Effect of Some Inorganic Anions on the Corrosion and Passivity of Tin in NaCl Solution

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THE anodic behaviour of tin in deaerated and aerated 0.1M NaCl solutions was studied by the potentiostatic technique. The effect of SO_3^{2-}, SCN^-, NO_2^-, HPO_4^{2-}, PO_4^{3-} and CrO_4^{2-} anions on such behaviour in the deaerated NaCl solution and of the latter two anions in the aerated solution was studied. The corrosion potential of tin shifted in the positive direction in presence of all examined anions (except PO_4^{3-}). Anodic polarization of tin in pure NaCl solutions showed that the values of the critical and passive c.ds. in the aerated solution are about twice the corresponding values in the deaerated one. The presence of all investigated anions increased both the primary passivation potential and the critical c. d. (except at 10^{-2}M NO_2^-). The passive c. d. was greatly diminished in presence of 10^{-3}M SCN^- and NO_2^- ions, suggesting adsorption of both anions at the passivating film. At 10^{-2}M of both CrO_4^{2-} and PO_4^{3-} ions, the passive c. d. was decreased and pitting attack by Cl^- ions was stifled. For the aerated NaCl solution, the presence of CrO_4^{2-} and PO_4^{3-} ions at a concentration $\geq 10^{-3}$M, inhibited the active dissolution of the metal. Similar result was obtained at 10^{-2}M NO_2^- in the deaerated NaCl solution.

THE effect of inorganic inhibitors on the anodic behaviour of iron and steel has been investigated extensively. However, little experimental work has been reported on the other non-ferrous metals. Lorking and Maney[1,2] studied the effect of pH and some inorganic anions (CrO_4^{2-}, SO_4^{2-}, PO_4^{3-} Cl^-) on the corrosion of Al. They found a correlation between the inhibition range and the range of low initial oxide solubility. The effect of several inorganic anions on the corrosion of zinc in aerated and deaerated aqueous solutions was studied by El Din *et al* [3,4]. Their results indicated that SO_4^{2-}, Cl^-, Br^-, I^-, ClO_4^- and NO_3^- promote corrosion, and that, NO_2^-, $H_2PO_4^-$, HPO_4^{2-} and CrO_4^{2-} act bifunctionally, promoting corrosion at high dilutions and stifling it at relatively high concentrations. The corrosion inhibition of zinc in NaOH solution by gelatine and some inorganic anions was studied by Abdul Azim *et al* [5]. They found that the concentration needed to establish certain inhibiting effeciency increases with the increase in alkali concentration. Tho effect of nitrates on the dissolution of tin in O_2– free solutions of sulphates and organic acids was investigated by Sherlock and Britton[6]. They have shown that, the rate of reduction of NO_3^- and hence, the corrosion rate, increased as the corrosion potentials became more positive, as a result of potential dependence of NO_3^- ion adsorption on tin. El Din *et al* [7]. observed that tin immersed in chromate solution of different concentrations undergoes pitting on addition of Cl^- ions to the solution. The effect of Cl^-, Br^- and I^- ions on the anodic behaviour of tin, nickel and SnNi alloy in alkaline media was recently studied by Abdel Aal and Osman[3]. Such anions were found to have an inhibitive effect on the active dissolution of tin.

This study is on the anodic behaviour of tin in 0.1 M NaCl solution and the effect of SO_3^{2-}, SCN^-, NO_2^-, HPO_4^{2-}, PO_4^{3-} and CrO_4^{2-} ions on such behaviour under potentiostatic polarisation.

EXPERIMENTAL

0.1 M NaCl solution was prepared from the Analar reagent (B.D.H., England) and bidistilled water.

In order to determine quantitatively the effect of SO_3^{2-}, SCN^-, NO_3^-, HPO_4^{2-}, PO_4^{3-} and CrO_4^{2-} ions on the anodic behaviour of tin in the sodium chloride solution, increments of a concentrated solution of their salts, were added to the cell.

Solutions were deaerated with purified nitrogen for over 6 hours before the electrode was introduced into the cell and continued for about 1 hour after that. All potentials are with reference to the saturated calomel electrode at 30°C.

Tin specimes : Specimens were cut from extra pure rods (S.K.C. Berlin), 5 mm in dia. and were inserted in Teflon so that only the flat surface was in contact with the solution.

Polarization measurements : Potentiostatic polarization was by standard potentiostat Wenking ST 72 and the over-voltage increases were obtained

by manually changing the potentiometer in step-wise fashion of a rate of 20 mV/2 min. After Setting the desired potential, the steady state current was recorded 2 min, later. Before each polarization, the specimens were cleaned cathodically in 2% Na_2CO_3 with vigrous H_2 evolution to remove any surface contamination and air formed oxide. This was preceded by surface polishing using successive grades of emery paper. Before use, an electrode was degreased with absolute ethanol (A. R.) grade, it was then washed with double distilled water and inserted in the polarization cell which was similar to that described elsewhere[9]. Each experiment was carried out with a newly polished electrode using a fresh solution.

RESULTS AND DISCUSSION

Open circut corrosion potentials : The steady state corrosion potentials, E_{corr} (attained after about one hour from (immerson) in deaerated 0.1 M NaCl solution containing SO_3^{2-}, NO_2^-, SCN^-, HPO_4^{2-}, PO_4^{3-} and CrO_4^{2-} ions in the concentration range 10^{-4}-10^{-2}M are given in Table I. The value of E_{corr} for tin in pure deaerated NaCl solution is about-810 mV (vs SCE).

