Inhibition of Steel Corrosion in 10% HCl Solution by Using of Henna

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Abstract

Corrosion of steel in 10% HCl solution under the effect of temperature variation in absence and presence of henna was held. Due to toxicity of many chemicals-used as inhibitors- as well as the expensive manufacturing costs and availability, the world orientation is to use safe and natural materials as an inhibitor.

In this paper a trial of using henna (which is used as hair treatments in human being) as an inhibitor to protect steel in the above corroding solution. Good results were obtained by using this natural material by using the weigh loss technique for corrosion detection.

الخلاصة

تمت دراسة تاكل الفولاذ في محلول HCl 10%تحت تاثير تغير درجة الحرارة بغياب ووجود مادة الحناء. نظرا لسمية الكثير من المواد الكيمياوية- المستخدمة كمثبطات تاكل- اضافة الى كلف التصنيع وتوفرها, كانت وجهة العالم باتجاه استخدام مواد امينة وطبيعية كمثبطات للتاكل.

في هذا البحث جرت محاولة استخدام مادة الحناء (المستخدمة في معالجة الشعر للانسان) كمثبط يستخدم لحماية الفولاذ في المحلول الاكال اعلاه. نتائج جيدة تم الحصول عليها باستخدام هذا المثبط باستخدام تقنية الفقدان بالوزن كاسلوب لفحص التاكل.

Introduction

Surface preparation and finishing require the use of mechanical means or the chemical one organic, inorganic, acid, alkalis solutions .etc (Lowenhiem, 1978). Any metal has its own course of preparation to the final finishing, e.g., plating or coating. One of the techniques used for descaling of rusts is to treat the surfaces of metals with acid solutions alone or in mixture at ambient or elevated temperature. Since one wants to control the dissolving layer of the surface for the case of technological purposes as well as economic and environmental one, the need for the usage of inhibitor is seemed to be insisted. There are many classifications for inhibitors, viz. anodic, cathodic, safe or unsafe and else can be found elsewhere (Shreir 1994).

There is increasing concern about the toxicity of corrosion inhibitors in industry. The toxic effects not only affect living organisms but also poison the earth as well as their manufacturing cost, a new trend to use natural inhibitors or what is termed ***Green Inhibitors*** was relied**.** Some workers used some plants extracts (Arora P. et al 2007), honey (Yin Jin Yee, 2004)….etc.

In this study the use of natural material known *henna* was done via exposing a steel slab to a 10 %HCl solution under various temperature values. These conditions were used as close to that used in industry during metal finishing knowing that there are many studies about corrosion inhibition of steel in hydrochloric acid solutions (Shreir, 1994).

Experimental Work

In this study detection of corrosion was done by the weight loss method.

Pieces of steel having the composition of table 1 were prepared by emery paper cleaning then rinsing in 3% HCl solution for a sufficient period and at the end of cleaning washing with distilled water and drying by soft tissue. The studied specimen was weighted to give w_1(before) in a four digit balance and hanged by a string made of a polymer in a beaker of 500 ml capacity for the specified time. To control the temperature of the beaker solution a Haak W13 water bath with accuracy of ±2°C was used. After putting the beaker in the water bath the temperature inside the beaker solution was detected until it reached to a steady value at which initiation of the run given the green light. At the end run, the specimen was picked up, washing it by distilled water drying it then weighting to yield the second (after) w_2 reading. The difference of the two values, i.e., w_1 and w_2 gave Δw(weight loss) .

Table 1: composition of the used steel

C	Mn	Si	Ni	S	Cr	Fe
0.1977	0.152	0.155	0.064	0.0265	0.021	0.9938

The solution used was 10 % HCl prepared form 36% HCl (analar grade) by dilution with tap water. The inhibitor used in this study is known as henna. Three concentrations of henna were used, i.e., 1, 2 and 3 gram for the specified run and it was used as it was sold without ant treatment, the solution volume was 500 ml. Figure1 shows the apparatus of the weight loss. Four specimens were used for a run and the average results were fixed.

Figure 1: the apparatus of the work

Results and Discussion

Table 2 demonstrates the weight loss values with and without the addition of henna(being used as inhibitor) at three temperature values; 27, 50 and 70°C as well as inhibition efficiency which is (Allam et al. 2006):

$$\eta = \frac{W_1 - W_2}{W_1} x100\% \qquad \text{……..1}$$

where:

$\eta = inhibition\ efficiency$

W_1 = weight of the uninhibited specimen in g.

