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INHIBITING EFFECT OF TRIPHENYL TETRAZOLIUM CHLORIDE (TTC) ON THE ACID CORROSION OF CADMIUM

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ABSTRACT

The effect of triphenyl tetrazolium chloride (TTC) as inhibitor on the corrosion behaviour of Cd in 1.0M HCl solution has been studied at different temperatures. The weight-loss technique showed that TTC affect the corrosion rate of the metal.

The protection efficiency increases with decreasing temperature and it rises in the presence of triphenyl tetrazolium chloride, the protection efficiency was 80% at 0.02M of TTC inhibitor concentration at 30°C. The result of the apparent activation energies in absence and in presence of inhibitor suggest that (TTC) does not change the mechanism of the rate determing step of the corrosion process. Potential measurements of Cd electrode showed that it was shifted to the noble direction with increasing TTC concentraion. Inhibition is due to formation of protective film by TTC on the metal surface.

INTRODUCTION

Many data on using sulphur-containing organic compounds such as thiourea and its derivatives as inhibitors has been published Trabanelli, and Carassite (1970). However, such compounds under go chemical changes to produce S^{-2} and HS^{-1} ions i.e. they may become corrosion promotors Kawashima, Hashimoto, and Shimodarira (1976). Therefore it is worth while to search for efficient sulphur free inhibitors as trizoles. Fox, Lewis and Bcden (1979), benzotriazoles Fox and Bradely (1980) and polyvinyl pyrrolidones Abo ElKhair, Khalifa, Abdel Hamid and Azzam (1987). The study of 2,3,5 triphenyl tetrazolium chloride showed that it is a good inhibitor Abd El Gulil and Abd El Fattah (1987) and Abd El Wahab, Khalifa and Abo El-Khair (1988).

In the present work the effect of 2,3,5 triphenyl tetrazolium chloride (TTC) as inhibitor on the corrosion behaviour of Cadmium metal in HCl solutions has been studied. The effect of TTC on the corrosion rate, corrosion potential and apparent activation energy of corrosion of Cd metal in HCl were investigated. The results were analysed with aview to determine the inhibiting efficiency of this compound at various temperatures and concentrations and to elucidate the mechanism of inhibition.

EXPERIMENTAL

The potential of Cd electrode was measured as a function of time within the period of three hours in 1M HCl containing triphenyl tetrazolium chloride (TTC) of concentration varying from 2×10^{-2} to 10^{-4}M.

The electrode was prepared from analar Cd (B.D.H). Before use the electrode was abroded successively to 00 finish, degreased with acetone and then washed thoroughly with water. Each experiment was carried out with a newly polished electrode and with fresh portion of solution. A saturated calomel electrode was used a s a reference electrode. The potential was measured with the aid of a Cambridge potentiometer.

Determination of the corrosion rate was also carried out using the weight-loss technique. Experiments were performed on Cd pieces measuring 25 cm^2. The test pieces were first degreased with methanol and then etched in concentrated HNO_3 for ½ minute. They were then washed with conductivity water, dried in alcohol and ether and then weighed. Corrosion tests were carried out in a 100 ml beaker in which the specimen was suspended for 30 minutes in the test solution. The specimen was then removed, rinsed with conductivity water and finally dried and weighed. All corrosion tests were carried out in aerated unstirred solutions. Results were duplicated and the mean was computed.

RESULTS AND DISCUSSION

Fig. 1 shows the variation of the protection efficiency, P of Cd metal as a function of the concentration of triphenyl tetrazolium chloride (TTC) in 1M HCl solution at different temperatures. The protection efficiency P of the inhibitor was calculated by the following equation (1).

$$P = 100(1-W_2/W_1) \qquad (1)$$

Where W_1 and W_2 are the corrosion rates in absence and in presence of a certain concentration of inhibitor. As shown the percentage inhibition increases with increasing the (TTC) concentration in the medium, approaching complete protection 80% at 0.02M (TTC) at 30°C.

Fig. 1 also shows the effect of the concentration of (TTC) at various temperatures on the protection efficiency of Cd. Clearly, the percentage inhibition increases with increasing (TTC) concentration. In general, the protection efficiency increases with decreasing temperature.

Fig. 2 show the variation of the corrosion rate of Cd in 1.0M HCl as a function of the concentration of (TTC) at different temperatures. It was observed that, at a constant temperature, the corrosion rate decreases as the concentration of (TTC) increases.