TABLE 1

Corrosion potentials of tin in deaerated 0.1 M NaCl solution containing some inorganic anions

Anion	Conc. ML^{-1}	Solution pH	E_{corr} mV (SCE)
SO_3^{2-}	10^{-4}	6.8	—744
	10^{-3}	7.3	—720
	10^{-2}	7.6	—740
SCN^-	10^{-4}	6.5	—580
	10^{-3}	6.54	—560
	10^{-2}	6.54	—610
NO_2^-	10^{-4}	6.5	—600
	10^{-3}	6.5	—680
	10^{-2}	6.54	—580
CrO_4^{2-}	10^{-4}	6.64	—580
	10^{-3}	7.2	—546
	10^{-2}	8.2	—540
HPO_4^{2-}	10^{-4}	6.84	—720
	10^{-3}	7.8	—688
	10^{-2}	8.45	—660
PO_4^{3-}	10^{-4}	9.2	—800
	10^{-3}	10.5	—820
	10^{-2}	11.1	—828

The data given in Table 1, indicate that the value of E_{corr} is shifted in the positive direction in presence of all examined anions (except PO_4^{3-} ions). For SO_3^{2-}, SCN^-, NO_2^- and HPO_4^{2-} anions, the positive shift in E_{corr}, suggests adsorption of such anions at the anodic sites, resulting in an increase in the cathodic areas at the expense of anodic sites, and the electrode becomes predominately under cathodic control. Similar results were obtained by El Din *et al*[4]. (4) for zinc in solutions of similar anions. The large positive shift in E_{corr} in presence of CrO_4^{2-} ions probably denotes passivation of the metal. The cathodic reaction of chromates may serve to supply the passivating current. Abu Zahra and El Din[10] reported that the reduction of Cr (VI) to Cr (III) is thermodynamically more feasible than the discharge of H^+ ions :

$$2\ CrO_4^{2-} + 5\ H_2O + 6e = Cr_2O_3 + 10\ OH \quad (1)$$

Simple immersion of iron in chromate solution was found to be sufficient to render the metal passive[11].

Anodic behaviour of tin in both aerated and deaerated 0.1 M NaCl solutions :

Anodic polarization curves of tin in both aerated and deaerated 0.1 M NaCl solutions (pH = 6.4) are shown in Fig. 1 Anodic passivation parameters are given in Table 2. It is seen that the curve representing the anodic behaviour in the deaerated solution manifests a pseudopassivation phenomenon, which starts at a potential of about -720 mV.

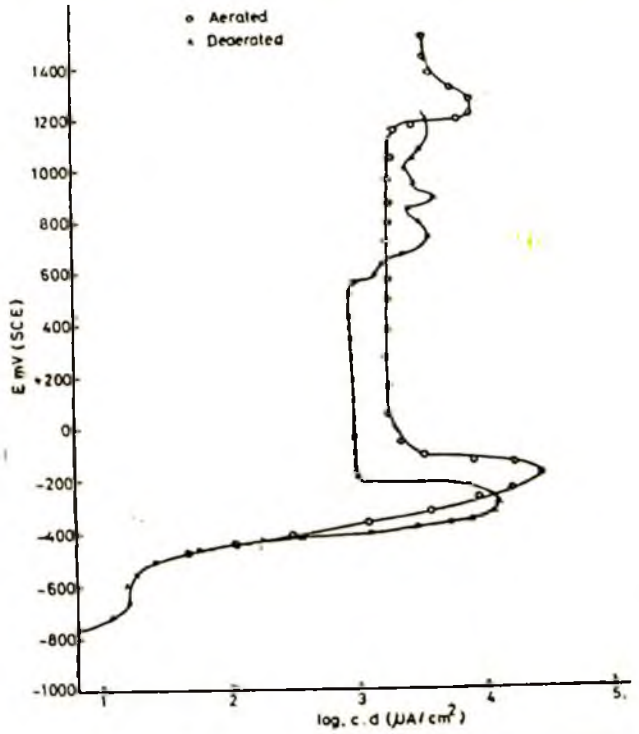


Fig (1) Potentiostatic anodic polarization of tin in both aerated and deaerated 0.1 M Nacl solutions

TABLE 2

Passivation parameters for tin in deaerated and aerated 0.1 M NaCl solutions (pH = 6.4)

Solution Conc.	E_{pp} mv (vs SCE)	I_{cc} mA/cm²	I_p μA/cm²
Dearated 0.1 M NaCl	—280	12.6	955
Aerated 0.1 M NaCl	—160	27.6	1820

