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NATURAL HONEY AS CORROSION INHIBITOR FOR METALS AND ALLOYS. I. COPPER IN NEUTRAL AQUEOUS SOLUTION

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Abstract— The inhibition action of natural honey on the corrosion of copper in a 0.5 M sodium chloride solution has been evaluated by weight loss measurements and cathodic polarization technique. A good inhibition efficiency is observed which increases with an increase in inhibitor concentration. After some time, the inhibition efficiency decreased due to the growth of fungi in the medium. The Tafel slope is changed markedly in the presence of natural honey. The adsorption of natural honey on the copper/chloride interface is found to follow the Langmuir isotherm. © 1998 Elsevier Science Ltd. All rights reserved

INTRODUCTION

Corrosion inhibitors are widely used in industry to reduce the corrosion rate of metals and alloys which is present in contact with aggressive environments. Copper is considered to be one of the most important metal which is frequently used in different industrial applications. The inhibition of copper corrosion in various media using large numbers of organic and inorganic compounds was studied. Results showed that organic compounds, especially those containing nitrogen[1–6] or sulfur[7,8] gave a very good inhibition for copper corrosion in different media.

Unfortunately, most of these compounds are synthetic chemicals which may be very expensive and hazardous to living creatures and environments. It is very important to choose cheap and safely handled compounds to be used as corrosion inhibitors. Natural honey, which contains a mixture of organic and inorganic compounds, fulfils these requirements. There is no report in the literature on the use of natural honey as a corrosion inhibitor for any metal or alloy.

In our laboratory, much work has been conducted to study the inhibitive action of natural honey on the corrosion of some metals and alloys in different media. In the present work, the inhibition of copper corrosion in a neutral solution by natural honey is evaluated using weight loss measurements and cathodic polarization technique.

EXPERIMENTAL METHOD

Copper strips of 1 cm^2 size were used for weight loss measurements. For potentiostatic studies, a cylindrical rod embedded in araldite with an exposed surface area of 1 cm^2 was used. The electrodes were polished with different grades of emery paper, degreased with

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Table 1. The composition of natural honey

Comp.	Water	Fructose	Glucose	Sucrose	Dextrin	Minerals	Acids	Unknown
%	17.7	40.5	34.0	21.9	1.15	0.18	0.08	4.9

acetone and rinsed with distilled water. AR grade sodium chloride was used for preparing solutions. The composition of natural honey was given[9] as shown in Table 1.

Weight loss measurements were carried out as described elsewhere.[10] Potentiostatic polarization studies were carried out using an EG&G model 173 potentiostat/Galvanostat. The electrode potential was measured against a saturated calomel electrode (SCE). A platinum foil was used as an auxiliary electrode.

RESULTS AND DISCUSSION

Weight loss measurements

Table 2 shows the values of inhibition efficiencies obtained from weight loss measurements for a copper electrode in a 0.5 M NaCl solution in the absence and presence of different concentrations of natural honey. Inhibition efficiency (p%) and a parameter (θ) which represents the part of the surface covered by inhibitor molecules were calculated using the following equations:

$$p\% = [(w_0 - w)/w_0] \times 100$$

$$\theta = [(w_0 - w)/w_0]$$

where w_0 and w are the weight losses in the absence and presence of inhibitor, respectively. Values of (p%) and (θ) obtained at different inhibitor concentrations are listed in Table 2. Inspection of Table 2 reveals that inhibition efficiency increases with an increase in honey concentration. This behavior could be attributed to the increase of the surface coverage (θ) due to the adsorption of honey on the metal surface as the inhibitor concentration was increased. However, the values of Table 2 indicate that natural honey exhibited a very good performance on the corrosion of copper in a 0.5 M NaCl solution.