It is well known that if the inhibitor functions via an adsorption mechanism, i.e., the degree of coverage equals the protection efficiency, the Langmiur isotherm relationship:

$$\log P/(1-P) = \log (I) + \text{constant} \ldots\ldots. \quad (2)$$

where (I) is the inhibitor concentration. This relation gives a straight line with a slope of unity. Fig.3 shows such plots, where equation (2) is not confirmed. Consequently, it can be concluded that the protection imparted by (TTC) agrees with the film theory of protective activity proposed by Balezin et al., Pulilova, Balezium and Drannik (1960) in which inhibition is due to the formation of a protective film on the metal surface. The diffusion of metal ions through this film becomes the rate-determining step. These results are in agreement with the previous results reported for the inhibition of Zn by (TTC) Abdel Wahab, Khalifa and Abo El-Khair (1985).

It is pointed Pulilova, Balezium and Drannik (1960) out that the logarithm of the corrosion rate is a linear function of 1/T (Arrhenius equation), where T is the temperature in Kelvin:

$$\log \text{corrosion rate} = -E_a/(RT) + B \quad \text{.........} \quad (3)$$

where E_a is the apparent activation energy, R is the universal gas constant (1.987 cal/mole. degree) and B is a constant. In Fig. 4 the logarithms of the corrosion rates of Cd are plotted as a function of (1/T) in absence and in presence of (TTC) inhibitor. From Fig. 4 the calculated value of the apparent activation energy in absence of inhibitor 11.0K cal/mole, this value agrees with that reported previously as Abo El-Khair (1987). This value is also of the order of the activation energies encountered for the hydrogen evolution reaction as Electrochemical Data (1952). This is in accordance with the fact that the hydrogen evolution reaction in the absence of an inhibitor is the rate-determining step for the overall corrosion reaction. For 10^{-3} 10^{-2} and $2x10^{-2}$ solutions, the calculated values of the apparent activation energies are 10.59-10.12 and 9.66K cal/mole, respectively differences are not considered to be significant. Therefore, the presence of (TTC), does not affect the activation energy of the corrosion process. These results indicate that (TTC) does not change the mechanism of the rate-determining step of the corrosion process, although it significantly reduces its rate.

The open-circuit potentials of Cd electrode immersed in solutions of 1.0M HCl in the absence and in the presence of (TTC) solutions of concentration ranging between $2x10^{-2}$M and 10^{-4}M was measured as a function of time till steady state values were established.

The steady state potential obtained after 140 min. after immersion is plotted as a function of the logarithm of the molar concentrations and the curve is shown in Fig.(5). As evident from the curve the potential increases with the (TTC)

- concentration, the shift of potential towards less negative value with increasing (TTC) concentration.

From all the previous data, it is indicated that the Triphenyl Tetrazolium chloride acts as an inhibitor for the acid corrosion of Cd metal in acidic solution.

