TRIBOLOGICAL PROPERTIES OF TIN AND BRONZE COATINGS ELECTRODEPOSITED FROM ACID BATHS

L. N. Bengoa[1*], N. Zabala[2], W. R. Tuckart[2], W. A. Egli[1]

[1] Grupo de Análisis Electroquímico de Pinturas y Recubrimientos, Centro de Investigación y Desarrollo en Tecnología de Pinturas, Av. 52 e/ 121 y 122, La Plata, Argentina

[2] Tribology Group, Engineering Department, Universidad Nacional del Sur - CONICET Av. Alem 1253, 1º Piso, 8000 - Bahía Blanca, Bs. As.- Argentina

[*] leandrobengoa@gmail.com

INTRODUCCIÓN

Electrodeposited copper, tin and bronze are widely used as protective and decorative coatings due to their good corrosion resistance and appearance [1]. However, there are some applications in which these properties are not enough and a low coefficient of friction is required. It is known that tin has a good lubricity and that this property depends on the morphology of the deposit [2]. Furthermore some authors have reported the use of electroplated bronze as a lubricating coating in the oil industry [3]. The bath commonly used for the electrodeposition of this alloy is a cyanide-based electrolyte which produces high quality deposits but has several environmental problems during use and disposal owing to its high toxicity. Many cyanide free baths have been developed, either acid or alkaline, but too little information about the performance of the resulting deposits have been reported.

The aim of this work is to develop an acidic non-cyanide electrolyte for the electrodeposition of high quality bronze coatings and evaluate their tribological behavior.

MATERIALS AND METHODS

All coatings were electrodeposited on cylinders of SAE 1020 steel mechanically polished to 180 grit. PSA-based and MSA-based electrolytes containing Sn^{+2} and/or Cu^{+2} were prepared. Cyclic voltammetry was used to study different organic additives added to the solutions. The Sn and Sn/Cu deposits were characterized with scanning electron microscopy and energy dispersive X-ray spectroscopy.

Tin deposits were obtained from both baths in order to compare their coefficient of friction with that of bronze. For the PSA electrolyte industrial additives were used. In the case of the MSA solution a selection of organic additives was necessary to obtain a homogeneous deposit.

Dry sliding wear tests were carried out by employing a home made ball on ring system. The coated samples rotated at constant speed of 12 rpm (0,37 m/min) against 6,35 mm diameter SAE 52100 steel ball used as the counter-body. The contact load was 10 N of normal load during a sliding distance total of 1700 mm.

All the sliding wear experiments were run in a standard laboratory environment: 298 ± 1 K and 50-55% RH. Wear quantification was pondered by measuring the width of wear track from OM micrographs. Coating wear was calculated assuming that the counter-body remains unchanged.

The reported results are an average of at least two test. The friction coefficient (COF) was recorded during the test and the value was defined according to standard ASTM G 115- 04.

RESULTS AND DISCUSSION

SEM micrographs (Fig. 1) show changes in the morphology of tin coatings when deposited from different baths.

A smooth and homogenous bronze deposit was obtained with a PSA-based bath containing 8 g/l Cu^{+2}, 30 g/l Sn^{+2} and 3 ml/l of benzyl alcohol added as an additive. The XRD shows the presence of a α-phase bronze. The alloy composition, determined through EDS, was 77%Cu-23%Sn.

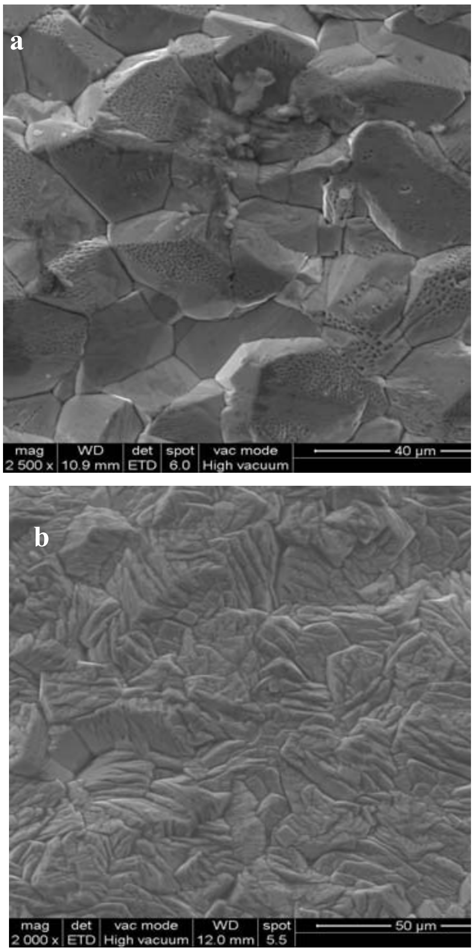

Fig. 1: SEM micrographs of tin coatings. a) electrodeposited from a MSA bath, 2500X; b) electrodeposited from a PSA bath, 2000 X.

Friction coefficient and the track width results obtained by each type of coating are shown in Table 1.

Coating	Track width [µm]	COF Steady State
BR1	780	0.40
SP1 PSA	670	0.19
SM1 MSA	870	0.22-0.7

Table 1: Friction coefficient and scare width of SP1, SM1 and BR1 coatings.

The wear rate of SM1 tin coating show an initial 0,2 COF and after 1 minute of run, a friction transition from moderate to severe appeared leading to a very high COF value of ~0,75 (typical of galling process) towards the end of the test.

OM images of the tribosurfaces show high adhesion and transfer from coating surface to the steel counterbody. This behaviour is in agreement with the observations found by C. Xu and coworkers [2] from tests made with a sliding reciprocating microtribometer.

CoF register for BR1 bronze coating shown a slight increasing from 0,24 in the beginning to 0,4 towards the end.

Finally, the tribological performace of SP1-PSA tin coating showed the best results in the present study. The wear damage was 15% lower than BR1 sample and 23% lower than SM1. In this sense, the initial COF was 0,12 and increased slightly up to 0,2 until the end of the test.

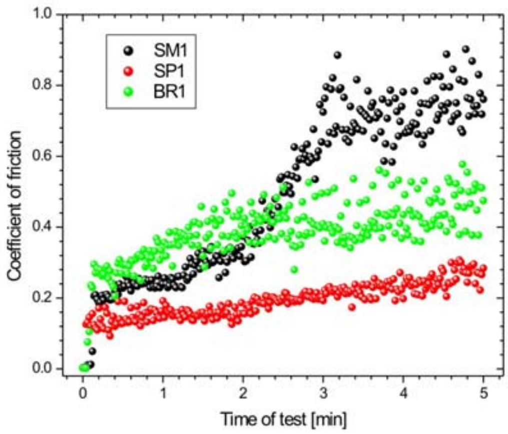

Fig. 3: Graphic of COF as a function of time of test of the coatings evaluated.

CONCLUSIONS

A novel cyanide-free bath for the electrodeposition of bronze was developed. The deposit obtained has a mono-phase (α-phase) matrix (77%Cu-23%Sn). Tin coatings were electrodeposited from different electrolytes and these coatings presented differences in morphology and tribological properties.

The SP1-PSA tin coating has a lower coefficient of friction and higher wear resistence than SM1-MSA tin and BR1 bronze coatings.

REFERENCES

[1] Modern Electroplating. 5th ed. The Electrochemical Society Series. 2010, New Jersey: John Wiley & Sons.

[2] Xu C., Zhang Y., Fan C., Chiu P., Abys J.A. Plat. Surf. Finish, 87, 88-92, 2000.

[3] Guise, R.J. and M.G. Edwards, US 7,472,927 B2, 2009: United States.