

Elaboration of tin deposits in the presence of Bis-glucobenzimidazolone

S. Cherrouf^{*(a)}, Y. Salhi^(a), A. Benabida^(a), H. Elgrini^(a), M. Cherkaoui^(a), L. Lakhrissi^(b), B. Lakhrissi^(b)

^(a)Laboratoire de Matériaux d'Electrochimie et d'Environnement, Université Ibn Tofaïl, Faculté des Sciences, Kénitra, Morocco.

^(b)Laboratoire d'Agroressources et Génie des Procédés, Université Ibn Tofaïl, Faculté des Sciences, Kénitra, Morocco.

* Corresponding author: cherrouf.sghir@gmail.com

Received 09 June 2014, Revised 16 July 2014, Accepted 17 July 2014.

Abstract

The tin deposit was elaborated electrolytically on an ordinary steel substrate in SnSO₄ based electrolyte in acid medium with and without additive (bis-glucobenzimidazolone) at ambient temperature. The influence of bis-glucobenzimidazolone on the electrochemical properties of the coating was investigated using both the stationary method and the chronopotentiometry. On the other hand, the surface state of the deposit obtained was characterized by optic microscopy. The results have shown a good surface quality of the deposit elaborated by addition of an optimal concentration of bis-glucobenzimidazolone in the electrolyte.

Keywords: Deposit, Tin, Bis-glucobenzimidazolone, Electroplating, cathodic polarization, Chronopotentiometry.

1. Introduction

Although the tin plating is known since the mid-nineteenth century, the process still has great interest and its development is always an actuality fact. This is due to the good weldability properties [1- 5], the non toxicity [1, 3, 5] and the relative corrosion resistance [1, 2, 5] of tin. Thus, the tin coatings have a wide range of applications: food and electronic industrie [1, 4-6]. Tin coatings may replace conventional deposits due to their inoffensive impact on the environment. For example, tin and tin alloys are required for the replacement of both chromium and cadmium deposits [3, 7-9].

In tin plating baths containing no organic additives, the tin is massively deposited under a low polarization. The deposit obtained is then porous, less adherent and dendritic with formation

of thin whiskers that are spontaneously developing on the tin surface, which may cause a short circuit between the anode and the cathode [4, 6, 8].

To solve or to minimize this problem, it is essential to modify the kinetics of deposition. Several authors have suggested the addition of organic compounds into the bath, which can slow the deposition rate. First of all, considerable efforts have been made in order to develop adequate additives and then to determine their intervention modes in both the mechanism and the kinetics of the deposit and therefore their influence on the coating structure [10, 11]. Various organic additives are used in tin plating baths such as surfactants, aromatic carbonyls, reaction products of aldehyde-amine [6, 8], the fluoro-carbon, the silicone, and the hydrocarbons-based products. The surfactants can be used to modify the polarization, remove hydrogen evolution, improve surface brightness [10, 11] and reduce roughness of deposits. Such additives may be nonionic, anionic or cationic.

In this study, we are interested in the effect of the addition of bis-glucobenzimidazolone into the tin plating bath on the tin deposit. The bis-glucobenzimidazolone influence on the electrochemical properties of the coating was studied by both the stationary method and the chronopotentiometry. Characterization of the surface state of the deposit elaborated was carried out by microscopy.

2. Experimental work

The solution of tin sulfate and sulfuric acid were prepared using analytical grade chemicals. The pH is around 1 as in industrial applications and temperature was kept at 20 ± 1 °C. Table 1 contains the electrolytes used. The compound added was the bis-glycobenzimidazolone. The bis-glycobenzimidazolone was synthesized by a method described by Lakhrissi and al. [12]. The structure is shown in Figure 1.

