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ELECTROLESS PLATING OF NICKEL ON ALUMINIUM

M. Sarwar, Aneela Akbar and Shams-un-Nisa*

PCSIR Laboratories, Lahore

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In the present investigation studies have been carried out for the electroless plating of nickel on aluminium. A suitable bath which consists of nickel sulphate, lactic acid, sodium hypophosphite and tartaric acid has been selected. This bath gives reasonably thick, adherent and flexible coating of nickel on aluminium. The bath is workable at 80° when its pH was maintained at 8. The immersion time for the plates was thirty minutes.

Key words: Electroless plating, Nickel, Aluminium.

INTRODUCTION

The survey of literature shows that not much work has been done in this field. However, there are some methods available for electroless deposition of Ni on Al. But most of the information is hidden in patents. It was, therefore, felt necessary to undertake this research.

Ni could be deposited by chemical reduction on Al, Mg, Fe, Brass and other catalytic base metals from a flouride hypophosphite bath – SO_4 and Cl' must not be greater than trace levels. Salts of organic acid were used as buffers to maintain pH at 5.0 to 6.8 [1].

In another method Al was Ni plated from an alkaline bath of $NiSO_4$, citric acid, sodium hypophosphite and NH_3 [2] but details are missing.

In a Ni bath all metals except Pd, Cd, Zn, Sn and Bi could be electrolessly plated. Complex composition with aliphatic acids and stabilizers were used but most of the information is hidden [3].

Feldstein and Nathan [4] described an electroless Ni plating bath which produced Ni coatings at room temperature and at uniform rate regardless of decrease in pH, but proper conditions are not mentioned [4].

In a Russian patent a Ni solution for coating was prepared by adding methyl tetra-hydro phthalic anhydride at 1.5 to 2.5 gm/litre to the solution, containing $NiSO_4$ 20-22, Na hypophosphite 20-40, Na acetate 8-10 gm/litre [5].

Another economical process has been described in literature where the substrate was dipped in a bath containing a metal salt and a reducing agent [6]. The solution being heated upto 95-100°. There are many other methods available in literature which are not reproduceable and most of the information is hidden in patent.

The aim of present study was to get full information where by nickel could be deposited on aluminium because most of the information whatsoever is available is hidden in patents. In the present investigation many such patents were tried which proved to be futile. In this investigation we have tried to develop simple, convenient and workable baths for electroless deposition of nickel on aluminium. Reasonable thickness, adherence and flexibility of this metal was achieved on aluminium surface during the study. The method can be applied on large scale to protect various aluminium parts with minimum cost.

EXPERIMENTAL

Apparatus

(1) Kocour electronic thickness tester was used throughout the experimental work.

(2) For pH measurements HANNA Italian pH meter was used.

(3) Sortorious electric balance was used for weighing.

(4) Temperature was maintained on thermostatic bath.

(5) Graduated cylinders and polypropylene beakers were used in the experiments.

Reagents. Nickel sulphate, nickel chloride, sodium hypophosphite, sodium citrate, sodium acetate and stannous chloride of analar quality were used during the experimental work.

Degreasing solution. Chloroform 40, alcohol 50 and 10 parts of 2N HCl was used for the degreasing of aluminium strips. This is our own composition.

Activating solution. A 2 % solution of NaOH was used as activating solution for the aluminium strips.

Procedure

The aluminium strips 10 cm x 4 cm were taken, buffed, cleaned and dipped into the degreasing solution

*Institute of Chemistry, University of the Punjab.

for about 5 minutes. The strips were then removed and washed thoroughly with water. These were immersed in the activating solution for 15 minutes, then removed and rinsed thoroughly with water. These strips were ready to be dipped into nickel bath. The bath had the following composition:

Nickel sulphate	2.5 g
Lactic acid	2.2 g
Sodium hypophosphite	2.4 g
Sodium tartrate	2.0 g

Total volume of bath taken was 100 ml, pH of the bath was maintained at 8.0 with sodium tartrate and temperature was kept at 80° and after specified period of time the thickness of the coating was measured with thickness measuring machine.

RESULTS AND DISCUSSION

A number of compositions were tried for the electroless plating of nickel on aluminium. The results of these compositions are shown in Table 1. It can be seen from this table that the most efficient composition is no. 10. In this investigation the said composition is described and all the other parameters of the same composition have been studied.

