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Castor Oil as Corrosion Inhibitor for Iron in Hydrochloric acid

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ABSTRACT

Weight loss method was used for studying corrosion behavior of iron in hydrochloric acid, with and without castor oil. It was observed that in acidic medium the % inhibition efficiency for corrosion increased with increasing castor oil concentration. The adsorption of castor oil on iron was found to follow the Langmuir adsorption isotherm at all concentrations.

Key words: Corrosion, Castor oil, Weight loss.

INTRODUCTION

Castor oil is a vegetable oil obtained from the castor plant, ricinus communis. It is colourless to very pale yellow oil with mild or no odour or taste. It is a monosaturated fatty acid in which about 90% of fatty acid chains are ricinoleic acid, 6% oleic acid, 5% linoleic acid and about 1%stearic acid and palmitic acid .It's boiling point is 313°C[1].

Castor oil has wide range of uses. In the food industry it is used as food additives[2-3]. In medicine, it is used as a laxative, and its derivative are used for skin problem, for skin conditioning etc [4]. Ricinoleic acid is the main component of castor oil and it exerts anti-inflammatory effects. Castor oil is added to many modern drugs for curing various many diseases[5-6].

Castor oil can be used as an effective corrosion inhibitor because of its structure[7]. It has high percentage of fatty acid and the presence of ricin & ricinoleic acid in castor oil worked as inhibitor in 0.5 N HCL solution.The oil formed a thin film on the surface of the metal (Fe) due to adsorption obeying Langmuir adsorption isotherm. It offers large surface coverage due to long hydrocarbon chains.The presence of OH groups in all the fatty acid chains makes the oil unusually polar. It is because of this hydroxyl groups only that castor oil becomes valuable as chemical feedstock. It allows chemical derivatization which is not practical with most of the other seed oils. Structure of the major component of castor oil is represented as shown in Fig 1.

EXPERIMENTAL

Castor oil used as inhibitor for iron was checked for its purity by its boiling point. Rectangular specimens, (coupons) of iron i.e. mild steel of size 3×2×0.2 cm were used for weight loss method. The

composition of these specimens was 1.5% C & remaining Fe. These specimens were degreased before use with fine emery paper. After washing with distilled water and acetone they were dried in oven at 50^{0}C for about 20 minutes and then cooled to room temperature in desiccators and weighed till constant weight was obtained. Each coupon was suspended by a glass hook in separate beakers containing 20 ml 0.5 N HCl solution for 24 hours immersion time. After this immersion time the test coupons were cleaned with distilled water and then dried and finally weighed to evaluate weight loss.

The percentage inhibition efficiency by the weight loss method was calculated by:

$$IE\ \% = [1-W1/W2] \times 100$$

Where W1 & W2 are the weight losses (g) for iron in the presence and absence of inhibitor respectively in 0.5 N HCl solution. The degree of surface coverage (θ) is given by the equation,

$$\theta = 1-(w1/w2)$$

and the corrosion rate in milli miles per year can be calculated by the equation,

$$\text{Corrosion rate} = 87.6\ w\ /pAt$$

Where w is the weight loss (g), p is the density of specimen (g/cm) A is the area of specimen (sq.cm) and t is the exposure time in hrs.[8,9].

RESULTS AND DISCUSSION

The value of inhibition efficiency (IE %), surface coverage and corrosion rate for different concentration of the inhibitor for 24 hours immersion period in 0.5 N HCl solution is shown in Table I. The above parameters were calculated from the weight loss values. The data shows that the inhibitor efficiency increased with the increase in concentration of the inhibitor.

Based on Langmuir adsorption isotherm the mechanism of corrosion can be explained on the basis of adsorption behavior of the inhibitors[10]. The reactions are as follows:

$Fe \rightarrow Fe^{+2} + 2e^-$ (anodic reaction) ...(1)

$2H^+ + 2e^- \rightarrow 2H_{ads}$ (cathodic reaction) (From acid) ...(2)

$O_2 + 6H^+ + 6e^- \rightarrow H_2 + 2H_2O$ (cathodic reaction) ...(3)

From weight Loss method the degree of surface coverage (θ) for different concentration of

Table 1: Inhibitor efficiency (IE %), surface coverage and corrosion rate obtained from weight loss method for iron in 0.5 n hcl for 24 h immersion time

S. No.	Conc. of inhibitor(g/L)	ΔW(g)	IE%	Surface coverage(θ)	Corrosion rate (mmpy)
1	0	0.497	-	-	0.03293
2	1	0.124	75.05	0.7505	0.008215
3	2	0.115	76.86	0.7686	0.00762
4	3	0.090	81.89	0.8189	0.00596
5	4	0.081	83.70	0.8370	0.00536
6	5	0.060	87.92	0.8792	0.00397

Table 2: Langmuir adsorption parameters for the adsorption of castor oil on the surface of iron

Temp (K)	K_{ads}	slope	$\Delta G_{ads.}$(KJ/mole)	R^2
303	2.9673	1.091	-12.57	0.996

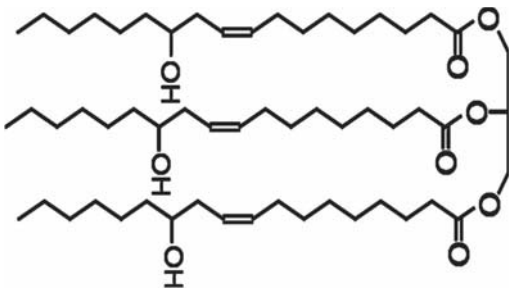

Fig. 1: Structure of the major component of Castor oil

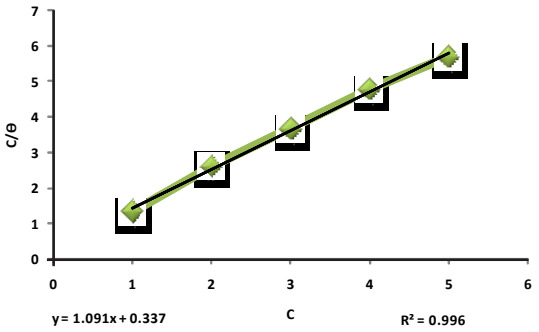

Fig.1 Graph of C/θ vs. C

inhibitor were evaluated graphically and from this the plot of C/θ vs. C shows a straight line (Fig.1) C/ θ = C+1/K here C is the concentration in gm/l, θ = Surface coverage, K is equilibrium constant of adsorption. The important phenomenon is that the adsorption isotherm in 0.5 N HCl is of Langmuir type with slope of almost unity and this shows that the inhibitor covers the metallic surface by general adsorption and a monolayer of the inhibitor is probably attached to the metallic surface.

The free energy of adsorption $\Delta G_{ads.}$ for castor oil on iron surface was calculated by the following equation

$$\Delta G_{ads.} = -2.303\ RT \log (55.5\ K_{ad}) \quad ...(4)$$

Where R is the gas constant, T is temperature in Kelvin, K_{ad} is the equilibrium constant of adsorption and 55.5 is the concentration of water in the solution.

The negative value of $\Delta G_{ads.}$ as shown in Table II, shows that the adsorption has taken place by physical process and not by chemical reaction. It also indicates the stability of the adsorbed layer on the metallic surface.

CONCLUSION

Castor oil acts as an excellent corrosion inhibitor in acidic medium .With a small amount of castor oil 1g/L to 5g/l in 0.5 N HCl solution, inhibition efficiencies of 75-87 % were obtained. These efficiencies were obtained by simple weight loss method at room temperature.

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