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Electrochemical Studies of Nickel from Sulfate bath with Succinic acid

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Abstract

In this research we studied the mechanism of the reaction in the medium [Nickel(II)-Succinic acid-Water] by using electrochemical methods.

This study showed that the deposition process of nickel(II) from its electrolytes on copper plates carried out in steady state galvanostatic and potentiostatic techniques. The deposition potential does not change throw painting time, and thus the surface of the electrode is homogeneous, the possibility of discharging nickel ions on any point of the surface is being equivalent, so the reduction of the nickel ions is followed by forming a smooth mirror-bright deposit.

Then we determined the basic composition for nickel painting electrolyte and the best conditions for exploitation it.

So we have got an argentous, glossy, scratch-resistant, steady nickel painting. Its thickness is about (25) microns and the yield is up to (85%).

Thus, this study could introduce a new electrolyte for painting with nickel which has good properties, free from defects.

Keywords: Nickel, Succinic acid, Deposition, Potential, Reduction, Electrical conductivity.

1. Introduction

Recently it has been found that the painting of minerals starting with their complexes differs from other well known a set of features:

It allows to control the thickness of the paint, its structure ,and its features. Also allows regularity distribution glphanic painting on mineral commodities that have different shapes [1].

Numerous studies have shown that the physico-mechanical properties of the nickel coating depend on the deposition parameters and the bath composition [2-8].

New buffering components have been studied because they offer higher buffer capacity than the boric acid does [9,10].

So, when selecting the Ligand it is preferred to choose the one which constitutes fixed complexes with metal ions, because the stability of the complex shapes of the metal in the electrolyte leads to maintain the high cathodal potential.

Thus, the crystallization of mineral leads to the emergence of a large number of crystal centers, then we get a soft, smooth and cohesive coating layer, which prolongs its age and increases their brightness.

Based on all of that, Succinic acid has drawn our attention as binary Ligand that can form annular compounds with nickel ions to perform the aim, as succinic acid shows a set of convenient properties that meet these requirements, and the requirements of the galphanic industry too [11].

It was established that the mirror-bright painting could be obtained from the electrolytes containing succinic acid without any brighteners [12].

2. Experimental Procedure

The materials used: succinic acid ($C_4H_6O_4$), Nickel sulfate ($NiSO_4.6H_2O$), Sodium hydroxide ($NaOH$), ammonium chloride (NH_4Cl), and ammonium hydroxide (NH_4OH), all of these were of high purity. The type of water used, is the binary distillation water. The experiments were carried out the lab temperature using solvents newly prepared.

We also used a cuprous plates ($A=1\ cm^2$), and they were mechanically polished with emery papers (down to dride 2000).

3. Results and Discussion

In order to assess the effect of succinic acid on the metal yield, we used the weight method.

The yield according to the current was calculated by using the relationship: $I_0\% = \frac{m_M}{q.I.t}.100$

$I_o\%$- the metal yield
M_M- the mass of the metal on the electrode
q- the electrochemical equivalent (equals ((1.095g/A.h)) for the nickel [13])
I-current intensity.

t- electrolysis time.

Before starting experience the selected electrolytes, we have experienced the paint with only nickel sulfate. We have got a porous, dark coating layer, and not so good, as in figure (1).

Figure-1: The copper electrode plated with only nickel sulfate

When we painted using succinic acid, we studied yield change depending on the pH change throw (t=15min) and (I= 2 A/dm^2), the results are represented in figure (2).

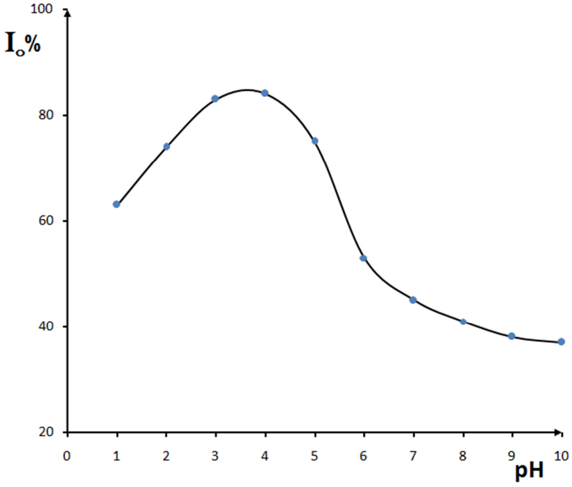

Figure-2: Yield change depending on the pH change

We studied also the yield change depending on the concentration of nickel succinics electrolyte [1:1], as in figure (3).

