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ELECTROLESS NICKEL PLATING ON ABS PLASTIC BY USING ENVIRONMENTALLY FRIENDLY CHEMICALS

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Abstract: In this study, electroless nickel (EN) plating on acrylonitrile butadiene styrene (ABS) engineering plastic by using environmentally friendly chemicals were studied. Electroless plating is a fundamental step in the metal plating on the plastic. This step makes the plastic conductive and makes it possible to a homogeneous and hard plating without using any hazardous and unfriendly chemical such as palladium, tin, etc. In the industry there are many distinct chemical materials both catalysts and activation solutions for the electroless bath which is one of the most important parts of the process. In this study the effects of plating bath compositions, plating time and sand paper size were investigated on electroless nickel plating. Experiments were carried out with 400, 800, 1500 grit sandpaper by applying sand attrition process and at 75°C, 85°C, and 95°C bath temperatures with 20, 40, 60 minutes of deposition time. The surface morphology and the amount of deposit analysis were performed by Fischerscope X-Ray XDL-B System, X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). Due to the results of experiments and analysis, the nickel plating on ABS plastic was succeeded with two different bath compositions. According to the results, the best plating on ABS plastic was obtained at maximum plating thickness as 2.47 µm with plating time as 60 min and at 95°C plating bath temperature by using 1500 grit sandpaper. Nickel plating was better with Bath 1 (6.2 µm) than Bath 2 (1.42 µm) on activated surfaces of ABS which were activated with 1500 grit sandpaper.

Keywords**:** ABS plastic, nickel plating, electroless plating.

Introduction

Plating is a surface covering in which a metal is deposited on a conductive surface. Plating has been done for hundreds of years; it is also critical for modern technology. Plating is used to decorate objects, for corrosion inhibition, to improve solderability, to harden, to improve wearability, to reduce friction, to improve paint adhesion, to alter conductivity, to improve IR reflectivity, for radiation shielding, and for other purposes. Jewelry typically uses plating to give a silver or gold finish. Thin-film deposition has plated objects as small as an atom, therefore plating finds uses in nanotechnology (https://en.wikipedia.org/wiki/Plating). Electroless (autocatalytic) plating involves the presence of a chemical reducing agent in solution to reduce metallic ions to the metal state. There are no external electrodes present, but there is electric current (charge transfer) involved. Instead of an anode, the metal is supplied by the metal salt; replenishment is achieved by adding either salt or an external loop with an anode of the corresponding metal that has higher efficiency than the cathode. There is therefore, instead of a cathode to reduce the metal, a substrate serving as the cathode, while the electrons are provided by a reducing agent (Schlesinger M, 2010). Electroless nickel plating is an auto-catalytic reaction used to deposit a coating of nickel on a substrate. Unlike electroplating, it is not necessary to pass an electric current through the solution to form a deposit. This plating technique is to prevent corrosion and wear. Electroless nickel plating techniques can also be used to manufacture composite coatings by suspending powder in the bath. Electroless nickel plating has several advantages versus electroplating (https://nzic.org.nz/ChemProcesses/metals/8G.pdf). Free from flux-density and power supply issues, it provides an even deposit regardless of workpiece geometry, and with the proper pre-plate catalyst, can deposit on non-conductive surfaces (Sudagar, J. et al. 2013; Rajaguru J.C. et al. 2012). ABS plastic is an important engineering material for its high thermal stability, excellent mechanical strength, and high resistance to chemical reagents. However, its application is limited because it is non-conducting and easily fretted. Metallized ABS can be widely used in many fields since its outstanding properties of engineering plastic and metal (http://www.steinwall.com/wp-

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content/uploads/2016/05/Acrylonitrile-Butadiene-Styrene-ABS.pdf). For many years, activation process for metallization of non-conducting substrates has attracted increasing attention (Tang XJ et al. 2009). The aim of this project is to investigate the effects of two different bath compositions by using electroless nickel plating technique applied on acrylonitrile butadiene styrene plastic.