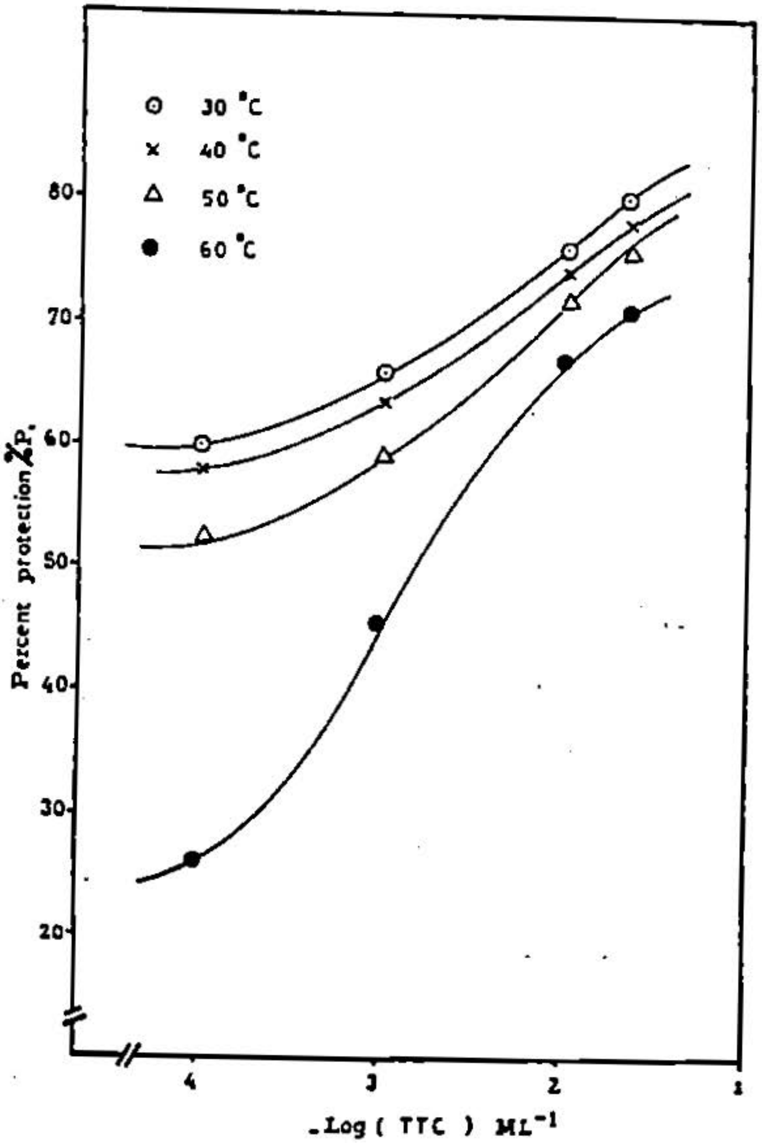


Fig (1) Effect of Concentration of TTC on the Protection efficiency of Cd in 1MHCl at various temperatures.

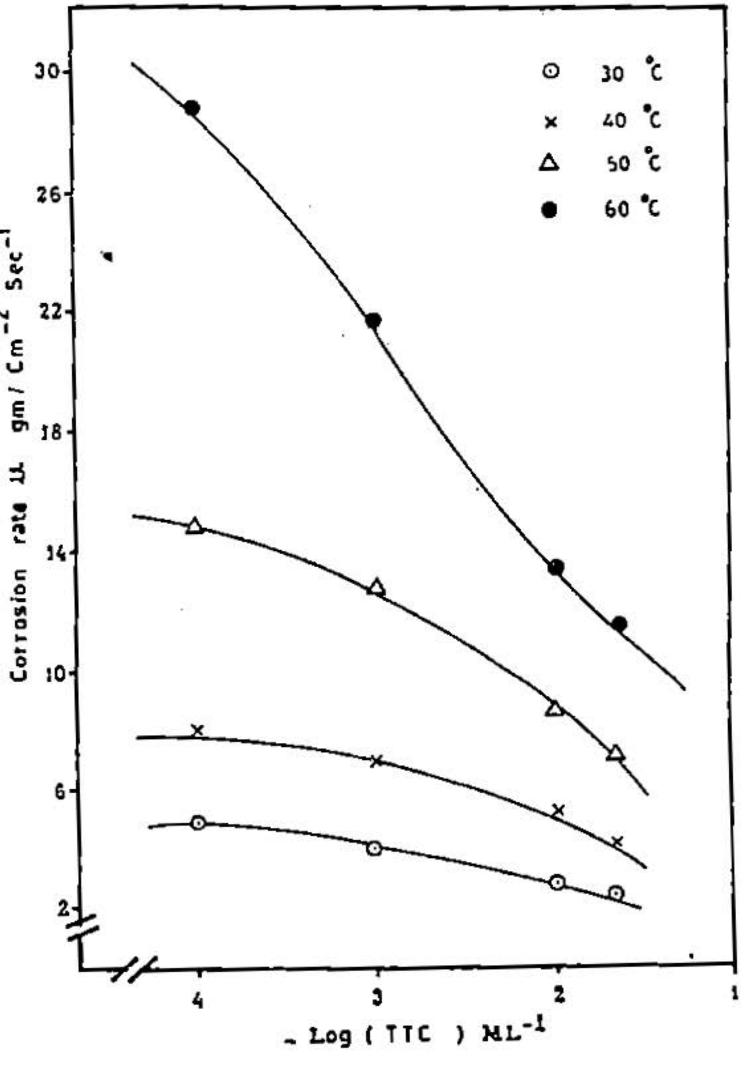


Fig (2) : Effect of the Concentration of TTC on the corrosion rate of Cd in 1MHCl at various temperatures.