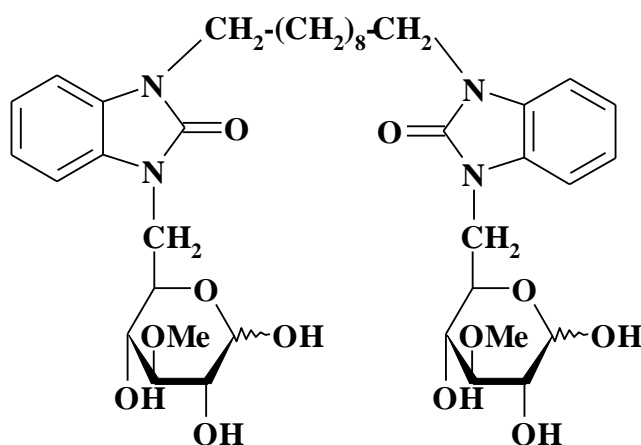


Figure 1. Structure of α,ω -N,N'-bis-[3-N-(6-deoxy-3-O-methyl-D-glucopyranos-6-yl)-2-oxobenzimidazol-1-yl]-decane

A 200ml cell was used. The substrates were iron plates (1cm^2), mechanically polished down to 1200 SiC paper, degreased in ethanol, etched in dilute sulfuric acid and rinsed with demineralized water prior experiment. The deposit rate was estimated from the weight gain

after a given immersion time (1/2-1h). The electrochemical measurements were run with a potentiostat (VoltaLab model PGZ100). The reference electrode was Ag/AgCl with all potentials referred. The surface of the deposits was examined by optic microscopy.

Table 1. Composition of studied baths.

Electrolytes	SnSO ₄ (M)	H ₂ SO ₄ (M)	Additive (M)
1	0.14	0.56	0
2	0.14	0.56	10 ⁻⁵
3	0.14	0.56	10 ⁻⁶

3. Results and discussions

3.1 Surface state of tin deposit

As shown on the photo 1, the tin deposit obtained in the basic bath containing no additive is very inhomogeneous, irregular, dendritic and has large black spots.

We also note that the surface is not totally covered, some of the coating is easily removed. In the presence of bis-glucobenzimidazolone, the surface state of the coating produced was largely improved. The deposit is more uniform and more adhering, it covers almost the entire surface. Different concentrations of additive were used, the optimum would be around 10⁻⁵ mole.L⁻¹ (photo 2).

Even with the naked eye, the contrast between the coatings produced in the absence and presence of bis-glucobenzimidazolone is striking. The one obtained in the basic bath (1) is much more burned

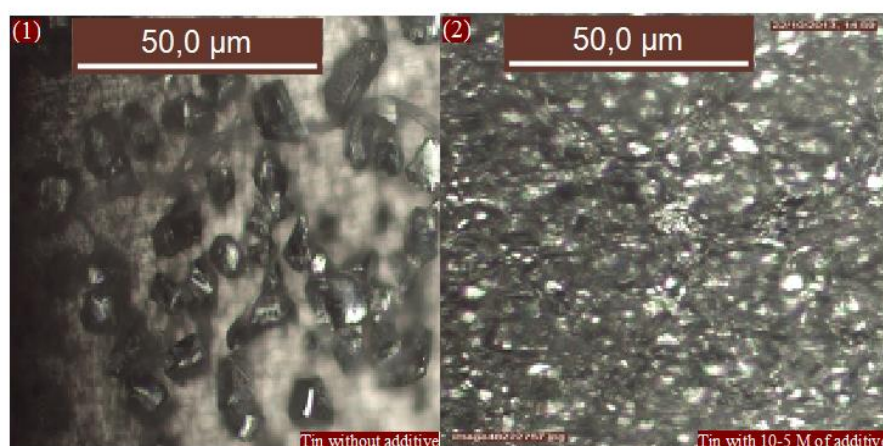


Figure 2. optic micrographs of the tin deposited from the electrolyte without bis-glucobenzimidazolone (1) and with 10⁻⁵ of bis-glucobenzimidazolone (2).

This improvement might be certainly attributed to a decrease of the deposition rate in the presence of the additive. Indeed, the literature review has shown that tin is massively deposited under a low polarization, which causes a burnt deposit of poor quality [7, 11].