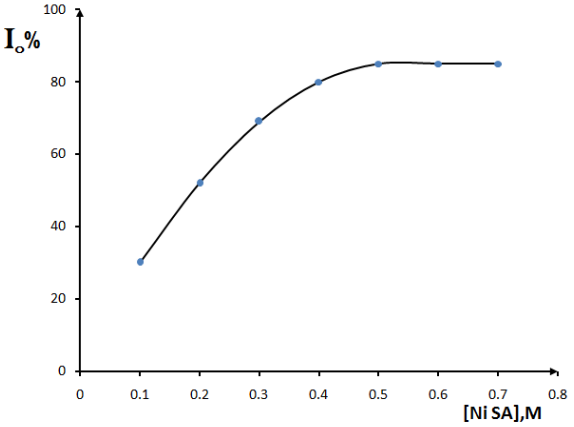

Figure-3:Yield change depending on the concentration of nickel succinics

We noticed that the highest concentrations of the nickel succinics electrolytes gives a bigger yield.
We studied the yield change throw on the current density change, as in figure (4).

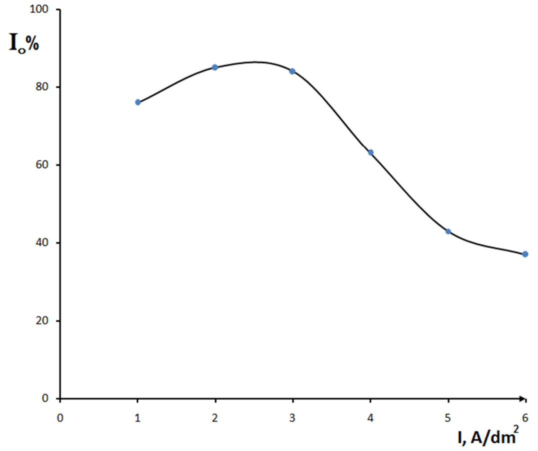

Figure-4:Yield change depending on the current density change

We saw that the current density values which gives the biggest yield are (2-3 A/dm^2).
The previous experience show us that the best requirements of nickel painting with succinic acid were at an acidic medium (pH=3-4), highest concentrations of (0.5M), Current density (I=2-3 A/dm^2), at painting time (15 min), we noticed during the electrical deposition of nickel from nickel succinic solution [1:1] on copper plate, that at the moment of working current, the potential shifts sharply into the negative values, then still in a specific value. The results are shown in figure (5).

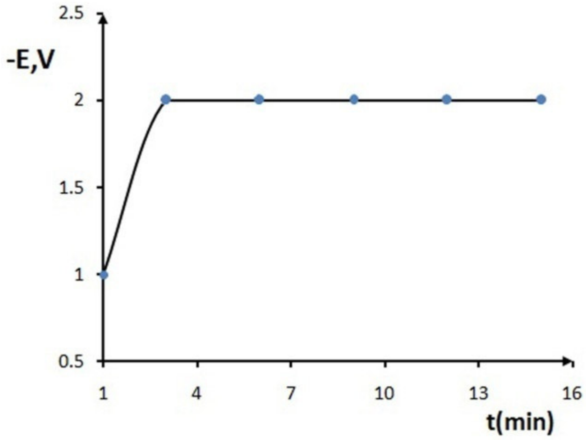

Figure-5:Potential electrode change throw the electrical deposition time in presence of succinic acid

Potential endurance throw the electrical deposition process refer to homogeneity on the electrode surface, the possibility of discharging nickel ions on any point of the surface is being equivalent, so the reduction of the nickel ions is followed by forming a smooth deposit. That is the reason of forming a mirror-bright paint.

Finaly it should be noted that when are using a nickel anode, the yield exceeded (100%), due to the dissolution of the nickel plate, as shown in figure (6).

It is worth mentioning that the quality of the paint has not changed, whether we used a coal anode or nickel anode, and this refers that the nickel ions resulting from the dissolution of the nickel electrode throw the painting process, have entered in a reaction with succinic acid "that is found in the solution", to form nickel succinics which have being discharged on the cathode later.

If it had not been like this "like being discharged directly on the cathode after the dissolution of the anode", it would have formed a dark, coarse-grained hard deposit, just like when we used only nickel sulfate.

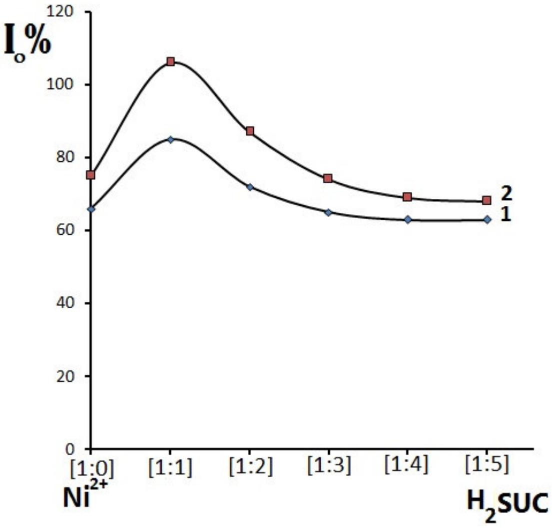

Figure-6:Yield change depending on succinic acid concentration in the solution; $[Ni^{2+}]=[H_2Suc]=0.5M$, $I=2A/dm^2$, t=15min; 1-Coal anode 2-Nickel anode

Here are some photographs of some electrodes that have been painted with nickel in presence of succinic acid.