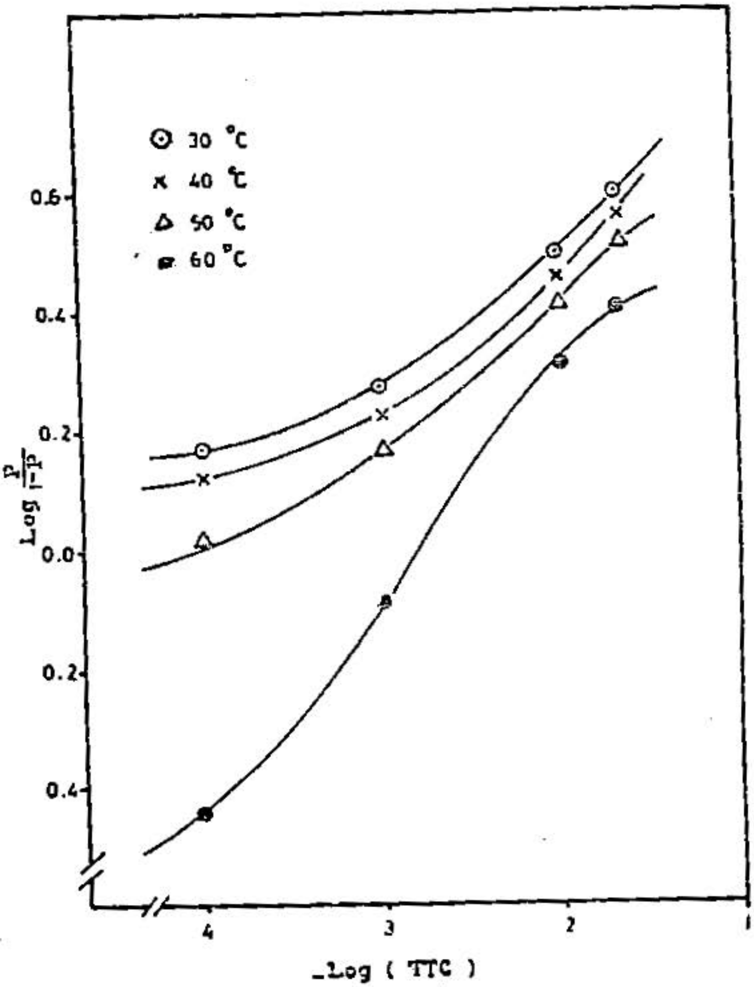
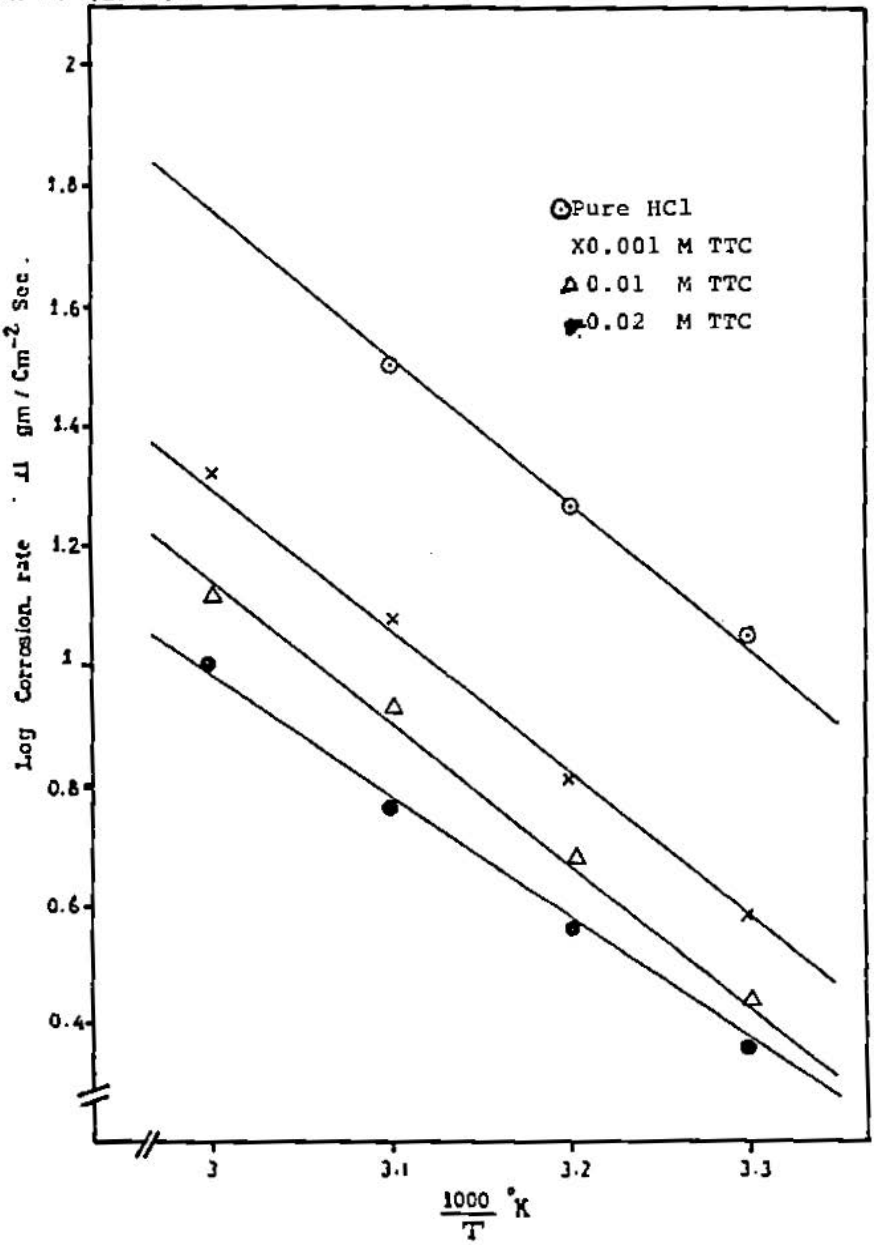