3.2 Deposition rate

First, we note that the deposition rate increases with the intensity of the applied current (table 2). The table 2 shows also that the deposition rate decreases in the presence of bis-glucobenzimidazolone for different applied currents. Thus, the rate passes from 29, 7 $\mu\text{m/h}$ to 11,3 $\mu\text{m/h}$ at 10 mA/cm^2 in the absence and presence of the additive. This confirms the observations of the surface state.

The bis-glucobenzimidazolone would act « solvating » the Sn^{2+} ion and decrease its diffusion coefficient. Since the mechanism of tin deposition is controlled by the matter transport, which would explain the decrease in deposition rate.

On the other hand, one can also think about the additive adsorption on the surface blocking actives sites and decreasing deposition rate as a result.

Table2. Deposition rate as function of current density and concentration of bis-glucobenzimidazolone.

Current density (mA.cm^{-2})	Concentration of the additive (mole.L^{-1})	R ($\mu\text{m/h}$)
10	Without additive	29.7
	10^{-6}	23.3
	10^{-5}	11.3
15	Without additive	32,8
	10^{-6}	24,1
	10^{-5}	12,8
20	Without additive	36,4
	10^{-6}	25.4
	10^{-5}	16,4

We noticed that the better surface was obtained for a current density equal to 15 mA.cm^{-2} with an addition in the bath of 10^{-5} mole.L^{-1} de bis-glucobenzimidazolone.

3.3. Electrochemical investigations

a- Polarization curves curried out with and without additive

After having found that the deposition rate decreased with the presence of the additive at deposition potential, it would be interesting to see this change over a wide domain of potential. Thus, as shown on figure (3), the cathodic stationary current-voltage curves related to the baths 1, 2, 3 were grouped. It is noted that the current increases more or less rapidly with the potential from -475 mV.

However, we note that in the presence of bis-glucobenzimidazolone (figure (3), curve 2 and curve 3), the current is lower than in its absence (figure (3), curve2

over a wide range of potential). This current decreases as the concentration of bis-glucobenzimidazolone increases, which confirms the influence of the additive on the deposition rate.

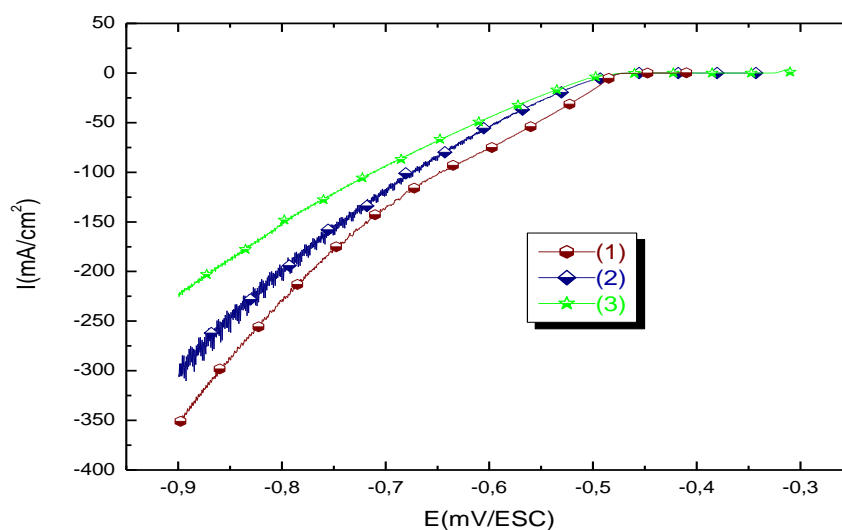


Figure 3 . $I=f(E)$ curves with stirring, scan rate = 1mV/S plotted in baths: (1), (2) and (3).

b- Chronopotentiometry with and without additive

The transitory curves $E=f(t)$ plot, for a current density of 10 mA/cm² in baths (1), (2) and (3) (figure 4), shows a stabilization of potential at - 476 mV for electrolyte (1) and - 480 mV for electrolyte (2) while it reaches - 490 mV in the case of electrolyte (3).

