Mansoura Journal of Chemistry Vol. 35 (2), December, 2008.

INHIBITION CORROSION OF TIN IN SODIUM BICARBONATE SOLUTIONS BY CAROB EXTRACT

M. Abdallah*, A. Y. El-Etre, E. Abdallah and Salah Eid
Chemistry Department, Faculty of science, Benha University,
Benha, Egypt.

(Received: 26 / 10 / 2008)

ABSTRACT

The corrosion behavior of tin electrode in $NaHCO_3$ solutions as well as the effect of aqueous extract of carob was investigated using potentiodynamic techniques. It was found that the corrosion rate decreases in the presence of the extract. The inhibition efficiency increases as the concentration of extract is increased. The inhibitive action of the extract was interpreted in view of adsorption of the extract components at the tin surface. The results showed that such adsorption follows Langmuir adsorption isotherm. The negative value of free energy of adsorption suggests a spontaneous process. Moreover, the addition of carob extract increases the resistance of tin toward pitting corrosion.

Keywords: Corrosion inhibitor, Tin, Carob, Natural products.

1. INTRODUCTION

The corrosion studies of tin are closely related to its wide application in industry. The corrosion behavior of tin has been studied galvanostatically and potentiodynamically in alkaline media **[Pugh (1967); Hampson (1968); Stirruo (1970); Dickinson (1978); Abd El Wahab (1978); Kapusta (1980); Abd El Rehim (1986); Abd El Rehim (1985); Abd El Rehim (1993); Hassan (2002); Abd El Aal (1980); Drogowska (1991) and Gervasi (1997)]**. Nowadays, besides the efficiency of the compound which used as inhibitor, another important factor has to be taken into account to choose the suitable inhibitor. In this sense, despite the demonstrated efficiency of chromate as inhibitor, the known toxicity and carcinogenic properties of Cr (VI) compounds exert a continuous pressure to use green inhibitors with null toxicity [Profile for Chromium (1989)]. The present work was under taken to study the corrosion behavior of tin in 0.1 M $NaHCO_3$ and the effect of addition aqueous extract of Carob **[Macleod & Forcen (1992)]** as an inhibitor.

2. EXPERIMENTAL

The working electrode was made of tin rods (99.999%) axially embedded in Araldite holders to obtain an exposed circular area of 0.53 cm^2. Before being used, the electrodes were polished successively with different emery papers until 1200 grads, degreased with acetone and then rinsed with distilled water. A Pt foil was used as a counter electrode. The potential was measured against a saturated calomel electrode (SCE) as a reference. All solutions were freshly prepared using analytical grade chemicals and distilled water. Dry carob was finely divided and extracted in water for 48 h. The filtrate was evaporated in a steam bath and the solid residue was left overnight in open air for complete dryness. Sucrose is the main component present in the extract. A stock solution was prepared, by weight, from the collected solid and used to prepare the desired concentration by dilution. All experiments were carried out at room temperature 25 ± 1°C. Potentiostatic polarization experiments were carried out using a PS remote potentiostat with PS6 software.

3. RESULTS AND DISCUSSION

3.1. Potentiostatic polarization

Fig. 1 represents the anodic and cathodic polarization curves of tin electrode in 0.1 M $NaHCO_3$ solutions devoid of and containing different concentrations of carob extract. Inspection of the curves of the below figure reveals that the polarization curves shift toward more negative potential and lower current density values upon the addition of the extract.