This value coincides approximately with the equilibrium potentials of the systems Sn/SnO and Sn/$Sn(OH)_2$ at the pH of the solution, ($E_{Sn/SnO}$ = -715 mV and $E_{Sn/Sn(OH)_2}$ = -728 mV). The primary passivation potential (E_{pp}) is about -280 mV, which is 250 mV more positive than the equilibrium potentials of the system SnO/Sn $(OH)_4$ and Sn $(OH)_2$/Sn $(OH)_4$. Such positive shift may be attributed to an overpotential associating the oxide (hydroxide) formation or to pH change at the vicinity of the electrode surface. It is thus assumed that passivation of tin in deaerated NaCl solution takes place in two steps, the first of which involves SnO or Sn $(OH)_2$. In the second step oxidation to Sn $(OH)_4$ takes place. This can be represented by the equations :

$$Sn + H_2O = SnO + 2H^+ + 2e \quad (2)$$

$$Sn + 2H_2O = Sn(OH)_2 + 2H^+ + 2e \quad (3)$$

$$SnO + 3H_2O = Sn(OH)_4 + 2H^+ + 2e \quad (4)$$

$$Sn(OH)_2 + 2H_2O = Sn(OH)_4 + 2H^+ + 2e \quad (5)$$

Similar mechanism was suggested by Do Duc and Tissot[12] for the passivation of tin in neutral phosphate solution using cyclic voltametric technique.

The primary passivation potential of tin in the aerated NaCl solution is about 120 mV more positive than that obtained in the deaerated one. Such an increase in E_{pp} can be attributed to an O_2 overpotential associating adsorption of the gas at the passivating oxide (hydroxide) film. It is worth remarking that the pseudo passivation phenomenon exhibited by the anodic polarization curve in the deaerated NaCl solution is not here manifested. This prabably indicates that the SnO or $Sn(OH)_2$ prepassive layer is less stable in the air saturated NaCl solution. Values of critical and passive current densities (I_{cc} and I_p) obtained in the aerated NaCl solution (Table 2) are about twice the corresponding ones obtained in the deaerared medium. Trabanelli *et al.*[13] found that the presence of oxygen causes an increase in the reactivity of nickel in all ranges of potential.

Current oscillations observed within the transpassive region of the anodic polarization curve in the deaerated solution denote pitting attack by Cl^- ions. In the aerated NaCl solution, although the potential range of the passive region becomes more wide, a sharp increase in I_p occurs at a potential of about + 1200 mV indicating passivity break-down. This was associated with oxygen evolution and the electrode was found to be covered with a black oxide film. Similar observation was reported by Pugh, Warner and Gabe (14) during anodic polarization of tin in Na_2CO_3 and NaOH solutions.

Effect of some inorganic anions on the anodic behaviour of tin in 0.1 M NaCl solution :

Effect of sulphites :

The curves shown in Fig. 2 represent the anodic behaviour of tin in deaerated 0.1 M NaCl solution containing 10^{-4}, 10^{-3} and 10^{-2} M SO_4^{2-} ion. Anodic passivation parameters are given in

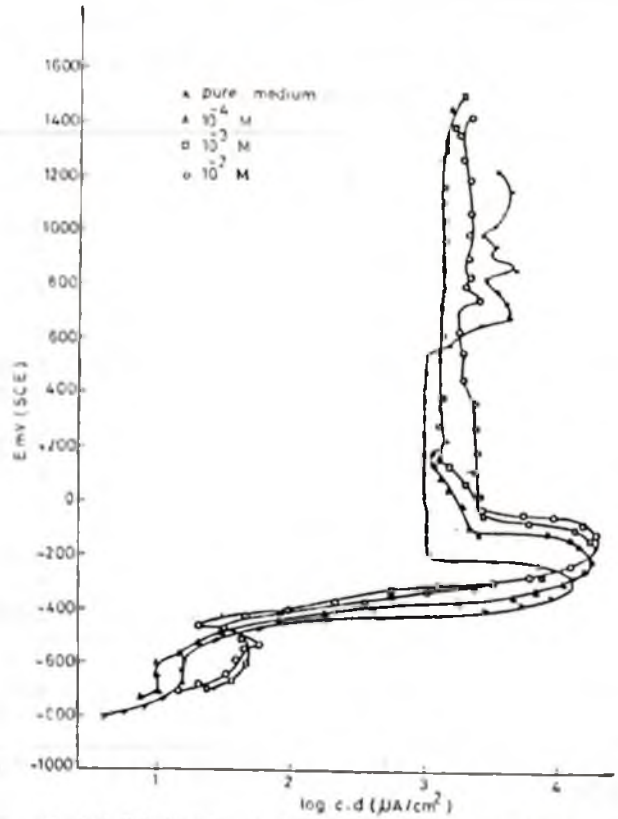


Fig (2) Potentiostatic anodic polarization of tin in deaerated 0.1 M Nacl solution in presence of SO_4^{2-} ions

Table 3. It is seen that although the psuedo passivation phenomenon manifested by the anodic polarizarion curve at 10^{-4} M SO_3^{2-} ion occurs within the same potential range as that of the pure medium, the value of E_{pp} is about 80 mV more positive than the corresponding one obtained in the latter solution. The pseudo and primary passivation potentials manifested by the anodic polarization curves in presence of 10^{-3} and 10^{-2} M SO_3^{2-} ion occur at −550 and −150 mV respectively. The latter value is about 130 mV more positive than that of E_{pp} obtained in the pure NaCl solution. In all cases, the value of I_{cc} is appreciably increased.

