Recycling of Expired Drugs as Additive in a Watts Nickel Electroplating Bath

Delia-Andrada Duca*, Nicolae Vaszilcsin, Mircea Laurențiu Dan

University Politehnica Timisoara, Faculty of Industrial Chemistry and Environmental Engineering, 300223, Parvan 6, Timisoara, Romania
e-mail: duca.delia@gmail.com

Abstract

In this paper are presented studies on the leveling effect of ***midazolam*** {8 - chloro - 6 - (2 - fluorophenyl) - 1 - methyl - 4H - imidazo[1,5-a][1,4]benzodiazepine}, and ***streptomycin*** {5 - (2,4 - diguanidino - 3,5,6 - trihydroxy- cyclohexoxy)- 4 -[4,5- dihydroxy - 6 - (hydroxymethyl) - 3 - methylamino- tetrahydropyran - 2 - yl]oxy - 3 - hydroxy - 2 - methyl- tetrahydrofuran - 3 - carbaldehyd}, in a Watts nickel electroplating bath, manifested by the increase of cathode polarization. These drugs were chosen because their pharmaceutical formulation of the commercial product contains only pure compound, without excipients.

Introduction

Watts nickel bath was discovered over 100 years ago [1] and it is still maintaining actuality and interest for the electrochemists thanks to the anticorrosive efficiency of nickel coatings [2] and ornamental effect [3] as well as due to the possibility of obtaining nanostructures and materials with special proprieties [4]. Nickel coatings are also used as substrate for hydrogen evolution reaction [5,6].

The composition of the deposition bath influences the quality of nickel deposits, such as hardness, internal stress, compactness and brightness, which can be enhanced by adding various agents [7]. Some of the well-known additives are aromatic compounds [8]. The drugs hereinbefore contain only active substance, without any excipients, reason why these studies are based on the use of expired drugs as additives in electrodeposition from Watts bath.

Experimental

Electrochemical studies were carried out using Biologics SP 150 and AUTOLAB 302N potentiostat/galvanostats, in a three-electrode electrochemical cell, consisting of working electrode (Pt, Cu, or Ni), two graphite roads as counter electrodes and Ag/AgCl as reference electrode ($E_{Ag/AgCl}$ = 0,197 V).

Experiments were performed in 0,5 mol L^{-1} Na_2SO_4, SB (0,5 mol L^{-1} Na_2SO_4 + 30 g L^{-1} H_3BO_3) solutions and Watts bath (300 g L^{-1} $NiSO_4 \cdot 6H_2O$ + 60 g L^{-1} $NiCl_2 \cdot 6H_2O$ + 30 g L^{-1} H_3BO_3), with different concentrations of additive – midazolam or streptomycin ($10^{-6} \div 10^{-3}$ mol L^{-1}).

