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Using natural materials as corrosion inhibitors for carbon-steel on phosphoric acid medium

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Abstract

The inhibitive action of pomegranate peel as a plant source the corrosion of carbon-steel in phosphoric acid solutions was studied using the weight-loss method. Organic compounds present in natural materials are successfully used to reduce the rate of corrosion because they are cheap, renewable and effective. The results showed that the inhibition potency was enhanced with increasing increasing the amount of the inhibitor and the immersion time but it decreased with the increase of the concentration of the acid solution. The results also revealed a gradual increase in the corrosion rate with the increase of temperature, while the corrosion protection efficiency and surface coverage decreased.

Keywords: pomegranate peel, corrosion rate, carbon steel, protection efficiency.

استخدام مواد طبيعية كمثبطات تأكل للحديد الكاربوني في وسط حامض الفسفوريك

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الخلاصة

تم دراسة الفعل التثبيطي لقشور الرمان كمصدر نباتي على تأكل الحديد الكاربوني في محاليل حامض الفسفوريك بطريقة الفقدان في الوزن.
المركبات العضوية الموجودة في المواد الطبيعية تستخدم بنجاح لتقليل سرعة التاكل وذلك لرخصها وامكانية تجديدها وفعاليتها.
اوضحت النتائج ان فاعلية التثبيط تزداد بزيادة كمية المادة المثبطة وزمن الغمر وتقل بزيادة تركيز الحامض .
وكذلك اشارت النتائج انه بارتفاع درجة الحرارة هناك زيادة تدريجية في معدل التاكل بينما قلت كل من كفاءة حماية التأكل ومعدل التغطية للسطح.

1. Introduction

The importance of studying he carbon-steel corrosion related to large applications of this metal in the different industries this due to the availability and a cheap cost [1]. Corrosion causes a deterioration of metal surfaces and alloys causing economic consequences in terms of replacement, repair, product losses, environmental pollution and safety [2]. For this reason, it is very important to prevent the corrosion. Suitable modification can be made to control the corrosion of metal, the use of proper inhibitors is one way to prevent the corrosion of metals [3]. A corrosion inhibitor is a substance added to the environment in a small amount to effectively prevent or decrease the rate of metal corrosion that is exposed to that environment [4]. Inhibitors can be widely divided into two broad categories, the first enhances the oxide film that the surface of metal through an oxidizing effect, and

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the second is adsorbed on the surface of metal adsorbed [5]. A large number of such inhibitors are compounds of organic source containing hetro atoms like Sulphur, nitrogen, oxygen and phosphorous. Most of these compounds are toxic, expensive, and non-biodegradable [6] causing a wide pollution problems. Plants are used in large quantities as inhibitors due to its environmentally acceptable, cost effective, and its abundant availability. For this reason, this natural product was used as corrosion inhibitors for alloys and metals [7]. The peels of orange, pomegranate and mango were seed in the study of the corrosion of zinc, aluminum, steel and copper in H_2SO_4 and HCL [8].

Okafor et al. in 2008 studied the effect of pomegranate alkaloids to reduce the corrosion of mild-steel in H_2SO_4 [9] . Henna has been tested for its effect to prevent the corrosion of nickel and zinc in neutral, alkaline and acidic media [10]. The use of eco-friendly inhibitors for corrosion of mild-steel in phosphoric acid medium was reported by Gunse and Chauhan in 2004 [11]. Black pepper, tobacco, acacia gum lignin and castor oil seeds can be good inhibitors for corrosion of carbon-steel in acid solutions [12]. This work seeks to study the use of natural materials (pomegranate peel) as corrosion inhibitor to reduce the rate of corrosion in solution of phosphoric-acid of various concentrations using the weight loss technique.

2. Method

Low carbon steel type (AlSI 5/35) used in this research was obtained from the ministry of Iraq industry with the following composition (Wt. %) C [0.38 - 0.44], P [0.035], S [0.035], Si [0.15 - 0.35], Mn [0.5-0.8], Cr [0.9-1.2]. The diameter of the test pieces is 17mm and their thickness about 7mm. Each specimen was washed with distilled-water, ethanol, dried in acetone then dried in desiccators using silica gel. Pomegranate peel was washed with distilled water to remove impurities and dust , dried in oven at 378K grinded in a ball mill,and finally sieved to particles size range of 0.3-0.6 mm.