Further inspection of Table 2 reveals that the inhibition efficiency of natural honey decreased markedly with an increase of the exposure time. It is of interest to mention

Table 2. Inhibition efficiency for different concentrations of natural honey for copper corrosion in 0.5 M NaCl solution

Conc. of Honey ppm	Inhibition Efficiency after 4	12	30 (days)	θ after 4 days
200	55.6	22.5	1.98	0.556
400	72.0	27.3	5.20	0.720
600	82.4	30.9	7.80	0.824
800	85.0	43.0	11.2	0.850
1000	89.0	45.0	10.5	0.890

that after several days from the beginning of the weight loss experiment, a white fungi colony could be easily recognized in the inhibited solution. It is well known that the carbohydrates which represent the main component of natural honey exhibits an ideal medium for fungi growth. The fungi colony grows with time at the expense of the honey concentration. Consequently, the inhibition efficiency is greatly reduced. Additional work should be conducted to identify and overcome the growth of such microorganisms in the medium. This may be carried out by using controlled amount of fungicides.

Surface coverage (θ) values have been obtained from weight loss measurements for various concentrations of natural honey. Fig. 1 shows the relationship between C/θ and C. A straight line with a unit slope was obtained, suggesting that the adsorption of natural honey on the copper/chloride interface obeys Langmuir's adsorption isotherm.

Potentiostatic polarization studies

Potentiostatic cathodic polarization was carried out in 0.5 M NaCl with different concentrations of natural honey (Fig. 2). The various electrochemical parameters were calculated from Tafel plots and shown in Table 3. The corrosion current density (I_{corr}) was calculated by extrapolating the cathodic Tafel line to the steady state potential (corrosion potential). The exchange current density (I_0) of the cathodic process was calculated using the following equation:[11]

$$I_0 = 10^{-a/b_c}$$

where a is the value of overpotential at the unit current density and b_c is the cathodic Tafel slope. The inhibition efficiency (p%), obtained galvanostatically, was calculated using the following equation:

$$p\% = [(I_f - I)/I_f] \times 100$$

where I_f and I are the corrosion current density in the absence and presence of inhibitor, respectively. It is found from Table 3 that the presence of natural honey shifted the corrosion potential towards the cathodic direction. The inhibition efficiency increased with an increase of natural honey concentration. It is of interest to note that the values of inhibition efficiency are higher than those obtained by weight loss measurements. This result may be due to the fact that the electrochemical measurements were carried out on freshly prepared solutions. On the other hand, the first result obtained by the weight loss technique was recorded after four days. During this period, the action of growing microorganisms had started. It is of interest to note that the exchange current of the cathodic process is greatly decreased upon addition of the inhibitor.

Further inspection of Table 3 reveals that the value of the cathodic Tafel slope decreased markedly upon addition of the natural honey, suggesting a variation in the mechanism of the corrosion process.

CONCLUSION

1. Natural honey acts as an inhibitor for the corrosion of copper in 0.5 M NaCl solution.
2. The inhibition efficiency of natural honey decreased markedly after several days due to the growth of microorganisms in the tested neutral medium.