Figure-7: A nickel-plate copper electrode with succinic acid in pH=3.5

Figure-8: A nickel-plate copper electrode with succinic acid in pH=7

Figure-9: A nickel-plate copper electrode with succinic acid in pH=10

Scanning Electron Microscope (SEM):
To make sure of the credibility of previous studies, we studied the nickel coating formed from the electrochemical deposition of nickel with succinic acid, using Scanning Electron Microscope device (SEM). The SEM images are showen in figures (10), (11).

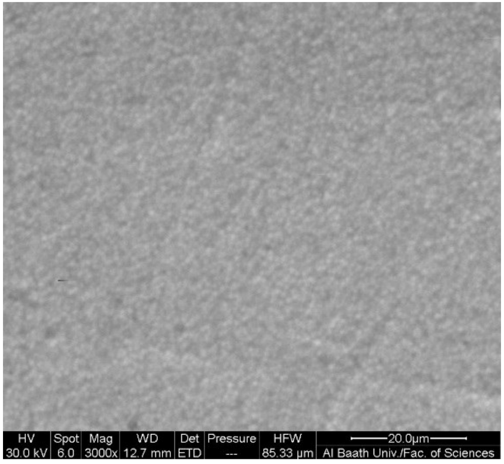

Figure-10: The SEM image of the nickel coating using succinic acid; $[NiSO_4]=[H_2Cuc]=0.5M$, $I=2A/dm^2$, $t=15min$, $pH=4$

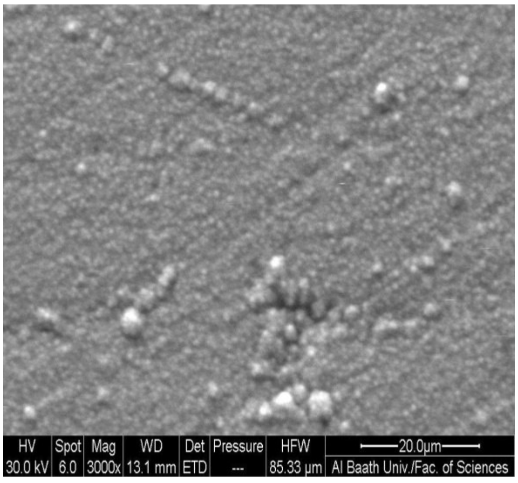

Figure-11: The SEM image of the nickel coating using succinic acid; $[NiSO_4]=[H_2Cuc]=0.5M$, $I=2A/dm^2$, $t=15min$, $pH=4.5$

4. Discussion:

The previous experiences define to the following results:

The solution containing only nickel sulfate (simple salt), gives a dark, hard, porous, non-homogeneous and irregular coating layer. Its structure looks like a tree with low yield (about 50%). But in the solutions containing nickel sulfate and succinic acid [1:1], in acidic medium, give a bright-mirror glossy, argentous coating layer, similar in appearance to the stainless steel alloy, and the yield according to the current is about (85%).
This layer is characterized by good resistance to abrasion and high severity, where as the coating thickness was (15-25) microns, it has been calculated by the relationship:

$$d = \frac{mM}{\rho . 100 . S} .10^4$$

ρ- Deposited miner density (it equals 9.8g/cm^3) for the nickel.

5. Conclusion:

1_ The study showed that the electrical reduction of nickel from nickel succinics solution on the cuprous electrodes, carried out in steady state galvanostatic and potentiostatic techniques. The possibility of discharging nickel ions on any point of the surface is being equivalent, so we get a smooth mirror-bright paint.
2_ This study allowed determining the structure of the nickel paint electrolytes, which provides high yield and excellent quality of the paint.
It found in the following conditions: pH=3.5-4 , I=2-3A/dm^2 , [Ni^{2+}]≥0.5M (concentration of nickel ions with succinic acid [1:1]) , the yield (up to 85%), and we get an excellent nickel paint, its thickness is about (25) microns, depending on the painting time.
3_ This research provide a new nickel paint electrolyte instead of the poisonous and polluted for the environment cyanide electrolytes.
In addition, this electrolyte is characterized with its few ingredients (nickel sulfate and succinic acid). Above of that, it is so economical, there is no need to add moderate salts to increase the electrical conductivity.
4_ The dissolution of anode material has a great importance in practical way, it maintains the balance of the bath, so we dispence with correction of the nickel ions concentration. The electrolyte is lasting for long time and becomes more effective.

Thus, we have reached the possibility of using succinic acid in nickel paint electrolytes that serves as a complex detector on one hand, and as a polished material on the other, so we dispense adding any puffers.

6. Recommendations:

We recommend using the electrolytes that is containing succinic acid in galvanic industry and as a buffer material, to protect the metals from corrosion and rust.

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