TABLE 3

Passivation parameters for tin in deaerated 0.1 M NaCl solution containing some inorganic anions

Anion	Conc. Ml−2	E_{pp} mV (vs SCE)	I_{cc} mA/cm2	I_p μA/cm2
SO_3^{2-}	10^{-4}	−200	17.4	1200
	10^{-3}	−150	20	1260
	10^{-2}	−150	20.5	1700—2100
SCN^-	10^{-5}	−160	25.1	398
	10^{-4}	−160	24	1000
	10^{-3}	−150	25.1	1100
	10^{-2}	−220	20	1400
NO_2^-	40^{-5}	−200	14.4	575
	10^{-4}	−280	13.8	880
	10^{-3}	−180	18.2	910
	10^{-2}	−200	4.6	1660
HPO_4^{2-}	10^{-4}	−100	22.9	1150
	10^{-3}	−100	21.9	1150
	10^{-2}	−100	17.4	1150

Although the value of I_p in presence of 10^{-4} and 10^{-3} M SO_3^{2-} ion is slightly increased, the passive region becomes more wide and current oscillations almost disappeared. It is thus assumed that although SO_3^{2-} ion at a concentration $\leq 10^{-3}$ M stimulates metallic dissolution in the active region, adsorption of such anions at the passivating film stifles pitting attack by Cl^- ions.

At 10^{-2} M SO_3^{2-} ion, the value of I_p is about twice that of the pure NaCl solution. This together with the higher value of I_{cc} obtained in the same solution, suggest that SO_3^{2-} ions at such higher concentration accelerate the dissolution of tin in both active and passive regions.

Effect of thiocyanates :

The anodic behaviour of tin in deaerated 0.1 M NaCl solution containing SCN^- ions in the concentration range 10^{-5} — 10^{-2} M is represented graphically in Fig. 3. Anodic passivation parameters are given in Table 3, These results indicate that E_{pp} and I_{cc} of tin in the pure medium are increased in presence of SCN^- ions at all examined concentrations. At 10^{-5} M SCN^- ion, although the value of I_{cc} is about twice that of the pure NaCl solution, the value of I_p is decreased to less than half of its original value. For solutions containing 10^{-3} and 10^{-2} M SCN^- ion the value of I_p is also increased. Current oscillations observed in pure NaCl solution, almost disappeared in solutions containing SCN^- ions in the concentration range 10^{-5}—10^{-3} M and the passive region becomes more wide. In presence of 10^{-2} M SCN^- ion the value of I_p is about 50% greater than the original value and the potential range of the passive region is contracted. At a potential of about + 200 mV, I_p increases rapidly, indicating passivity breakdown. It is thus concluded that SCN^- ions promote the dissolution of tin in the active region, irrespective of concentration, while their effect in the passive region depends on it. At 10^{-5}M SCN^-

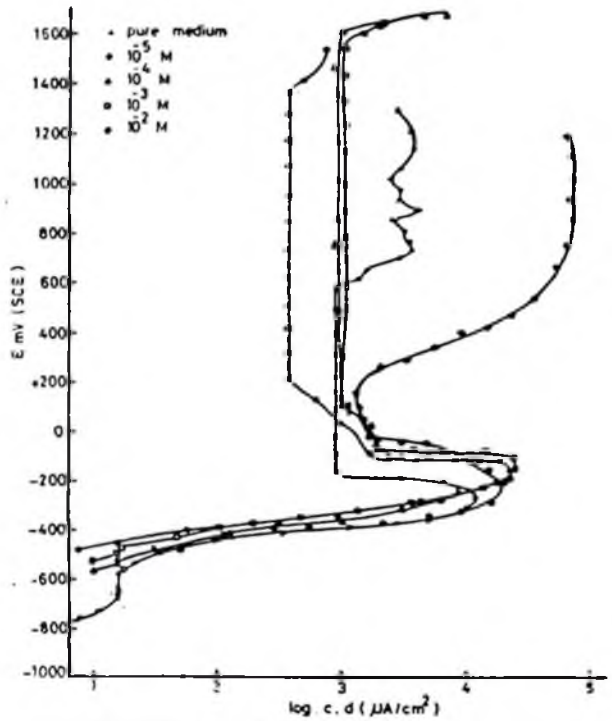


Fig. 3. Potentiostatic anodic polarization of tin in deaerated 0.1 M NaCl solution in presence of SCN^- ions.

ion, preferential adsorption of such anions at the passivating film results in a decrease in I_p and prevents pitting attack by Cl^- ions. At 10^{-4} and 10^{-3}M SCN^- ion, although adsorbed ions do not affect greatly the value of I_p, they inhibit attack by Cl^- ions. At the highest examined concentration, SCN^- ions cause passivity breakdown.