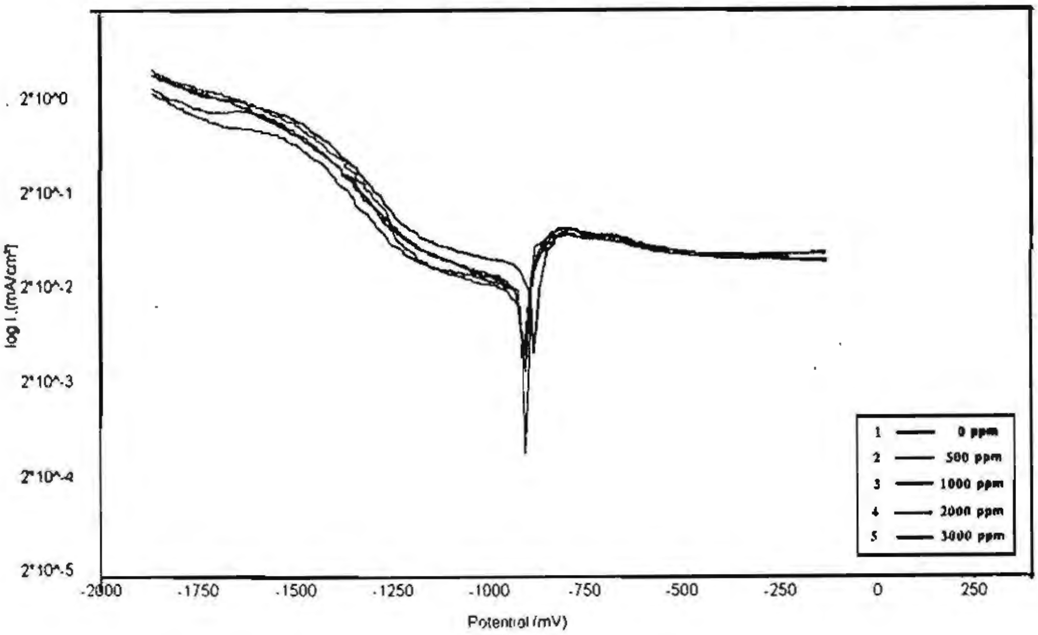

Fig.(1): Polarization curves for tin electrode in 0.1 M $NaHCO_3$ containing different concentrations of Carob extract at scan rate 10 mV/s.

This behavior reflects the inhibitive action of carob extract. The corrosion parameters of tin electrode in the free and inhibited $NaHCO_3$ solutions were obtained from the curves of Fig. 2 and given in Table 1. The data in Table 1 shows that the corrosion potential shifts to more negative values as the concentration of added extract is increased. On the other hand, the corrosion current density is markedly decreased upon addition of the extract. The extent of its decrease increases with increasing extract concentrations. Moreover, the numerical values of both anodic and cathodic Tafel constants decreased as the concentration of extract was increased.

Table (1): Electrochemical parameters of tin in 0.1 M $NaHCO_3$ in presence different concentrations of Carob extract.

Inh. conc. (ppm)	β_a mV.dec^{-1}	β_c mV.dec^{-1}	E_{corr} mV	I_{corr} mA.cm^2	IE %	θ
0	119.45	-336.46	-868	7.843	-	-
500	82.08	-220.85	-894	5.725	27	0.27
1000	73.79	-203.13	-895	4.556	42	0.42
2000	76.02	-162.58	-895	3.372	57	0.57
3000	57.97	-111.20	-895	2.560	67	0.67

3.2. Adsorption behavior

The inhibiting action of carob to tin corrosion could be attributed to the adsorption of its components on the metal surface. The adsorbed molecules form a barrier between the aggressive medium and the metal surface [**Abdallah (2004)**]. The inhibition efficiency is directly related by the fraction of surface covered by the adsorbed molecules (θ). Therefore, θ was calculated as (θ = IE/100) and its values corresponding to different carob concentrations were given in Table (1). Inspection of the table reveals that, the value of θ increases as the additive concentration is increased.

To study the adsorption behavior of carob extract on tin surface in the given medium, the adsorption isotherm must be defined. Therefore, the relation between the concentration of extract (C) and the fraction of tin surface covered by the adsorbed compounds (θ) was obtained. It was found that the additive concentration is directly proportional to C/θ. Thus, plotting C against C/θ gave straight line with slope value of almost one (Fig 2). This result suggests that the adsorption of carob components on tin surface in $NaHCO_3$ solution follows Langmuir adsorption isotherm which could be represented as following [**Abdallah (2004)**]:

$$C/\theta = C + 1/k$$

Where k is the adsorption constant. Langmuir isotherm postulates that there is no interaction between the adsorbed molecules and hence the free energy of adsorption, ΔG_{ads}, is independent on θ value. The free energy of adsorption could be calculated using the following equation:

$$\log k = -1.74 - [\Delta G_{ads} / 2.303\ RT]$$

Value of -26.24 KJ was obtained for ΔG_{ads}. The negative sign indicates that the adsorption of the carob extract on tin surface in

$NaHCO_3$ medium is a spontaneous process. Moreover, the calculated values of free energy of adsorption suggest a physical adsorption of the carob compounds on tin surface.