Experimental Study

In this study, the electroless nickel plating on ABS plastic were investigated. Experimental study consisted of four parts: Preparation of materials, etching, coating and analysis; and this study was carried out at room temperature in the fume hood. The effects of two different bath compositions on plating were investigated.

1. ABS plastic is grounded with 400, 800 and 1500 grit sandpapers.
2. Bath 1 and Bath 2 are prepared with different concentrations as listed in Table 1.

Table 1.Bath compositions for electroless nickel deposition (Schlesinger M, 2010)

	Alkaline Baths	
Bath Constituents (g/L)	**Bath 1**	**Bath 2**
Nickel Chloride	20	20
Sodium Hypophosphate	20	20
Sodium Citrate	10	10
Ammonium Chloride	35	35
pH	9-10	9-10
Temperature (°C)	85	85

3. Bath solutions are heated to plating temperatures: Bath 1 to 95°C, Bath 2 to 85°C.
4. According to the two different baths and for three sandpapers, 18 samples of ABS plastic are prepared.
5. NaOH is gradually added during the process to make sure that the pH of the plating solution is between 8-10 and 9-10 for Bath 1 and Bath 2, respectively.
6. 3 sets of ABS plastic specimen are prepared and plated for 20 minute intervals. First 3 samples are taken out of the baths at the end of 20 minutes, the other 3 are taken out of the baths at the end of 40 minutes and the final 3 samples are taken out of the baths at the end of 60 minutes.
7. All samples are left for drying at room temperature for 24 hours.

Sample Analysis

X-ray Analysis

Deposition amounts were determined by using X-Ray analysis and this analysis was performed at TKF Metal Plating Industry.

XRD Analysis

According to the results obtained from X-Ray analysis, the samples in which two of them that gave the best plating results were analyzed in XRD at Metallurgical and Materials Engineering Department in Dokuz Eylül University, İzmir. The best plating results were obtained from the samples at which, nickel plating is better with Bath 1 (6.2 μm) than Bath 2 (1.42 μm) on activated surfaces of ABS which are activated with 1500 grit sandpaper.

SEM Analysis

After determination of XRD analysis of the three samples, SEM analysis were performed at Metallurgical and Materials Engineering Department in Dokuz Eylül University, İzmir.

Results and Discussion

In this study the effect of plating time, plating temperature and sandpaper sizes on the amount of deposit are investigated for each baths. The plastic samples are prepared by etching with 400, 800 and 1500 grit sandpapers for each temperature (75ºC, 85ºC and 95ºC) and for each plating times (20, 40 and 60 min). After the samples are plated, they are analyzed with X-ray analysis, firstly. According to the results from X-Ray analysis of samples; amount of deposit versus plating time graphs are plotted (Figures 1-6). As time increases, plating amounts are increased for both Bath 1 and Bath 2. The effect of temperature is also investigated in the same graphs (Figures 1-6). When temperature increases plating amounts are also increased for both baths as expected.

