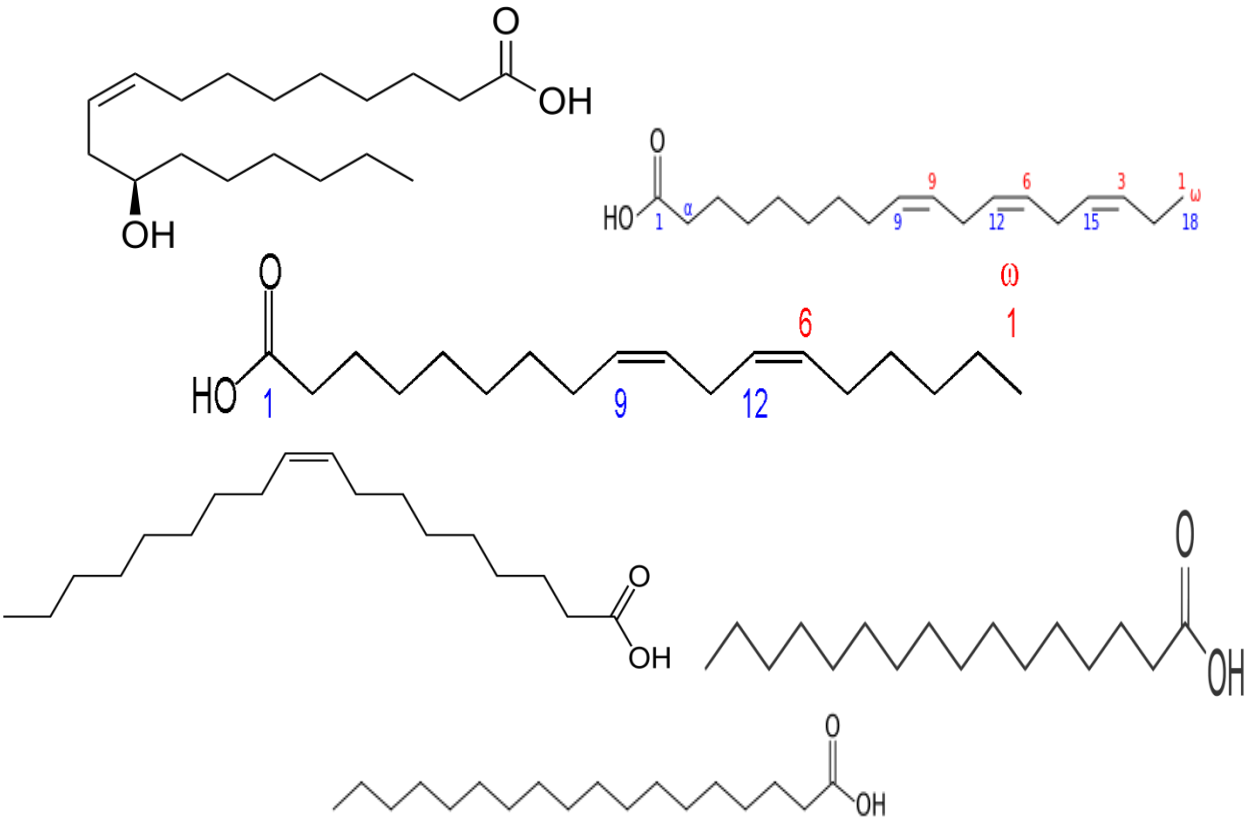


X axis : Temperature (^{0}C)
Y axis : Inhibitive Efficiency (%IE)

4. CONCLUSIONS

The adsorption of castor seed extract is uniform over the surface. The extract acted mainly as anodic type inhibitor. The inhibition is due to the formation of the film on the metal/acid solution interface through adsorption of castor seed extract molecules. Chromatographic separation of the extract resulted in the isolation of





CHEMICAL CONSTITUTION OF CASTOR SEED

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BIOGRAPHIES

Dr. Mahima Srivastava is M.Sc. [GOLD MEDALLIST], Ph.D and Associate Professor, Department of Chemistry, DBS (PG) College, Dehradun, Uttarakhand, INDIA. She has a teaching experience of more than fourteen years.