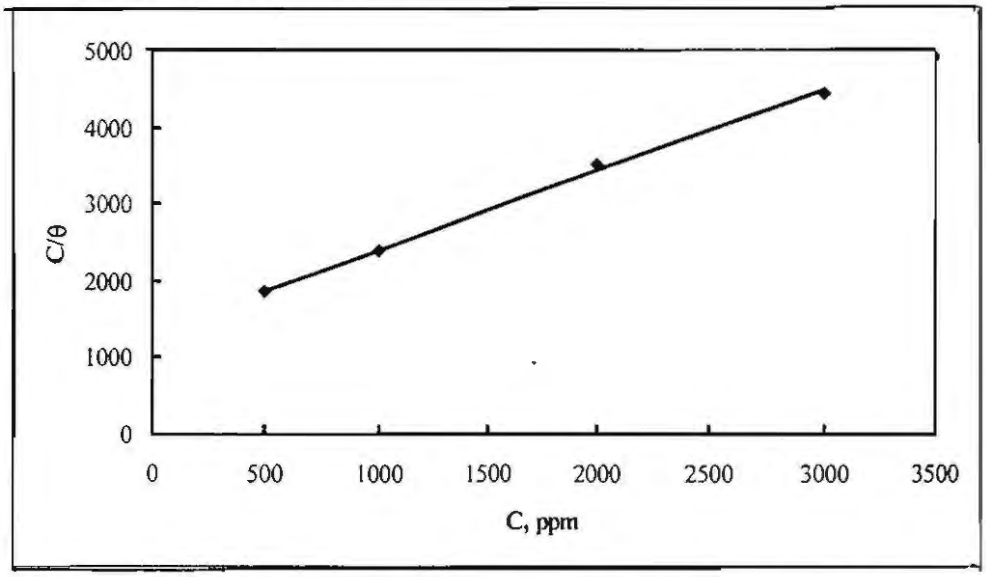

Fig.(2): The relation between C, ppm of carob extract and (C/θ) for tin electrode in 0.1 M $NaHCO_3$.

3. 3. Potentiodynamic anodic polarization

The effect of the concentration of the extract on the potentiodynamic anodic polarization of tin in [0.1 M $NaHCO_3$ + 0.1 M NaCl] at scan rate of 1mV/s is illustrated in Fig. 3. It was found that increasing the concentration of carob extract causes a shift of the pitting potential into noble direction indicating an increased resistance to pitting attack.

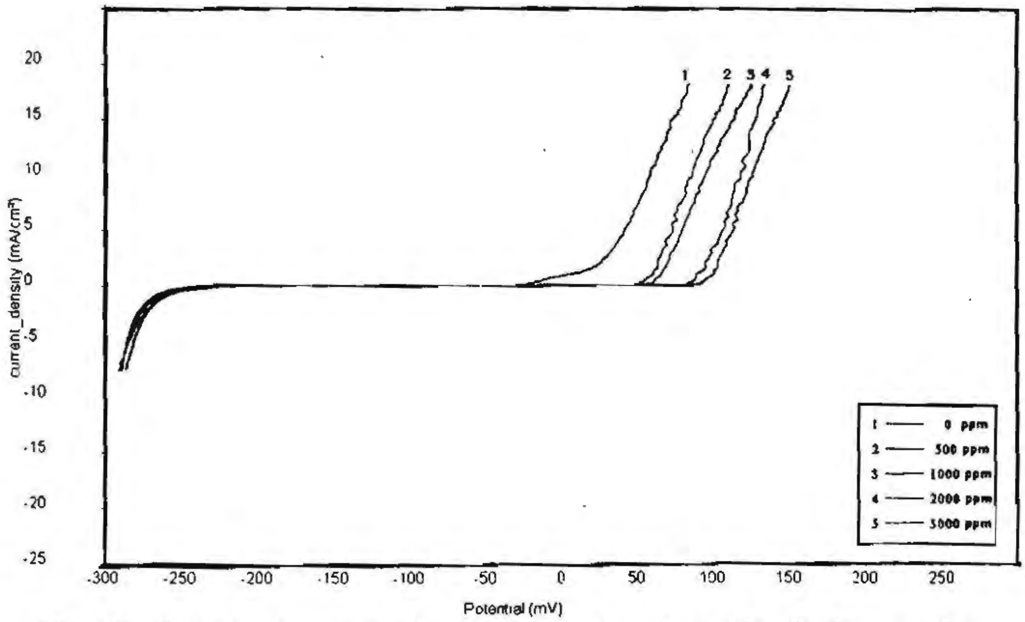

Fig. (3): Polarization curves for tin electrode in 0.1 M $NaHCO_3$ + 0.1 M NaCl containing different concentration of Carob extract at scan rate 1 mV/s.

The anodic shift of pitting potential increases as the concentration of carob extraction is increased. Straight line relationship is obtained between E_{pit} and log C_{inh}. (Fig. 4) according to the equation [**Abdallah, et. al (2006)**]:

$$E_{pit} = a + b \log C_{inh}.$$

Where a and b are constants which depend on both the type of additive and the nature of the electrode.