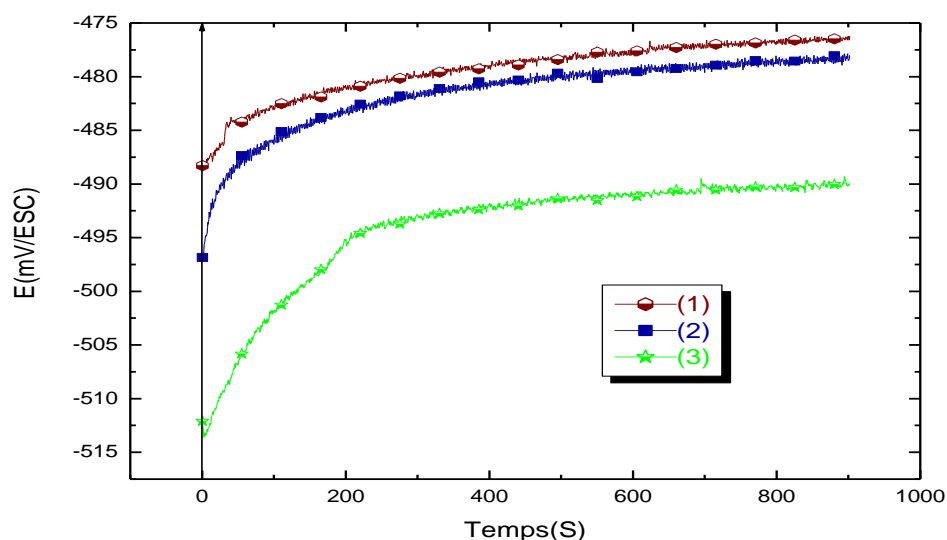


Figure 4 . Chronopotentiometry curves for a current density of 15 mA/cm² with magnetic stirring in baths: (1), (2) and (3).

This potential drop after the addition of bis-glucobenzimidazolone may be attributed to a partial blockage of the surface by adsorption of the additive.

c- Effect of applied current

The figure (5) illustrates the chronopotentiometry curves plotted from bath (3) on steel electrode for different current densities.

We note that the potential of stabilization increases with applied current as expected confirming the variation of deposition rate with the current density.