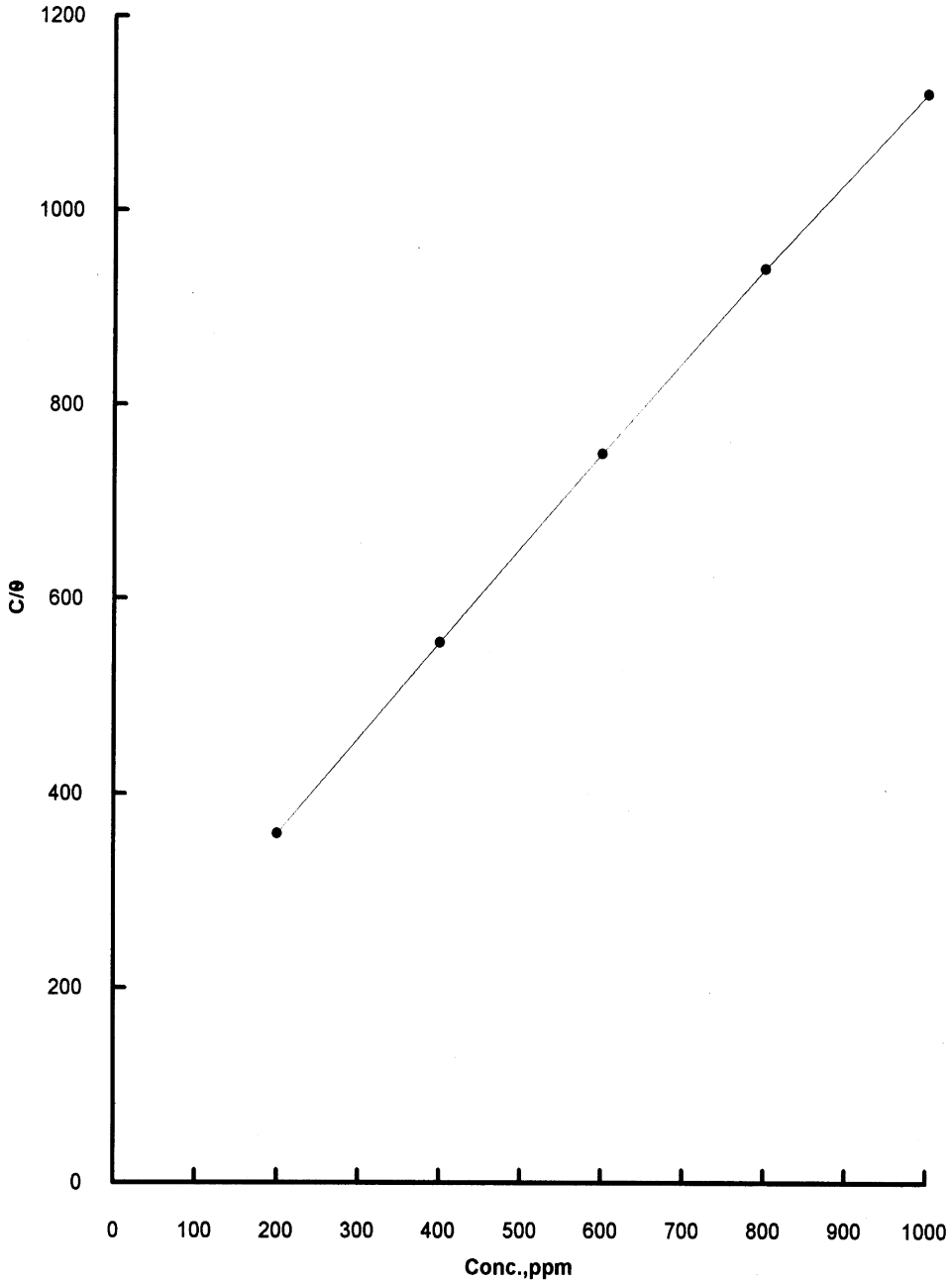

Fig. 1. The relationship between inhibitor concentration (C) and (C/θ).