Corrosion weight loss teste

The experiment was carried out by immersing the sample in 25 ml H_3PO_4 solution with and without 0.5 g of pomegranate peel powder at room temperature . Different concentrations of H_3PO_4 acid was used ranged (2M, 4M, 6M, and 8M) at different temperatures. Afterwards, each specimen was washed using distilled-water to remove corrosion products. The specimens were immersed in the acid solution for 2h.

The corrosion rate (R) in [mg. $cm^{-2,}$ $hour^{-1}$] was evaluated using equation (1)

$$R = (\Delta m) / \Delta T \qquad \text{...} (1)$$

Where ΔT is the immersion time.

Δm in [mg] is the weight-loss.

Protection inhibition efficiency (%) is determined using equation (2)

$$\%P = [(1- R_w) / R_{w.out}] \times 100 \qquad \text{...................................} (2)$$

Where R_w, $R_{w.out}$ are the corrosion rate of carbon-steel in the presence and absence of pomegranate peel, respectively.

The degree of surface coverage ϴ is calculated from the relation

$$\Theta = R_{w.out} - R\ w. / R_{w.out} \qquad \text{…………………………} (3)$$

3. Results and Discussion

3.1. Effect of H_3PO_4 concentration

Figure-1 shows the effect of H_3P0_4 concentration at different temperatures (293, 303, 313, and 323) K with the presence of 0.5 g of pomegranate peel powder. The graphs reveal that the value of the percentage protection efficiency %P of the pomegranate decreases with increasing H_3PO_4 concentration. If the concentration of the acid increases the ability of the inhibitor to protect the metal surface decreases because a uniform layer of rust is formed when the surface is exposed to corrosive aqueous medium that prevent the inhibitor molecules to reduce the rate of metal wastage.

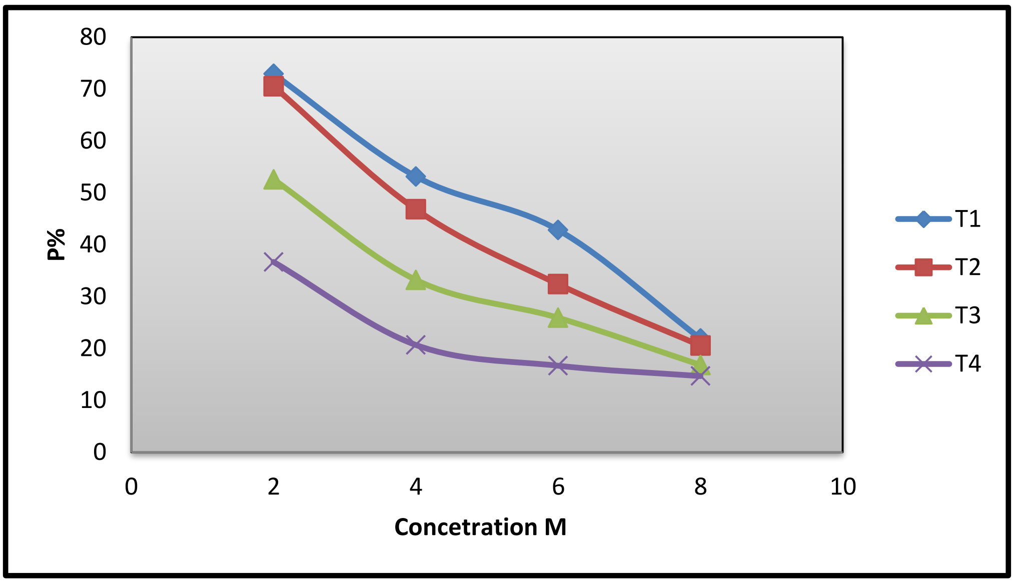

Figure 1- Effect of the concentration of the acid solution on the corrosion of carbon-steel

3.2. Effect of the time of Immersion.

Figure-2 shows the variation of the percentage protection efficiency with immersion time at room temperature. There is a slight increase in the %P (inhibition efficiency) with respect to the time of immersion of the metal in the acid solution. This can be explained as the immersion time increase, the inhibitor molecules have enough time tobe adsorbed at the active sites on the surface and so protect it.