It can be seen from the Table 1 that in most of the cases nickel chloride and nickel sulphate were used in the baths and complexing agents used were citrate, acetate and tartrate. As is clear from the results, tartrate seems to be the best complexing agent. The baths in which tartrate has been used as complexing agent gives better results. The best reducing agent is hypophosphite.

Effect of pH on the deposition of nickel on aluminium. The deposition of nickel was tried at room temperature at different pH values. The room temperature at the time of experiment was 32 ± 1°. The dipping time was kept at 15 minutes. The results are shown in Table 2.

Effect of temperature on the deposition of nickel on aluminium. The pH of the bath was fixed at 8.0 and temperature was varied to see its effect on deposition rate. It has been found that the rate of deposition was more at elevated temperature. The dipping time was fixed at 15 minutes. The results are shown in Table 2.

The rate of deposition increases with temperature and attains maximum value at 85°. It is therefore, very important to maintain temperature to get uniform deposits. Overheating of the bath should be avoided. Otherwise decomposition of solution takes place.

Effect of dipping time on the deposition of nickel on aluminium. Keeping other factors constant the effect of time was studied. It was found that dipping time played an important role in the electroless deposition of nickel on aluminium. The results are shown in Table 2, against temperature was maintained at 80°.

Solution maintenance. To maintain the bath in proper working condition, the addition of sodium hypophosphite

Table 1. Different bath compositions.

Bath composition in 100 ml at pH 8.0		Temperature °C	Maximum thickness achieved in 35 min. um
1. Nickel chloride 5.0 g Sodium hypophosphite Sodium potassium Tartrate	2.5 g 7.5 g	25	5.8
2. Same but increased the amount of NH_4OH to 80 ml		25	7.9
3. Same as in No. 2		80	14.4
4. Nickel sulphate Sodium citrate Sodium acetate Sodium hypophosphite pH	1.5 g 0.2 g 0.2 g 0.2 g 6.2	25	1.7
5. Same as in No. 4		80	4.4
6. Nickel sulphate Stannous chloride Lactic acid Sodium tartrate pH	2.5 g 2.5 g 2.2 g 2.0 g 6.2	25	2.1
7. Same as in No. 6		80	Colour of the plate turned black
8. Nickel sulphate Sodium citrate Sodium acetate Sodium hypophosphite pH	3.0 g 1.0 g 1.0 g 1.5 g 7.5	25	No deposition
9. Same as in No. 8		80	4.7
10. Nickel sulphate Lactic acid Sodium hypophosphite Sodium tartrate pH	2.5 g 2.2 g 2.4 g 2.0 g 8.0	25	10.1
11. Same as in No. 10		80	20.9

Table 2. Effect of pH, temperature and dipping time on deposition of nickel on aluminium.

pH	Thickness um	Temperature ^oC	Thickness um	Dipping time	Thickness um
2	0.82	32	1.77	15	9.5
3	0.94	40	3.50	20	16.70
4	1.06	50	5.70	25	19.50
5	1.18	60	7.00	30	20.70
6	1.29	70	8.40	35	20.90
7	1.40	80	9.5	40	21.00
8	1.77	85	9.6		
9	1.20				
10	0.70				

Dipping time 15 minutes at 32^o	Dipping time 15 minutes at pH 8	Temperature 80^o at pH 8

and $NiSO_4$ are very essential at regular intervals of time. Addition becomes necessary after completing 8 cm^2 work/100 ml of solution. The additions of hypophosphite and nickel salt were done after estimating their strength when the concentration of phosphite reached 20 g/100 ml the bath was discarded.

Adherence and flexibility. It can be tested by twisting the strip couple of times. If on twisting the coating was chipped off this showed that the coating was not very adherent and if it developed cracks, this meant that the coating was adherent as well as flexible.

CONCLUSION

Electroless plating of nickel on aluminium involves few steps as described in the procedure. It is important to follow them in the same sequence. Among these activation step is very important. The surface of aluminium should be cleaned and made uniform prior to activation. It was found that on such activated plate the rate of deposition was quick. For the proper deposition of proper thickness, the maintenance of pH, immersion time and temperature are very important as shown by results in Table 2. Many different composition were tried but the good results were achieved only with the composition described in procedure. The procedure described is simple, economical and reasonably applicable for surface protection.

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