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Licorice root extract as corrosion inhibitor for tin in sodium chloride solutions

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Abstract

The corrosion behavior of tin electrode in 0.6 M NaCl solution as well as the effect of addition aqueous extract of licorice root were investigated using potentiodynamic techniques. It was found that 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 the adsorption follows Freundlich adsorption isotherm. The negative value of free energy of adsorption suggests a spontaneous process. Moreover, the addition of licorice root extract increases the resistance of tin toward pitting corrosion.

Keywords: Corrosion inhibitor, Tin, Licorice root, Natural products.

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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 different media [1-13]. Many organic compounds have been used as corrosion inhibitors. Most organic compounds used are extremely expensive and hazardous in nature. Trials were made to find very low cost, non –toxic, natural and eco-friendly inhibitors for protection of metals and alloys against corrosion in aqueous solutions [14-22].

The present work aims to study the corrosion behavior of tin in 0.6 M NaCl and the effect of addition aqueous extract of Licorice root [7, 23-24] 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 licorice root was finely divided and extracted in water for 48 hours. The filtrate was evaporated in a steam bath and the solid residue was left overnight in open air for complete dryness. Glycyrrhizin is the main component [7, 23-24], its structure present in fig. (1). 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 [14].

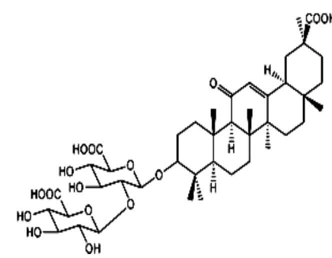

Fig (1): Glycyrrhizin structure

3. Results and discussion

3.1. Potentiodynamic polarization

Fig. 2 represents the anodic and cathodic polarization curves of tin electrode in 0.6 M NaCl solutions devoid of and containing different concentrations of licorice root extract. Inspection of the Figure reveals that the polarization curves shift toward lower current density values upon the addition of the extract.

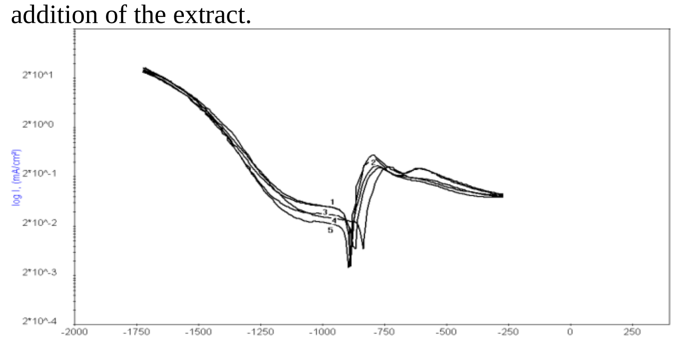

Fig (2): polarization curves for tin electrode in 0.6 M NaCl solution in presence of different concentrations of licorice root extract at scan rate 10 mV/sec. (1) 0, (2) 1000, (3) 2000, (4) 2500 and (5) 3000 ppm.

This behavior reflects the inhibitive action of licorice root extract. The corrosion parameters of tin electrode in the free and inhibited NaCl solutions were obtained from the curves of Fig. 2 and given in Table 1. The data in Table 1 show that the corrosion current density is markedly decreased upon addition of the extract. Moreover, the values of cathodic Tafel constants were affected as the concentration of extract was increased. These findings suggest that licorice root extract acts as slightly cathodic inhibitor [16].

Table (1): Electrochemical parameters of tin in 0.6 M NaCl in presence of different concentrations of Licorice root.

Inh. conc. (ppm)	β_a mV. dec^{-1}	β_c mV. dec^{-1}	E_{corr} mV (SCE)	I_{corr} µA/cm^2	θ	%IE
0	66.37	-1003.70	-886	17.130	-	-
1000	55.23	-99.70	-886	13.260	0.2559	25.59
2000	61.87	-815.48	-866	10.994	0.3582	35.82
2500	79.22	-560.08	-835	9.798	0.4280	42.80
3000	*61.9*	*-372.16*	*-896*	*5.793*	*0.6618*	*66.18*

3.2. Adsorption behavior

The inhibiting action of licorice root 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. The inhibition efficiency is directly related by the fraction of surface covered by the adsorbed molecules (θ). Therefore, θ was calculated as IE/100 and its values corresponding to different licorice root concentrations were given in tables (1). Inspection of these data reveals that, the value of θ increases as the additive concentration is increased.

To study the adsorption behavior of licorice root on tin surface in the given medium, the adsorption isotherm must be defined. This result suggests that the adsorption of licorice root components on tin surface in NaCl solution follows Freundlich adsorption isotherm and is given by the general equation:

$$\theta = K.C^n$$

or alternatively by:

$$\log \theta = \log K + n \log C$$

where K and C are the equilibrium constant of adsorption process and additives concentrations, respectively.