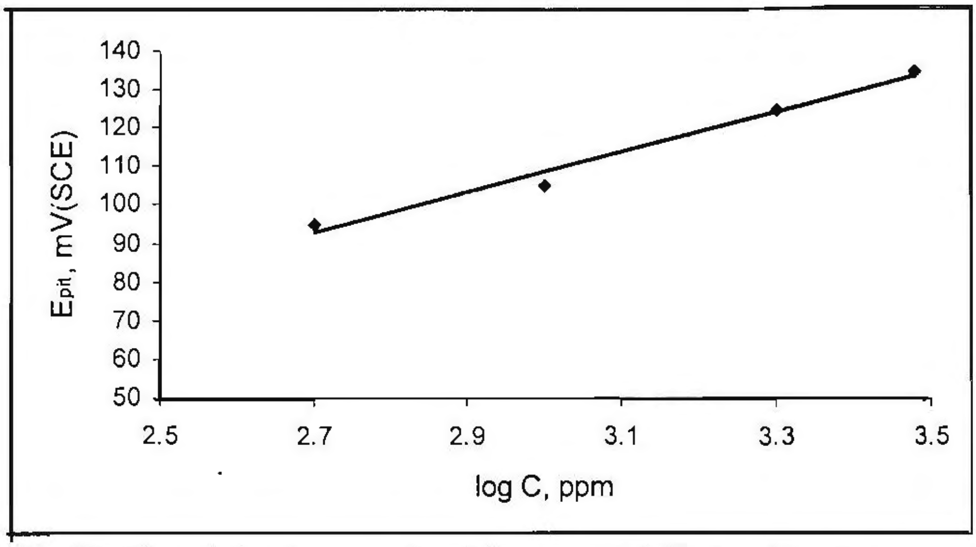

Fig.(4): The relation between the pitting potential (E_{pit}) and log C, ppm of carob exract.

4. CONCLUSION

The aqueous extract provides a fair protection for tin against general corrosion in bicarbonate solution as well as pitting corrosion in NaCl containing solution. The inhibition action of the extract was attributed to the adsorption of extract components, mainly sucrose, on tin surface following Langmuir adsorption isotherm.

REFERENCES

Abd El Aal M.S. and Osman A.H., Corros., 36 (1980) 591.

Abd El Rehim S.S., El Samahi A.A. and El Sayed A., Br. Corros. J., 20 (1985) 196.

Abd El Rehim S.S., El Sayed A. and El Samahi A.A., Surf. and Coatings Technol., 27 (1986) 105.

Abd El Rehim S.S., Taha F., Saleh M.B. and Mohamed S.A., Collect Czech. Chem. Commun., 58 (1993)2013.

Abd El Wahab F.M., Abd El Kader J.M., El Shayeb H.A. and Shams El Din A.M., Corros. Sci., 18 (1978)997.

Abdallah M., Corros. Sci., 46 (2004) 1981.

Abdallah M., Helal E. H. and Fouda A. S., Corros. Sci., 48 (2006) 1639.

Abdallah M., Potrngaliae Electrochim Acta, 22 (2004) 161.

Dickinson T. and Lotfi S., Electrochim. Acta ,23 (1978) 995.

Drogowska M., Menard H. and Brossard L., J. Appl. Electochem., 21 (1991) 84.

Gervasi C.A., Varela F.E., Vilche J.R. and Alvarez P.E., Electrochim. Acta, 42 (1997) 537.

Hampson N. and Spencer N.F., Br. Corros. J., 1 (1968).

Hassan H.H., Abd El Rehim S.S. and Mohamed N.F., Corros. Sci., 44 (2002) 37.

Kapusta S.D. and Hickerman N., Electrochim. Acta, 25 (1980) 1625.

Macleod G. and Forcen M., Phytochemistry, 31(1992)3113.

Pugh M., Warner L.M. and Gabe D.R., Corros. Sci., 7 (1967) 807.

Stirruo B. andHampson N., J. Electrochem. Soc., 67 (1970) 43.

US Public Health Service Toxicological Profile for Chromium, Agency for Toxic Substances, US PublicHealth Service, Report no. ATSDR/TP-88/10 (1989).

تثبيط تآكل القصدير فى محاليل بيكربونات الصوديوم بمستخلص الخروب

متولى عبدالله - يسرى العتر - ايمان عبدالله - صلاح عيد

تم دراسة التآكل لقطب القصدير فى محاليـل بيكربونـات الـصوديوم باسـتخدام مستخلص الخروب بواسطة جهاز البتنشوديناميك وقد وجد أن معدل التآكل يقل فـى وجـود مستخلص الخروب وأن كفاءه التثبيط تزداد بزيادة تركيز المستخلص وقد اعزى ذلـك الـى امتزاز مكونات المستخلص على سطح القصدير وأن هذا الامتزاز يتبع ايزوثرم لانجمير وقد دلت القيمة السالبة للطاقة الحرة لعملية الامتزاز على تلقائية العملية وقد وجد أن مـستخلص الخروب يزيد من مقاومة التآكل الثقبى.