Effect of nitrites : Figure 4 shows the anodic polarization curves for tin in deaerated 0.1 M NaCl

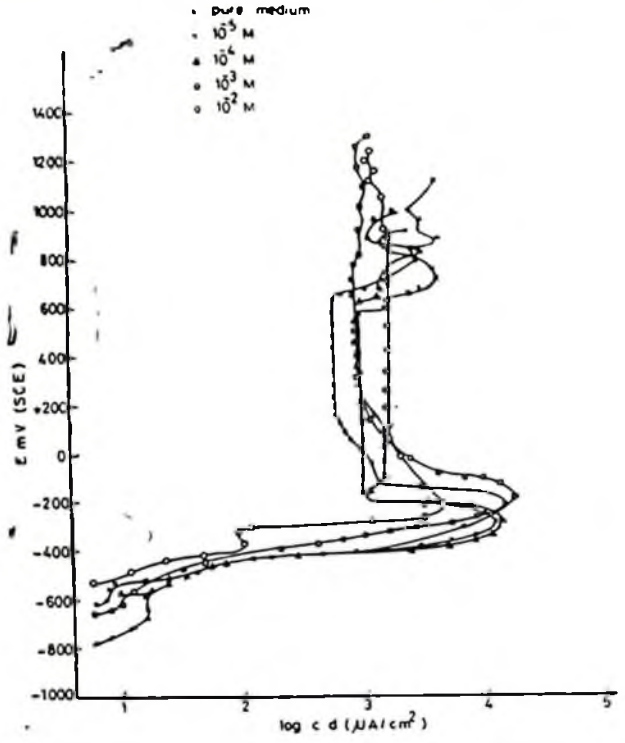


Fig (4) Potentiostatic anodic polarization of tin in deaerated 0.1 M NaCl solution in presence of NO_2^- ions

solution containing NO_2^- ions in the concentration range 10^{-5}-10^{-2}M. Anodic passivation parameters are given in Table 2. These results indicate that the anodic behaviour of tin in presence of 10^{-4}M NO_2^- ion is approximately the same as that of the nitrite free solution. Although the anodic behaviour of tin at 10^{-5} NO_2^- ion is similar to that of the pure medium, the value of E_{pp} is shifted by about 80 mV in the positive direction and I_{cc} is slightly increased. However, the value of I_p is decreased by about 50% of its original value. In presence of 10^{-3}M NO_2^- ion E_{pp} occurs at about-180 mV, which is 100 mV more positive than that of the pure NaCl solution. The value of I_{cc} is increased by about 50%, indicating acceleration of the dissolution of the metal in the active region. However, the value of I_p is slightly decreased and current oscillations becomes less pronounced. It is thus assumed that at such NO_2^- ion concentration, adsorption of the ions at the passivating film decreases the attack by Cl^- ions. The anodic polarization curve at 10^- ion manifests a pseudo-passivation potential at about-380 mV, E_{pp} is about-200 mV and I_{cc} is decreased to about $\frac{1}{3}$ of its original value. Although the value of I_p is increased by about 70% in presence of such NO_2^- ion concentration, the potential range of the passive region becomes more wide and current oscillations almost disappeared. Thus it is concluded that NO_2^- ions at a concentration $\leq 10^{-3}$M accelerates the dissolution of the metal in the active region, while inhibit or have no effect on such dissolution in the passive region. At the highest concentration of NO_2^- ion (10^{-2}M), mettalic dissolution in the active region is appreciably inhibited and the increase in I_p is probably ascribed to oxidation of NO_2^- ions at the preanode layer.

Potential measurement on zinc in neutral solutions of NO_2^- ions carried out by El Din and Khedr[4] have shown that NO_2^- ions promote corrosion at high dilutions but inhibit it at higher concentrations.

Effect of hydrogen phosphates : The anodic behaviour of tin in deaerated 0.1 M NaCl solution

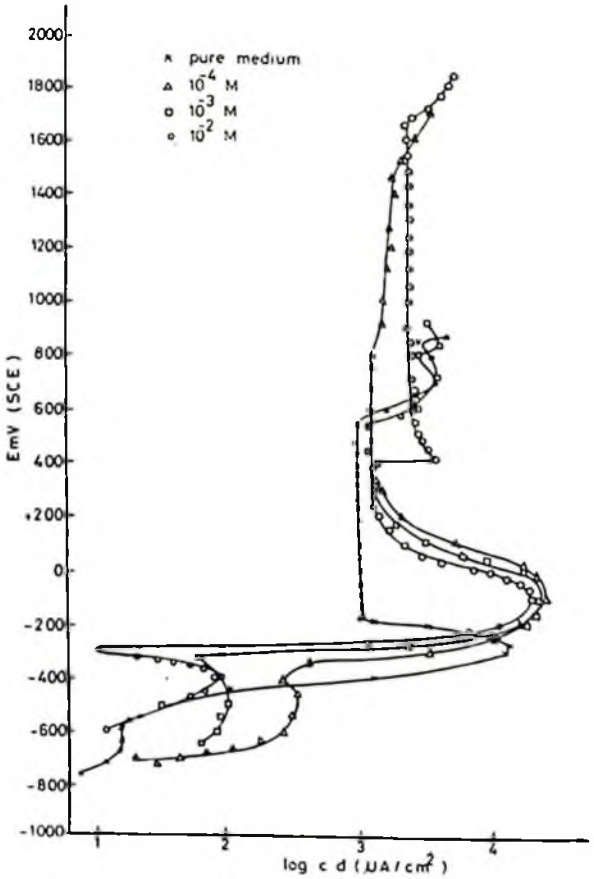


Fig (5) Potentiostatic anodic polarization of tin in deaerated 0.1 M NaCl solution in presence of HPO_4^{2-} ions