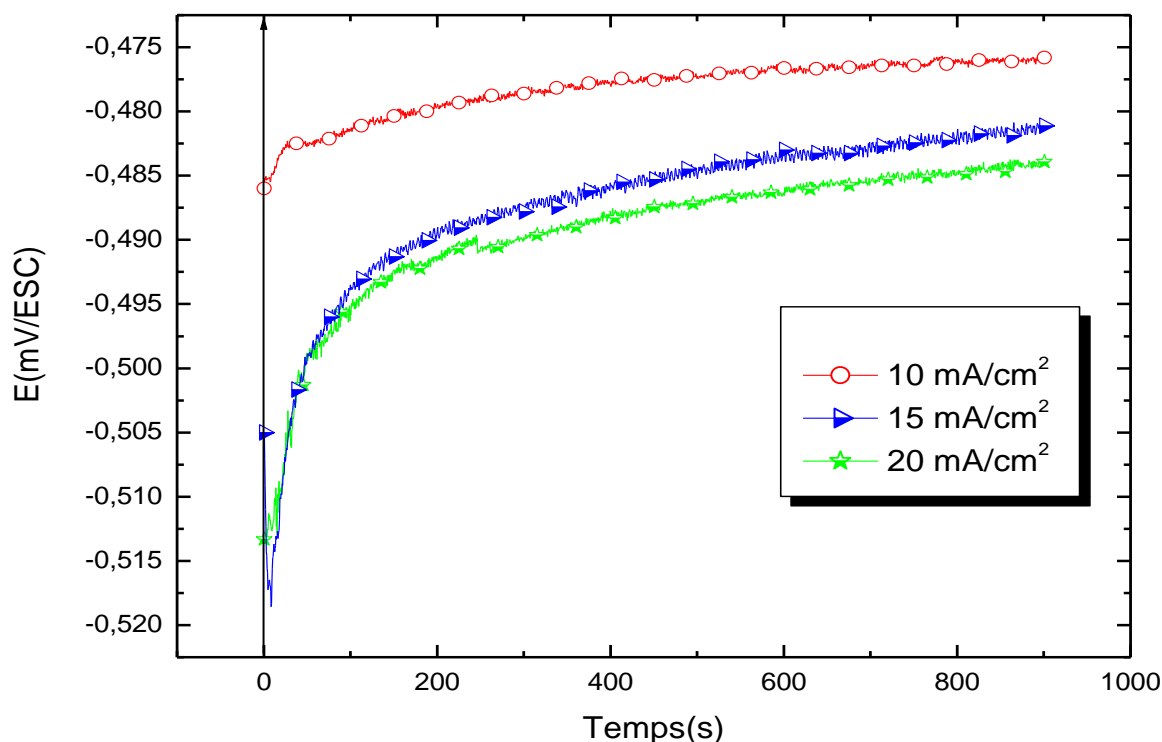


Figure 5 . Effect of current density on the chronopotentiometry of tin deposit.

4 . Conclusion

The addition of bis-glucobenzimidazolone into the base electrolyte of tin deposit containing SnSO_4 and sulfuric acid, leads to an improvement of the coating quality. Thus, the coating is more homogeneous, more regular and less burnt than the one obtained from the base bath. This improvement may be attributed to a slowdown in the process of tin reduction by adsorption of bis-glucobenzimidazolone on the surface blocking a part of the active sites.

Acknowledgements : we would like to thank our both professors M.Cherkaoui and B.Lakhressi for the supervision during this work.

References

- [1]: Ewa Rudnik*, Grzegorz Włoch Appl. Surf. Sci. 265 (2013) 839-849
- [2] : M.Charrouf, S. Bakkali, M. Cherkaoui and M. EL Amrani , J.Serb.Chem.Soc 71,6 (2006) 659-666

- [3]: Von Wan Zhang, Jonas Guebey, Michael Toben and Katharina Weitershaus, Luzern/Schweiz.(2011),520-528
- [4]: Eric Chason*, Nitin Jadhav, Fei Pei, Eric Buchovecky, Allan Bower, Progress in Surf. Sci., 88, 2 (2013) 103-131
- [5]: Ewa Rudnik , Marek Wojnicki, Grzegorz Włoch. Surf. and Coatings Technology, 207, 25 (2012) 375-388
- [6]: S.Bakkali, T. Jazouli, M.Cherkaoui,M. Ebn Touhami, N. El Hajjaji, E.Chassaing, Plat. Surf. Finish. 90 (2003) 46
- [7]: Strafford, K.N., Reed, A. (1984) Coat. and Surf. Treat. for Corr. and Wear Resist. 74.
- [8]: G. S. TZENG*,S. H. Lin, Y. Y. Wang, C. C. Wan. J. of Electroanal. Chem. 26 (1996) 419-423
- [9]: Ester Guaus and Joan Torrent-Burgues, Portugaliae Electrochimica Acta, 19 (2001) 247-261
- [10]: A. Aragon, M. G. Figueroa, R. E. Gana and J. H.Zagal,J.Appl.Electrochem., 22, 558 (1992).
- [11]: C.T.J. Low, F.C. Walsh . J. of Electroanal. Chem, 615, 2, (2008), 91-102
- [12] : B.Lakhrissi, El Azzaoui B., Nabil A., Essassi E.M., Massoui M., Goethals G., Villa P., Solans C., Azemar N., Comelles F., Garcia-Celma M.J., Sadurni N., Godé P. Jorn. Com. Esp. Deterg. 30 (2000) 233–243.