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Food Colourant as Corrosion Inhibitors for Aluminium-Copper Alloy in Trichloroacetic Acid

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The inhibition of corrosion of aluminium-copper alloy (Al-Cu alloy) in trichloroacetic acid (TCA) is not much available. Therefore is this work the role of some food colourant in inhibiting the corrosion of Al-Cu alloy in solution of TCA has been reported. In order to determine the effect of inhibitor concentration on inhibitive efficiency weight losses were determined in 0.1 M TCA. At an inhibitor concentration 0.5% (w/v) the inhibitor efficiencies of various food colourants increased in the order:

Fast red < Tatrazine < Carmosine < Sunset yellow < Amaranth

The inhibition increases with increase in food colourant concentraton.

INTRODUCTION

The inhibition of corrosion of aluminium-copper alloy (Al-Cu alloy) in trichloroacetic acid (TCA) is not much available[1–4]. Therefore, in this work, the role of some azo dyes in inhibiting the corrosion of Al-Cu alloy in solution of TCA has been reported.

EXPERIMENTAL

The chemical composition of the experimental alloy under investigation is given as follows (%):

Cu 3.88, Mn 0.87, Fe 0.43, Si 0.59, Mg 0.32, Al remainder.

The specimen size and the method of carrying out the corrosion tests were the same as described earlier[2]. The test specimens were exposed to TCA solution in the concentration range 0.1–1 M containing 0.05–1.0 (w/v %) of azo dyes.

RESULTS AND DISCUSSION

The results are given in Figs. 1 and 2 and Tables-1 and 2, the inhibitor efficiency expressed as per cent inhibition (P.I.) is defined as:

$$P.I. = \frac{W_n - W_i}{W_u} \times 100$$

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where W_i is the weight loss (mg) of alloy in inhibited acid and W_u is the loss (mg) in uninhibited acid solution.

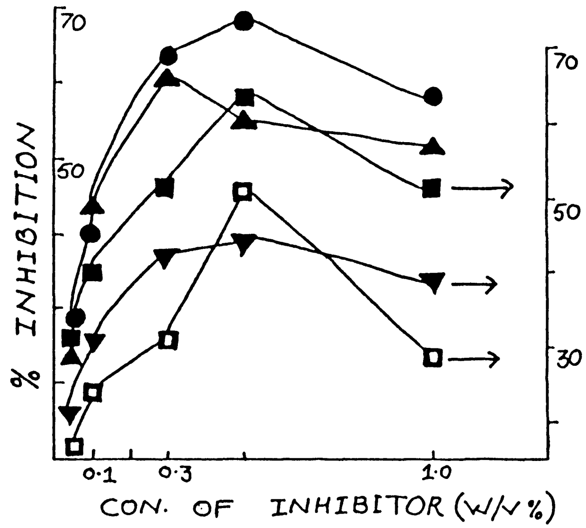

Fig. 1. Effect of dyes concentration on inhibition of aluminum-copper alloy in 0.1 M TCA
▲-▲ Carmosine, ●-● Amaranth, ■-■ Sunset yellow,
▼-▼ Fast red E, □-□ Tartrazine

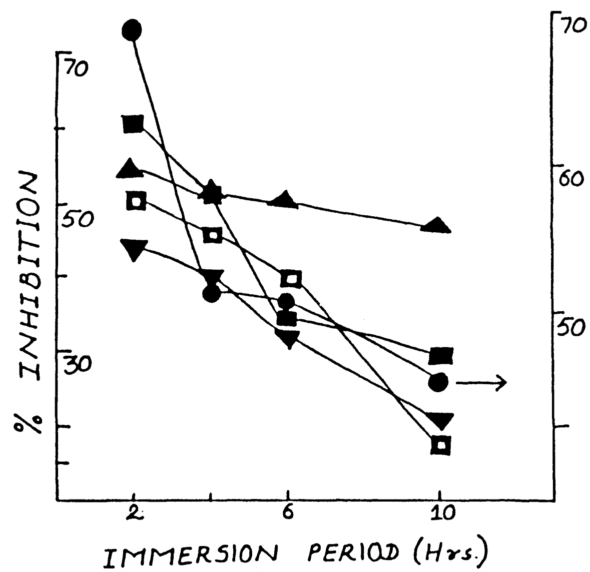

Fig. 2. Effect of immersion period on inhibition of aluminium-copper alloy in 0.1 M TCA.
▲-▲ Carmosine, ●-● Amaranth, ■-■ Sunset yellow,
▼-▼ Fast red E, □-□ Tartrazine

The specimens immersed in solution of acid containing very little or no inhibitor developed a loose greenish film which could be easily removed by a jet of water or rubbing with rubber bung. The film material, when separated by rubbing, dissolved easily in the acid (*e.g.*, HNO_3) and thus appeared to be due to the presence of cathodic elements (*e.g.*, copper). The cleaned specimens appeared dull metallic, inhibited 0.5 M TCA, there was extensive pitting all over the surface, particularly at edges. The specimens immersed in 1 M TCA were at times perforated and fell down from the glass-hooks. The specimens were covered with spongy copper at those places where there was pit formation. The fluffy deposited metal at times settled down at the bottom of the beaker. It was interesting to observe that those specimens which suffered a good deal of corrosion in TCA became appreciably hot within 2–4 min after cleaning. No such effect has been observed in 2s, 3s, and Ms7s aluminium. The phenomenon thus appears to be related to the presence of copper in the alloy.