containing HPO_4^{2-} ions in the concentration range 10^{-4}-10^{-2}M is represented graphically in Fig. 5. Anodic passivation parameters are given in Table 3. It is seen that the pseudo-passivation phenomena exhibited by all anodic curves occur within the potential range -400 to -500 mV. The primary passivation potentials manifested by these curves occur at one and the same value namely +100 mV, which is about 180 mV more positive than the corresponding value obtained in the pure medium. This is associated with an appreciable increase in I_{cc}, attaining a value about twice the original one at 10^{-4} and 10^{-3}M HPO_4^{2-} ions. Although values of I_p at all examined concentrations of HPO_4^{2-} ion are approximately the same (about 1150 μA/cm^2), the potential range of the passive region decreases in the direction of increasing HPO_4^{2-} ion concentration. In presence of 10^{-4}M HPO_4^{2-} ion and at potentials > +800 mV the value of I_p increases gradually with potential attaining a value about twice the original value at a potential of about +1500 mV where the transpassive region starts. On the other hand, current oscillations observed in the pure NaCl solution almost disappeared at such HPO_4^{2-} ion concentration. It may be assumed that although HPO_4^{2-} ions at such low concentration have a stimulating effect on the metal dissolution in both active and passive regions, they prevent pitting attack by Cl^- ions via precipitation of the insoluble $SnHPO_4$ salt at the sensitive points where attack may occur. The oxide film formed on iron in solutions containing $NaHPO_4$ as inhibitor was found to contain iron phosphate as minor constituent [15].

At 10^{-3}M OPO_4^{2-} ion, the stimulating action of the ions on the dissolution of the metal in both active and passive regions is associated with current oscillation within the trans-passive region. Few number of pits was observed at the electrode surface and the loosely adherent white precipitate spalled off the surface. At the highest HPO_4^{2-} ion concentration, the passive region becomes much narrower and passivity break down occurs at about +400 mV. This is followed by a slight decrease of current density attaining a steady state value which is about twice that of I_p before passivity breakdown. it is suggested that precipitation of the insoluble $SnHPO_4$ salt at the points where breakdown occurs does not provide the same degree of passivity as the stable oxide (hydroxide) film.

Effect of phosphates : Figure 6 and 7 show the anodic polarization curves of tin in both deaerated and aerated 0.1 M NaCl solutions in presence of PO_4^{3-} ions. Anodic passivation parameters are given in Table 4.

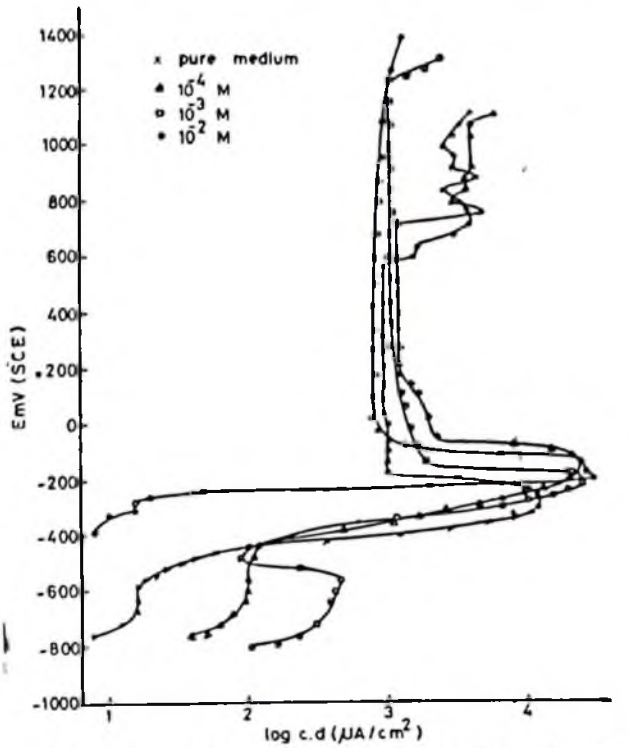


Fig.(6):Potentiostatic anodic polarization of tin in deaerated 0.1 M Nacl solution in presence of po_4^{3-} ions.

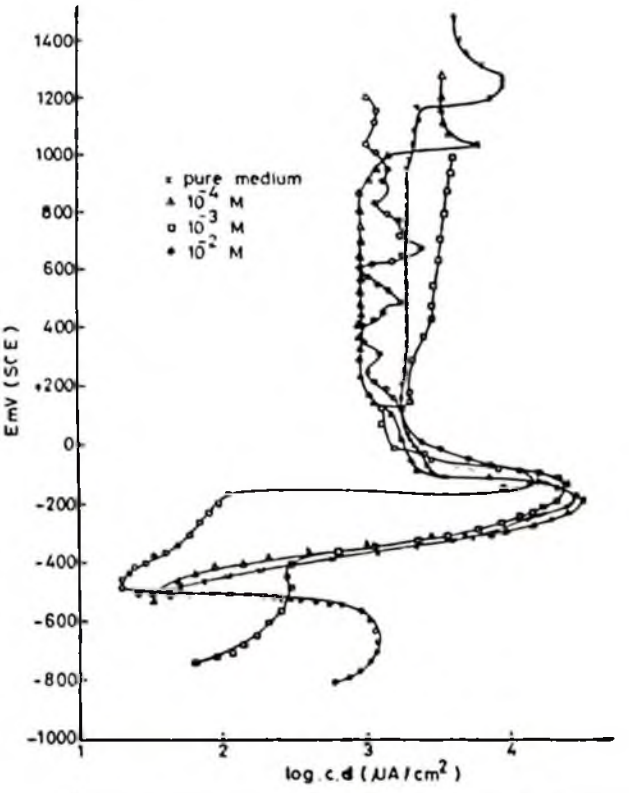


Fig (7) Potentiostatic anodic polarization of tin in aerated 0.1 M Nacl solution in presence of po_4^{3-} ions