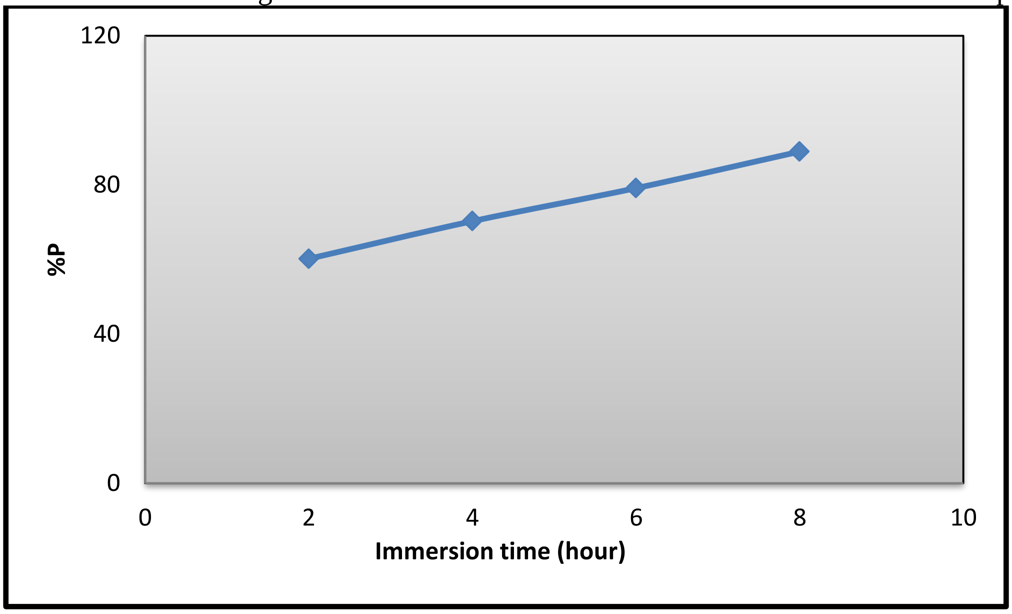

Figure 2- Effect of the time of immersion on corrosion of carbon-steel in 1M H_3PO_4 at 298K.

3.3. Effect of amount of the inhibitor

The effect of the amount of pomegranate peel is shown in Figure-3. There is a slight increase in the inhibition efficiency with the increase of the amount of pomegranate peel. This demeanor may be contacted to the large amount of the covered sites on the metal surface with the adsorbed molecules.

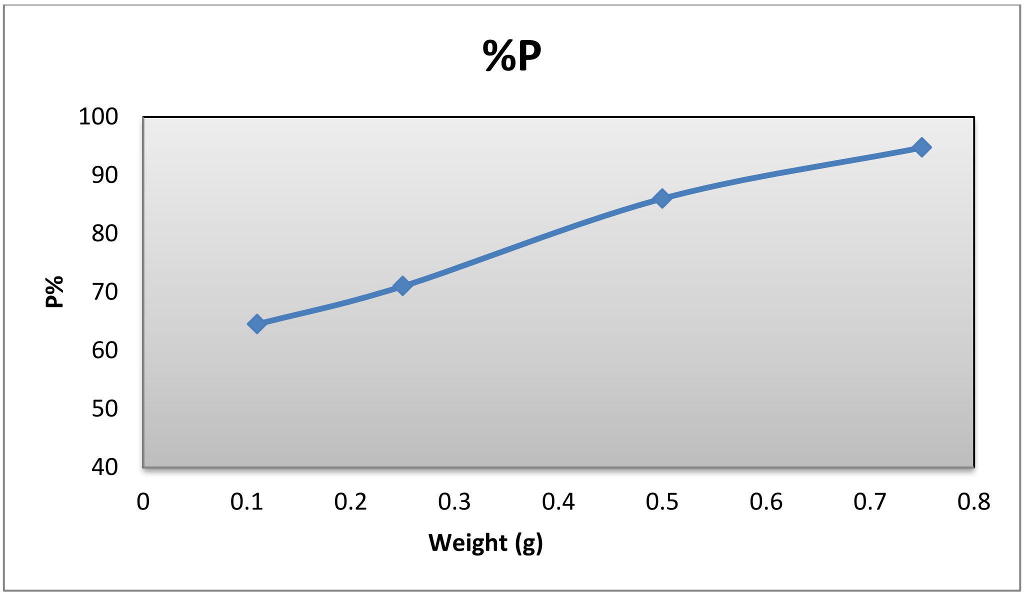

Figure 3- Effect of amount of pomegranate peel on the corrosion of carbon-steel in 4M H_3PO_4 at 298K.