Fig (3) : Plot of log $\frac{P}{1-P}$ vs. log concentration (TTC) for Cd in 1MHCl at various temperatures.



Fig(4): Arrhenius plot of the corrosion rate of Cd in 1MHCl in absence and in presence of (TTC).

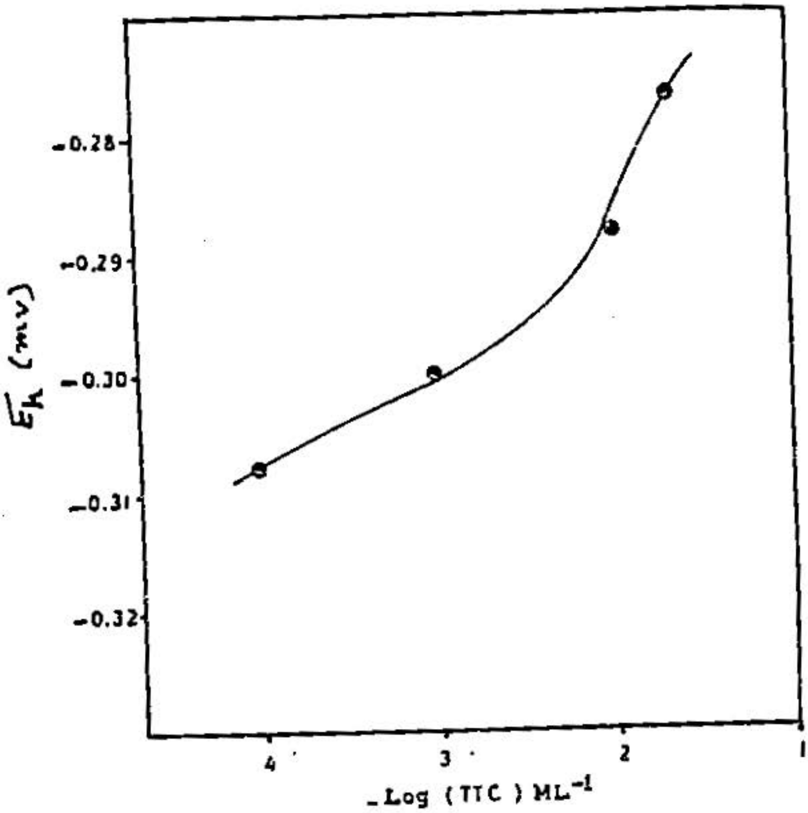


Fig (5): Plot of Cd potential versus log concentration of (TTC) in 1MHCl.

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" بسم الله الرحمن الرحيم "

تأثير مادة الثلاثى فينيل كلوريد التترازوليوم كعامل مثبط لتآكل فلز الكادميوم في الوسط الحامضى

في هذا البحث تم دراسة تأثير ثلاثى فينيل كلوريد التترازوليوم كعامل مثبط لتآكل فلز الكادميوم فى محلول حامض الأيدروكلوريك عند تركيز ١ مولار. وقد تمت الدراسة عند درجات حرارة مختلفة (٣٠°م - ٦٠°م) فى وجود العامل المثبط بتركيزات تتراوح بين (٢ × ١٠^-٢ مولارى الى ١ × ١٠^-٤ مولارى) وفى عدم وجود العامل المثبط .

وبقياس النقص في الوزن اتضح أن ثلاثى فينيل كلوريد التترازوليوم يمكن استخدامه كعامل مثبط للتآكل .

وقد وجد أن نسبة الحماية (P) تزداد بزيادة تركيز العامل المثبط كما أنها تقل بزيادة درجة الحرارة . وقد وجد أن أعلى نسبة حماية ٨٩٪ عند درجة حرارة ٣٠°م .

كما قيس أيضا جهد قطب الكادميوم فى محلول حامض الايدروكلوريك ١ مولارى بدون وبوجود العامل المثبط (TTC) وقد وجد أن جهد القطب يتجه الى الأقل سالبية بزيادة تركيز العامل المثبط .