For deaerated solutions, the pseudo-passivation potentials manifested by the anodic curves

TABLE 4

Passivation parameters for tin in 0.1 M NaCl solution containing CrO_4^{2-} and PO_4^{3-} ions

Anion	Conc. ML-1	Deaerated			Aerated		
		E_{pp} mV (SCE)	I_{cc} mA/cm²	I_p μA/cm²	E_{pp}mV(SCE)	I_{cc} mA/cm²	I_p μA/cm²
CrO_4^{2-}	10^{-4}	—200	26	1590	—170	15.9	2500
	10^{-3}	—200	26.8	1200	—180	20.4	1900
	10^{-2}	—160	19	500	—170	24.8	660
PO_4^{3-}	10^{-4}	—160	25	1200	—180	30	880
	10^{-3}	—200	26.4	1050	—120	24	1260
	10^{-2}	—200	31.6	795	—100	15	1000

10^{-4} and 10^{-3}M PO_4^{3-} ion occur at -600 and -550 mV respectively. The primary passivation potentials exhibited by such curves have values 100±20 mV more positive than that of tin in the pure NaCl solution. The positive shift in E_{pp} is associated with an increase in I_{cc}, the value of which in such solutions is about twice the value of the pure medium. At 10^{-4}M PO_4^{3-} ion the value of I_p is about 25% greater than the original one and the electrode undergoes pitting attack by Cl^- ions, similar to the phosphate free solution. Inspite of the slight increase in I_p in presence of 10^{-3}M PO_4^{3-} ion, the potential range of the passive region becomes more wide and current oscillations disappeared. Similar bahaviour is observed in presence of 10^{-2}M PO_4^{3-} ion although the value of I_p in such solution is slightly lower than that of the pure medium. The increase in I_{cc} with the increase of PO_4^{3-} ion concentration is probably attributed to the higher pH range found in solutions containing Na_3PO_4. The potentiostatic anodic polarization of tin in deaerated alkaline media, studied by Abdel Aal and Osman[8] indicated that the value of I_{cc} increases with the increases of the pH of the solution.

Broadening of the passive region together with the stifling of pitting attack by Cl^- ions in presence of 10^{-3} and 10^{-2}M PO_4^{3-} ion, is probably ascribed to the precipitation of tin phosphate at the sensitive points where attack by Cl^- ions may occur. Similar views have been reported by Pryor and Cohen [15] for the corrosion inhibition of iron using phosphates in chloride solutions.

Inspection of the results obtained in the aerated NaCl solution containing PO_4^{3-} ions, indicates that the behaviour of tin at 10^{-4}M PO_4^{3-} ion is similar to that of the pure medium. Although the value of I_p is appreciably diminished, passivity breakdown occurs at a much lower potential. In solutions containing 10^{-3} and 10^{-2}M PO_4^{3-} ion, although E_{pp} is shifted in the positive direction, I_{cc} is appreciably decreased, its value at 10^{-2}M PO_4^{3-} ion is about $\frac{1}{3}$ the original value. It is also observed that inspite of the pronounced decrease in I_p in presence of 10^{-3}M PO_4^{3-} ion, the passive region is appreciably contracted and I_p increases abruptly at a potential of about +150 mV, then gradually as the potential made more positive. At 10^{-2} M PO_4^{3-} ion current oscillations occur at a much lower potential than that of O_2 evolution. This was

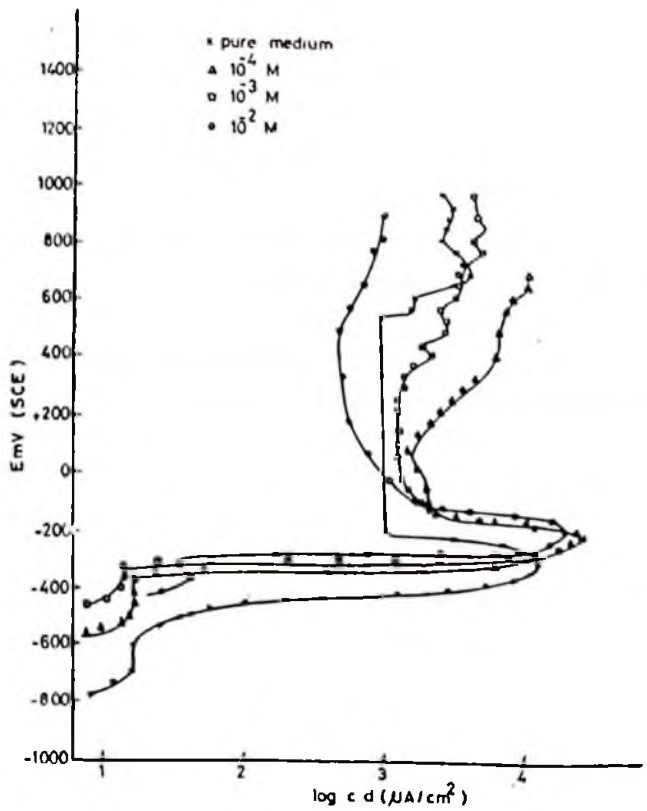


Fig (4): Potentiostatic anodic polarization of tin in deaerated 0.1 M NaCl solution in presence of CrO_4^{2-} ions

associated with the spall off of the white precipitate overlaying the black oxide film. Such precipitate was observed at all examined PO_4^{3-} ion concentrations.