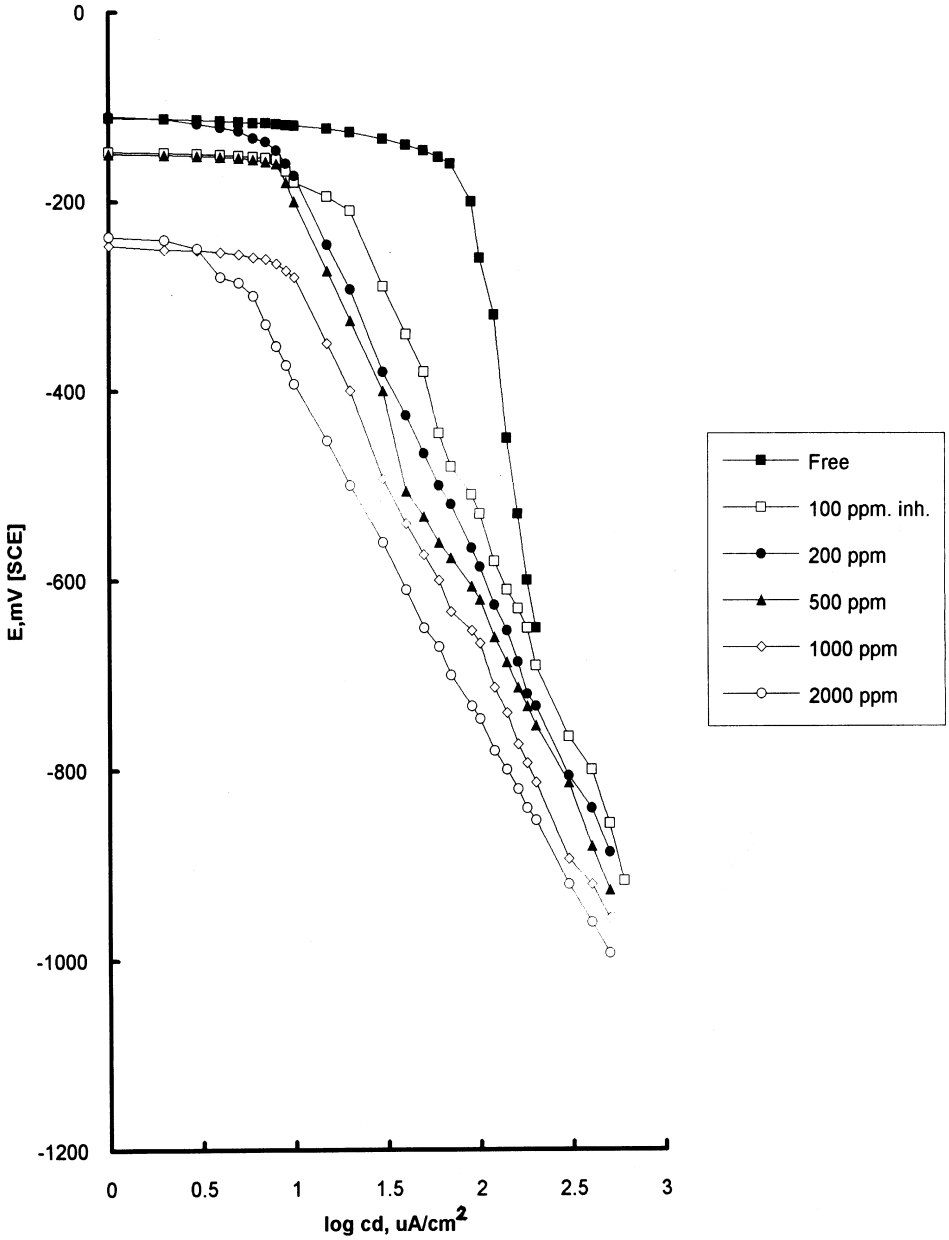

Fig. 2. Potentiostatic polarization of copper in inhibited and uninhibited 0.5 M NaCl solutions.

Table 3. The electrochemical parameters obtained from cathodic polarization of copper in 0.5 M NaCl solutions in absence and presence of different concentrations of natural honey

Honey conc. (ppm)	E_{corr} (mV (SCE))	I_{corr} ($\mu A/Cm^2$)	p%	*bc*	I_0 ($\mu A/Cm^2$)
0.00	−110	79.43	–	1275	44.0
200	−140	13.8	82.6	450	5.2
400	−109	7.94	90.0	420	3.3
600	−142	6.02	92.4	405	2.2
800	−250	3.98	94.4	375	1.0
1000	−230	1.90	97.6	345	0.49

3. The adsorption of natural honey on the copper surface in neutral chloride solution obeys Langmuir's adsorption isotherm.

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