Effect of Inhibitor Concentration: In order to determine the effect of inhibitor concentration on inhibitive efficiency, weight losses were determined in 0.1 M TCA containing 0.05–1% (w/v) of inhibitor at 303 ± 0.5 K for an immersion period of 2 h. From Fig. 1, it is evident that the extent of inhibition increase with increases in inhibitor concentration up to 0.5% (w/v) except carmosine. In the case of carmosine the inhibitor efficiency decreases 4%. At an inhibitor concentration 0.5% (w/v) the inhibitor efficiencies of various colourants increase in the order:

Fast Red E(44.98%) < Tartrazine < Carmosine < Sunset Yellow < Amaranth (69.2%).

Effect of Concentration: To determine the effect of acid concentration on inhibitive efficiency, weight losses were determined in different concentrations of acid (0.1 M to 1.0 M) containing a constant inhibitor concentration 0.5% (w/v). From the results given in Table-1, it may be generalized that the inhibition of all the inhibitons increases with increase in the acid concentration up to 0.5 M. Beyond this concentration, the efficiency of all the inhibitors decreases.

At an acid concentration 0.5 M the inhibitor efficiencies of various inhibitors increased in the order:

Tartrazine (68.3%) < Fast red < Carmosine < Amaranth < Sunset yellow (79.3%)

Effect of Exposure Period: In order to examine the effect of the immersion period on inhibition, it was measured for different exposure periods ranging from 24 to 10 h in 0.1 M TCA inhibited with 0.5% (w/v) of inhibitor. The results given in Fig. 2 indicate that the efficiency decreases with increase in the period of immersion. The decrease in the case of carmosine, amaranth, sunset yellow, fast red E and tartrazine is 11, 6.5, 21, 22 and 27% resepctively.

The Effect of Temperature: To study the effect of temperature on inhibitive efficiency, weight losses were determined in 0.1 M TCA containing 0.5% (w/v) inhibitor at solution temperature of 303, 313, 323 and 333 K. The results are given in Table-2. The inhibitive efficiency of all the inhibitors except amaranth was also found to increase with rise in temperature. In the case of amaranth, the efficiency remains almost constant. Such inhibitors are of practical interest where retardation

TABLE-1

EFFECT OF ACID CONCENTRATION ON INHIBITION EFFICIENCY OF FOOD COLOURANT FOR ALLUMINIUM-COPPER ALLOY IN TCA

Immersion period 2 h; Temperature 303 ± 0.5 K; Inhibitor conc. 0.5% (w/v)

Inhibitor	Percentage Inhibition (P.I.) for an acid concentration (M)				
	0.1	0.2	0.3	0.4	0.5
nil	(102.0)	(180.2)	(630.5)	(1800.0)	(3250.0)
Carmosine	55.08	62.30	71.90	75.20	39.80
Amaranth	69.20	71.90	78.50	79.10	49.10
Sunset yellow	62.40	71.40	74.30	79.30	28.60
Fast red	44.98	62.30	64.00	72.30	37.60
Tartrazine	51.20	58.30	61.20	68.30	25.80

( ) corrosion loss in mg in uninhibited TCA

TABLE-2

EFFECT OF TEMPERATURE ON INHIBITION EFFICIENCY OF FOOD COLOURANT IN 0.1 M TCA

Immersion period 2 h; Inhibitor conc. 0.5% (w/v)

Inhibitor	P.I. of Inhibition at temperature (K)				Energy of activation kJ/mole for temperature (K)			Mean E kJ/mole	E from graph log $\rho v_s(1/\tau)$
	303	313	323	333	303–313	313–323	323–333		
Nil	(255.0)	(300.0)	(801.4)	(2147.5)	12.81	82.86	88.16	61.28	60.32
Carmosine	55.08	60.83	61.58	70.87	2.00	81.01	63.35	48.78	45.50
Amaranth	69.20	68.00	67.88	70.87	15.31	82.91	79.40	59.20	58.50
Sunset yellow	62.40	63.16	65.43	74.92	11.50	77.26	59.44	49.40	48.30
Fast Red	55.98	46.00	47.57	48.31	11.34	80.10	86.90	59.44	60.10
Tartrazine	51.40	56.66	61.25	65.54	3.77	73.19	77.67	51.54	52.30

( ) weight loss in mg in uninhibited TCA of corrosion at elevated temperature is desired. The efficiency of different inhibitors at 333 K was found to increase in the order:

Fast red E (48.3%) < Tartrazine < Amaranth = Carmosine < Sunset yellow (74.92%)

The values of energy E, for the corrosion losses in inhibition as well as uninitiated acid were calculated by the following equation:

$$\log \frac{\rho_1}{\rho_2} = \frac{E}{2.303}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

where ρ_1 and ρ_2 are the corrosion rates ($mg/dm^2/h$) at temperatures T_1 and T_2 (K) respectively. The values of E are given in Table-2; the mean values of E are found to increase in the order:

Carmosine (48.78) < Sunset yellow (49.40) < Tartrazine (51.54) < Amaranth (59.2) < Fast red E (59.44) < Uninhibited TCA (61.28 K/mole)

The nearly equal values of E for all the inhibitors indicate that they are similar in mechanism of action. The higher values of E (*viz.*, 61.28 kJ/mol) in uninhibited acid show that temperature co-efficient of the reaction in uninhibited acid is high. The decrease in the value of E in inhibited acid is probably accounted for by the increase in the surface area of the metal covered by the inhibitor molecules with rise in temperature. When there is specific adsorption on the metal, the corrosion reaction can proceed by diffusion of the corrosive through the fine pores of the protective layer formed. The kinetics of the corrosion process then acquire the character of a diffusion process, which explains the low temperature coefficient of the reaction[7, 8].

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