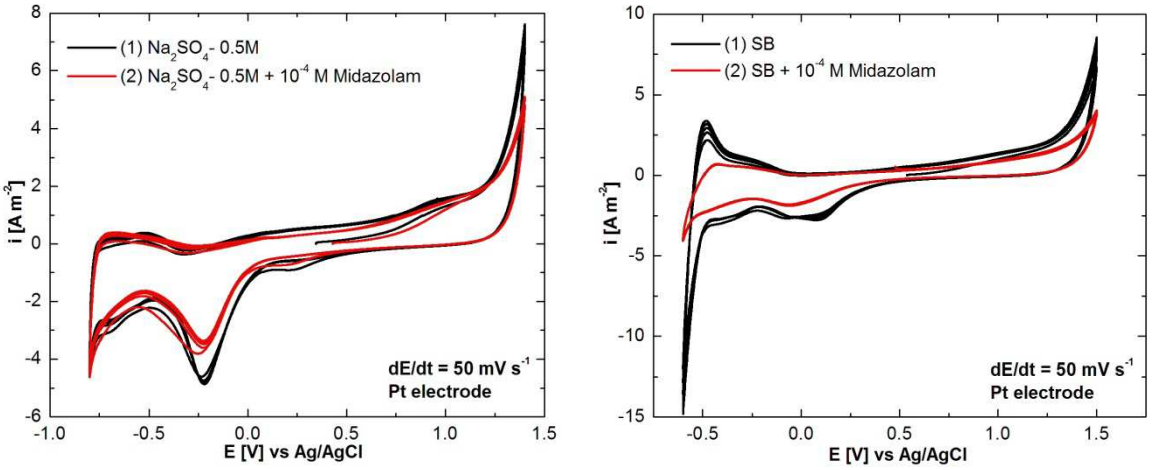
Results and discussion

Preliminary information about the electrochemical behavior of midazolam and streptomycin were determined by cyclic voltammetry. It has been observed how expired drugs influence electrode processes.

In these studies, Pt electrode as working electrode was used. The base curve, obtained in blank solution presents the characteristics of polarization curves drawn in 0,5 mol L^{-1} Na_2SO_4. Further, the electrolyte solution was acidified with 30 g L^{-1} H_3BO_3, reaching the same pH as in the Watts bath (pH = 3,5 ÷ 4,5).

In figure 1 there are presented cyclic voltammograms recorded with a scan rate of

50 mV s^{-1}, on Pt as working electrode, in 0,5 mol L^{-1} Na_2SO_4 (a) and SB (0,5 mol L^{-1} Na_2SO_4 + 30 g L^{-1} H_3BO_3) (b), without and with 10^{-4} mol L^{-1} midazolam.



a) **b)**

Fig. 1. Cyclic voltammograms (5 cycles) on Pt electrode in a) 0,5 mol L^{-1} Na_2SO_4 and b) SB, without and with 10^{-4} mol L^{-1} midazolam.

From the above figure it can be observed the inhibitory effect of the drug on electrochemical processes.

Conclusion

Experimental studies presented in this paper shows that both midazolam and streptomycin can be used as leveling additive in nickel Watts bath, manifesting inhibiting effect for the cathodic process of nickel deposition.

References

[1] H. Brown, B.B.Knapp, Nickel, in F.A. Lowenheim (Editor), Modern Electroplating, Third Edition, Wiley Interscience Publication, New York, 1974, 287-341.
[2] S. Hassani, K. Raeissi, M. Azzi, D. Li, M. A. Golozar, J. A. Szpunar, Improving the corrosin and tribocorrosion resistance of Ni-Co nanocrystalline coatings in NaOH solution, Corrosion Science, 51, 2009, 2371-2379.
[3] T. Sakamoto, K. Azumia, H. Tachikawaa, K. Iokibea, M. Seoa, N. Uchidac, Y. Kagayac, Electrochim. Acta, 55, 2010, 8570-8578.
[4] E. Rudnik, M. Wojnicki, G. Włoch, Effect of gluconate addition on the electrodeposition of nickel from acidic baths, Surface and Coatings Technology, 207, 2012, 375-388.
[5] B. Pierozynski, I.M. Kowalski, Hydrogen Evolution Reaction at Pd-Modified Nickel-Coated Carbon Fibre in 0.1 M NaOH Solution, International Journal of Electrochemical Science, 8, 2013, 7938-7947.
[6] M. Torabi, A. Dolati, A kinetic study on the electrodeposition of nickel nanostructure and its electrocatalytic activity for hydrogen evolution reaction, Journal of Applied Electrochemistry, 40, 2010, 1941-1947.
[7] Y.D. Gamburg, G. Zangari, Theory and Practice of Metal Electrodeposition, Springer, 2011, ISBN: 978-1-4419-9669-5.
[8] E.M. Oliveira, G.A. Finazzi, I.A. Carlos, Influence of glycerol, mannitol and sorbitol on electrodeposition of nickel from a Watts bath and on the nickel film morphology, Surface and Coatings Technology, 200, 2006, 5978-5985.