3.4. Effect of rising temperature

The calculated data of corrosion rate, (p %) percentage protection efficiency and (θ) the degree of coverage of carbon-steel surface with the inhibitor at different temperatures are listed in Table-1.

Table 1- Corrosion rate, Protection efficiency and the degree of coverage at different temperatures

Temp / K	Conc. M	Rat. $mg.cm^{-2}$ $hour^{-1}$	Ө	Protection inhibition %
293	0	0.0256		
303		0.03132		
313		0.0661		
323		0.03		
293	2	0.0095	0.6289	62.89
303		0.0092	0.70512	70.512
313		0.0314	0.52575	52.575
323		0.019	0.3666	36.66
293	4	0.012	0.53125	53.125
303		0.0166	0.46795	46.795
313		0.0442	0.331818	33.1818
323		0.0238	0.2066	20.66
293	6	0.0108	0.57812	42.81
303		0.0211	0.3237	32.37
313		0.049	0.259	25.9
323		0.025	0.1666	16.66
293	8	0.02	0.21875	21.875
303		0.0248	0.2053	20.53
313		0.055	0.1679	16.79
323		0.0245	0.1466	14.66

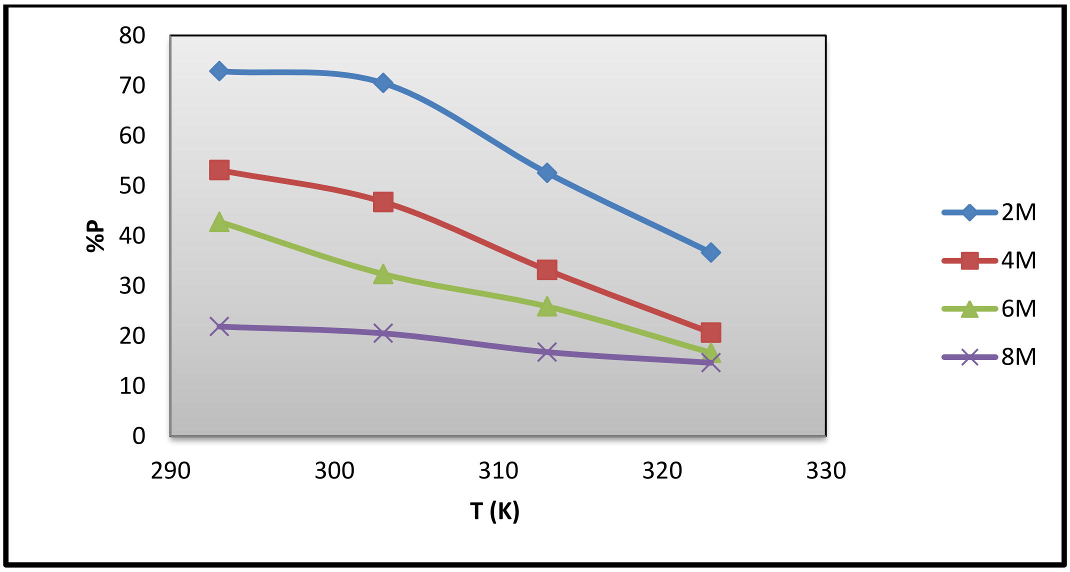

Figure 4- Effect of rising temperature on the carbon-steel corrosion for different H_3PO_4 concentrations and 0.5 g pomegranate peel.

Figure-4, shows the effect of increasing the temperature on the protection inhibition This figure shows that %P decreases with the increase of the temperature. Furthermore, there is an increase in the corrosion rate with the increase of temperature. This can be attributed to the higher dissolution of carbon steel with the rising temperature and a prosperity of desorption process of the inhibitor due to the increase of solution agitation resulting from higher corrosion rates , this causes a reduction in the ability of the inhibitor to be accumulated on the active surface metal sites [13] .

4. Conclusions

From the previous results obtained it can be concluded that

1- Pomegranate peel is an effective natural corrosion inhibitor for carbon-steel in H_3PO_4 medium.

2- Protection efficiency increases with the increase in the amount of pomegranateand the time of immersion and decreases with the increase of the H_3PO_4 solution concentration.

3- The protection efficiency %p decreases with increasing the temperature while the corrosion rate increases.

5. References

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