Effect of chromates : The potentiostatic anodic polarization curves of tin in both aerated and deaerated 0.1M Na Cl solutions containing CrO_4^{2-} ion in the concentration range 10^{-4}-10^{-2}M are shown in Figs. 8 and 9. Anodic passivation

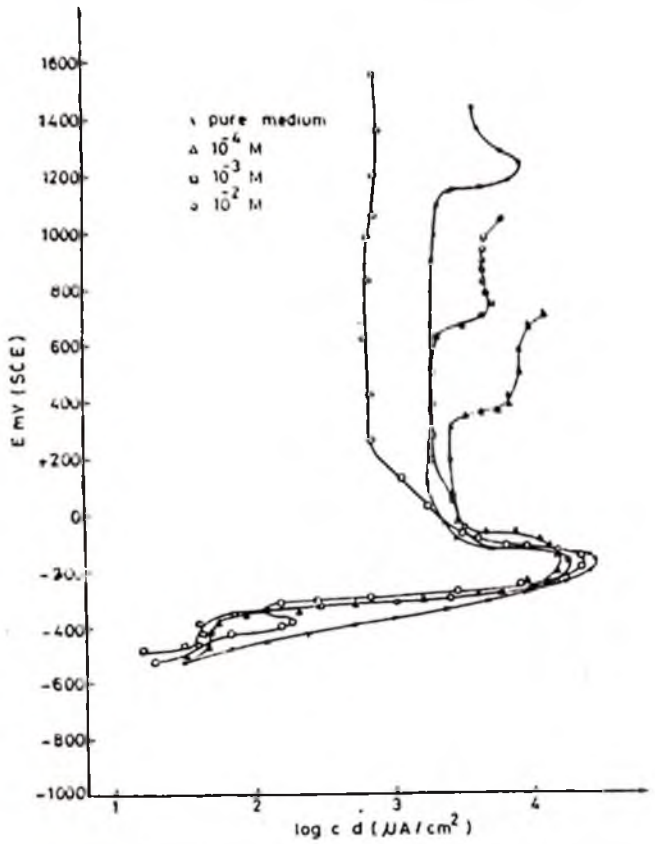


Fig (9) Potentiostatic anodic polarization of tin in aerated 0.1 M Nacl solution in presence of CrO_4^{2-} ions

parameters are given in Table 4. The results obtained in the deaerated solutions show that values of E_{pp} and I_{cc} are increased in presence of CrO_4^{2-} ions. Those of I_{cc} at 10^{-4} and 10^{-3}M CrO_4^{2-} ion are more than twice the original value. The value of I_p at 10^{-4}M CrO_4^{2-} ion attains a value of about 1600 μA/cm^2 at a potential of about +100 mV, then it increases rapidly as the potential made more positive indicating passivity breakdown. It was observed that the electrode is severely corroded. In presence of 10^{-3}M CrO_4^{2-} ion, the value of I_p is about 20% greater than the original value and current oscillations associating the transpassive region are still pronounced. Heavy pitting of the electrode surface was clearly observed. At the highest concentration of CrO_4^{2-} ion, although the value of I_{cc} is about 50% greater than that of the pure NaCl solution, I_p is decreased to about half of its original value and current oscillations almost dis-appeared.

As shown in Fig. 9, the anodic polarization curves of tin in aerated NaCl solutions containing CrO_4^{2-} ions, manifest pseudo-passivation phenomena within the potential rage -350 to -450 mV indicating that SnO or $Sn(OH)_2$ prepassive layer is relatively more stable in chromate containing solutions, than in the chromate free one. The primary passivation potential of tin in the pure NaCl solution is not affected appreciably by the presence of CrO_4^{2-} ions. However, the value of I_{cc} appreciably decreased. Value of I_{cc} in solutions containing 10^{-4}, 10^{-3} and 10^{-2}M CrO_4^{2-} ion are 15.9, 20.4 and 24.8 mA/cm^2 respectively. In the first two solutions the value of I_p is increased and passivity breakdown accurs at much lower potentials than that of the pure NaCl solution. At the highest concentration of CrO_4^{2-} ion the value of I_p is about $\frac{1}{3}$ of the original value and the passive region extends to potentials > +2000 mV. It is thus concluded that CrO_4^{2-} ions accelerate metallic dissolution in the active region in the deaerated solutions while inhibit it in the air saturated solutions. At the passive region CrO_4^{2-} ion at a concentration $\leq 10^{-3}$M increases the case of attack by Cl^- ions in both aerated and deaerated solutions.

At 10^{-2}M CrO_4^{2-} ion preferential adsorption of CrO_4^{2-} ions at the passivating film probably prevent attack by Cl^- ions. Similar view was reported by Matsuda and Uhlig (16) for inhibition of corrosion of iron by chromates.

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