A plot log θ against log C gives a straight line of intercept, log K, this plot is shown in Fig. (3).

The equilibrium constant of adsorption K is related to the standard free energy of adsorption, equation [15]:

$$K=1/55.5 \exp(-\Delta G^o_{ads}/RT)$$

where T is the absolute temperature and R is the gas constant (8.314 J. mol^{-1}.K^{-1}). The numerical value 55.5 is the concentration of water in mol.L^{-1} which will be replaced with 1000 g.L^{-1} (which is the unit used to determine the additive concentration) in our calculations [20]:

$$K=1/1000 \exp(-\Delta G^o_{ads}/RT)$$

The equilibrium constant and the adsorption free energy of licorice root extract adsorbed on the surface of tin 0.6 M NaCl are 0.239 and -13.57 kJ. mol^{-1}.K , respectively. The standard free energy change of adsorption is associated with water adsorption/desorption equilibrium which forms an important part in the overall free energy changes of adsorption. The negative value of ΔG^o_{ads} indicates that the adsorption process of these compounds on the metal surface is spontaneous one. Moreover, the small value of free energy of adsorption suggest a physical adsorption of the licorice root compounds on tin surface [21].

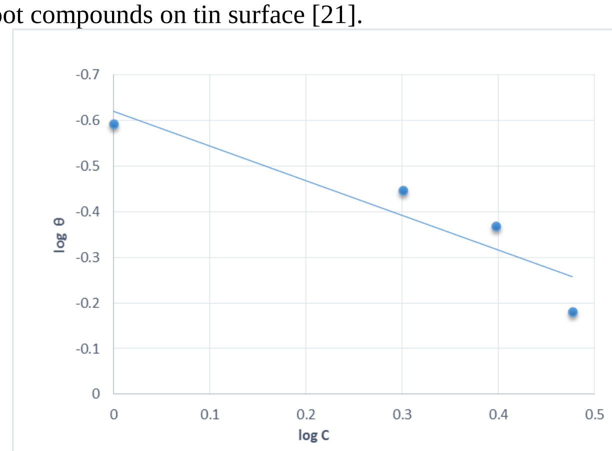

Fig (3): The relation between log θ and log C, g/L for tin electrode in 0.6 M NaCl.

3. 3. Potentiodynamic anodic polarization

The effect of increasing concentration of the extract on the potentiodynamic anodic polarization of tin in 0.6 M NaCl at scan rate of 1mV/s is illustrated in Fig. 4. It was found that increasing the concentration of licorice root causes a slight shift of the pitting potential into noble direction indicating an increased resistance to pitting attack [7].

The anodic shift of pitting potential increases as the concentration of licorice root extraction is increased. Straight line relationship is obtained between E_{pit} and log C_{inh}. (Fig. 5) according to the equation [7]:

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

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

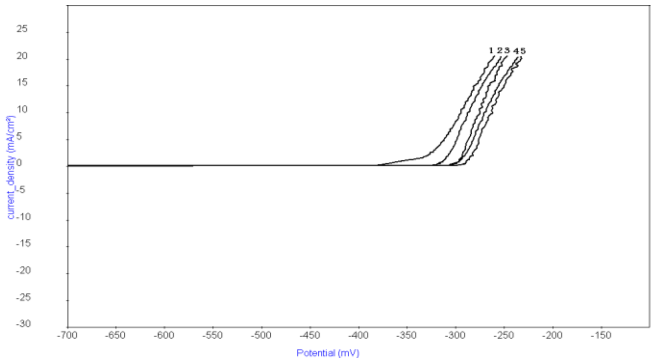

Fig (4): Potentiodynamic anodic polarization curves for tin electrode in 0.6 M NaCl and different concentrations of licorice root extract at scan rate 1 mV/sec. (1) 0, (2) 1000, (3) 2000, (4) 2500 and (5) 3000 ppm.

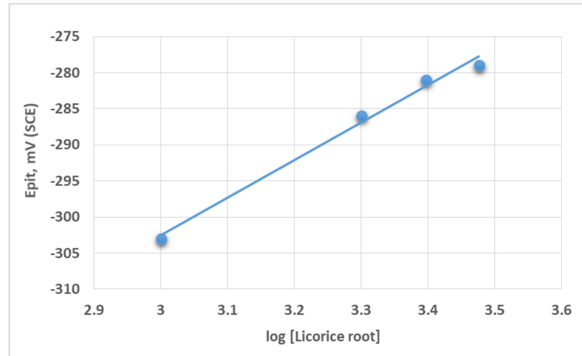

Fig (5): The relation between the pitting potential (E_{pit}) and log C, ppm.

4. Conclusion

The aqueous extract of licorice root provides a good protection for tin against general corrosion in sodium chloride solution as well as pitting corrosion. The inhibition action of the extract was attributed to the adsorption of extract components, mainly sucrose, on tin surface following Freundlich adsorption isotherm.

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