W_2 = weight of the inhibited specimen in g.

Table 2: Weight loss against temperature in the presence and absence of henna, the values between brackets are the inhibition efficiency.

Time, hr	W (g) atΔ C°27				C°50				C°70			
	Quantity of Henna in g				Quantity of Henna in g				Quantity of Henna in g			
	0	1	2	3	0	1	2	3	0	1	2	3
0.5	0.0054	0.0073 (0.351)	0.0041 (0.240)	0.0011 (0.796)	0.0167	0.0066 (0.604)	0.007 (0.850)	0.0087 (0.479)	0.0999	0.0096 (0.903)	0.0157 (0.842)	0.0253 (0.746)
1	0.0236	0.0041 (0.826)	0.0021 (0.911)	0.0013 ((0.944	0.0188	0.0059 (0.686)	0.0113 (0.398)	0.0099)0.473)	0.2142	0.0341 (0.840)	0.0406 (0.810)	0.041 (0.808)
1.5	0.0364	0.013 ((0.642	0.0031 (0.914)	0 ((1	0.091	0.0052 (0.942)	0.0106)0.883)	0.012 (0.868)	0.46	0.0379 (0.917)	0.0597 (0.8700	0.0729 (0.841)

According to these values, the following discussion will be treated:

1-effect of temperature:

A (uninhibited). As the temperature is increased the weight loss increased further for the same time interval (see figure 2).

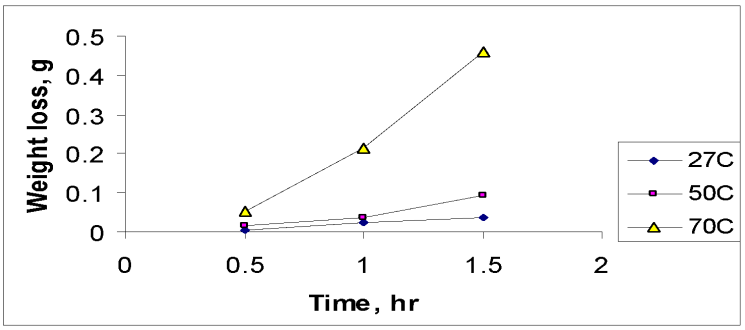

Figure 2: effect of temperature on weight loss at various temperature (without inhibitor)

This proportionality of temperature on weight loss (corrosion current) is expected since the corrosion process is an electrochemical reaction, that is sensitive to the temperature through the activation energy.

B(inhibited case): According to table 2, there is no precise conclusion about temperature effect on corrosion (weight loss) in presence of henna, the explanation for this behavior will be dealt with next.

2-effect of time.

A(uninhibited): for the uninhibited case, approximately a linear relation of the weight loss vs. progress of time and this is a natural result according to Faradays laws, of course in the absence of corrosion products or the depression of depolarizer ion.

B(inhibited): figures 3, 4 and 5 summarize the effect of time on inhibition efficiency at the specified temperature. At 27°C the best efficiency is at 3 g of henna, while at 50 and 70°C a random action is seen and in general corrosion rate is increased which could not be attributed to fail in henna action but to the increase of corrosion intensity with increase of temperature. In our opinion this phenomena could be attributed to kinetic factors of the corrosion process and mainly with respect to the structure of the henna like the density of electrons on the active group of the molecule and so on, which could be affected by temperature rise, therefore, the action of this inhibitor is not by blocking action, rather by kinetic one which explains why inhibition efficiency is decreased as the temperature increased for the same period. This fact was deduced from plotting weight loss against 1/T in order to find the value of corrosion activation energy which takes the form:

$$W = K.\exp(-E/RT) \quad \text{.....2}$$

where
W is the weight loss value
K is a constant
E is the activation energy

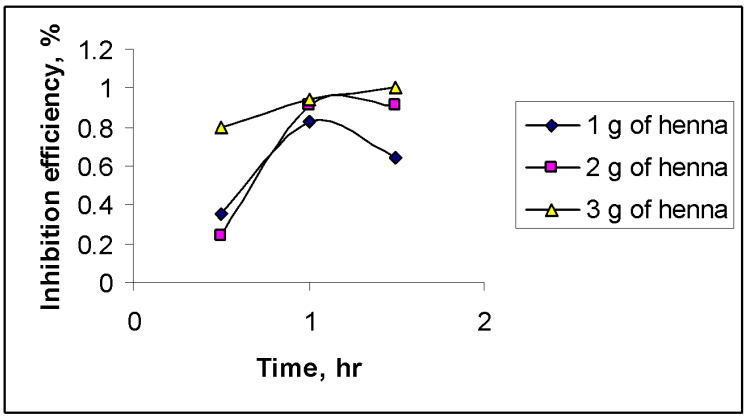

Figure 3: Efficiency of inhibitor as function of time at 27C

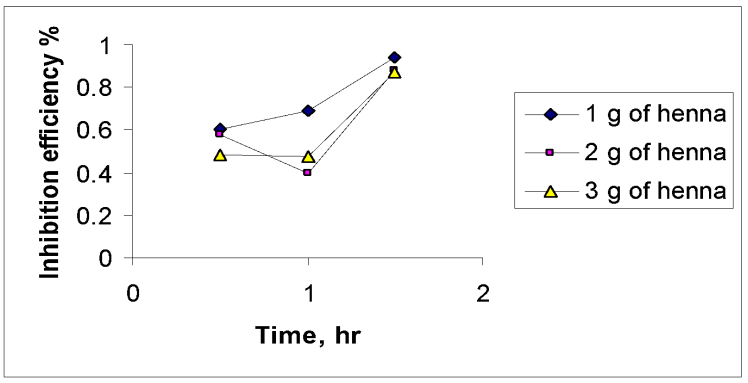

Figure 4 : Efficiency of inhibitor as function of time at 50C

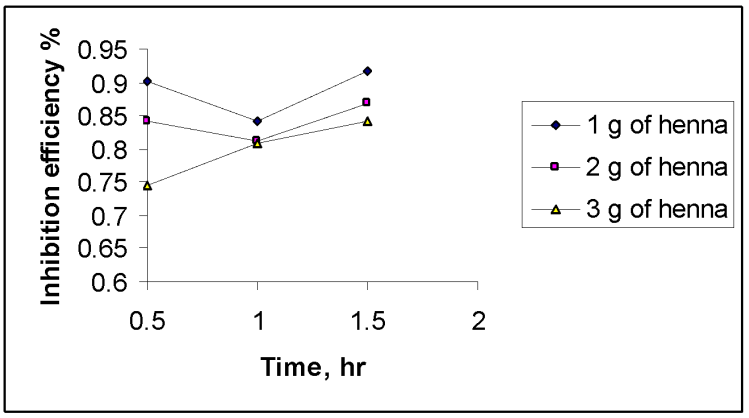

Figure 5 : Efficiency of inhibitor as function of time at 70C

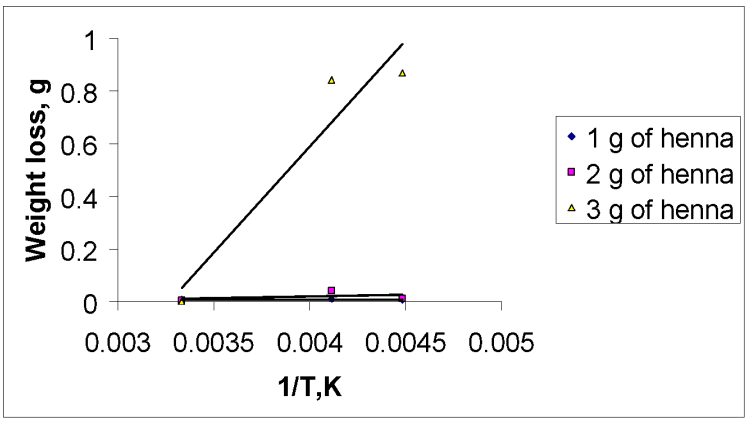

Figure 6: the relation of 1/T against weight loss in the presence of different inhibitor concentrations

Figure 6 shows such relation and table 3 summarizes the E values.

Table 3: activation energy values for the corrosion of steel in presence of henna

Quanity of inhibitor (henna), g	1	2	3
Activation energy, kJ/mol	0.00046	-0.104	-6.67

In general the minimum corrosion rate lies in presence of henna at 3g for the experiment temperature range, i.e., 27-70°C.

Conclusions

Henna is safe and excellent inhibitor for corrosion protection in 10% HCl solution and henna action does not affected by temperature rise. It is thought to act via kinetic action. High values of inhibition efficiency were detected by using variable concentrations of this substance at various temperatures.

References

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