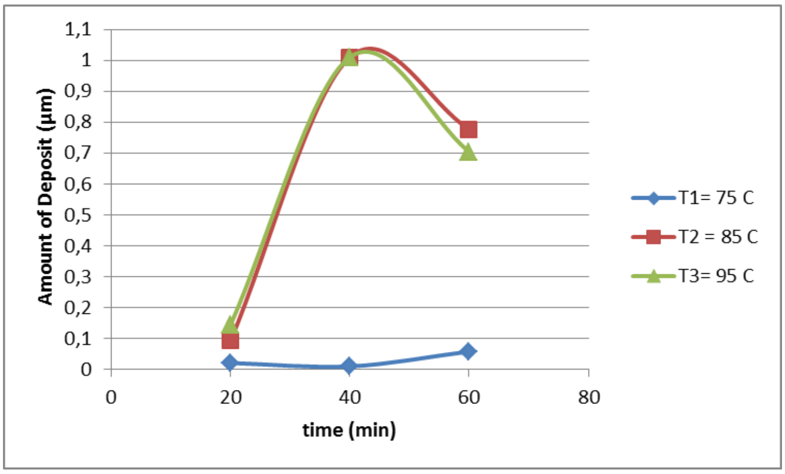


Figure 1. Time effect on amount of deposit in Bath 1 for 400 grit size sandpaper

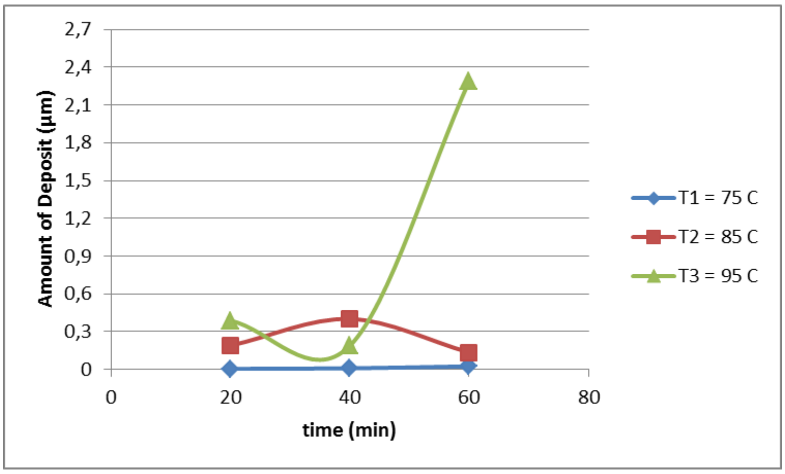


Figure 2. Time effect on amount of deposit in Bath 1 for 800 grit size sandpaper

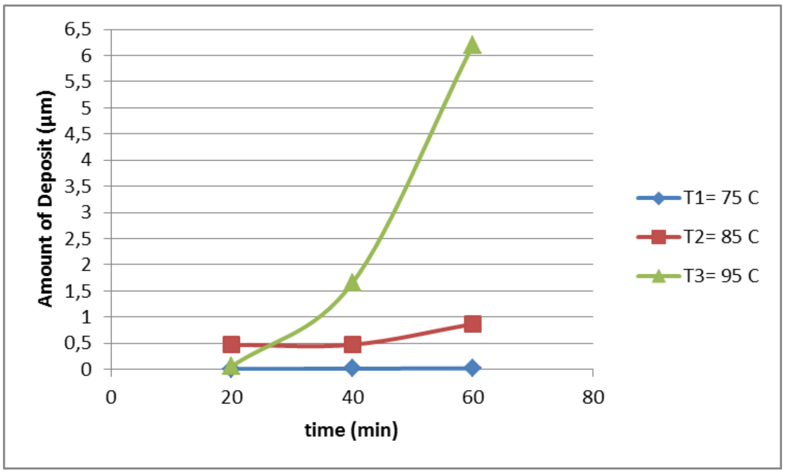


Figure 3. Time effect on amount of deposit in Bath 1 for 1500 grit size sandpaper

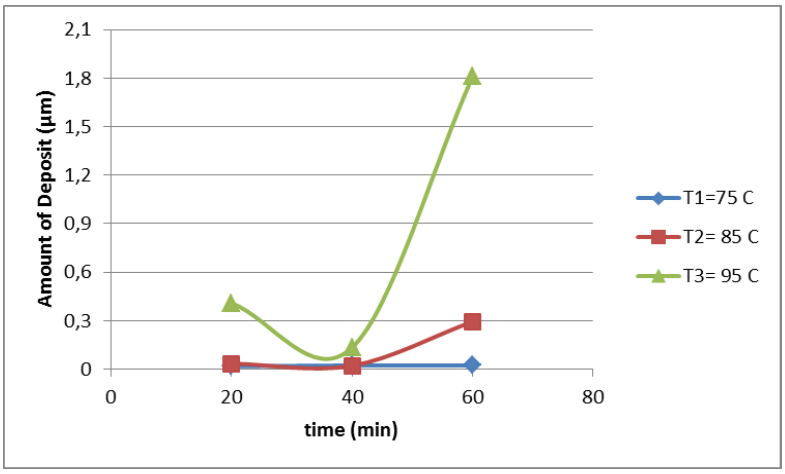


Figure 4. Time effect on amount of deposit in Bath 2 for 400 grit size sandpaper

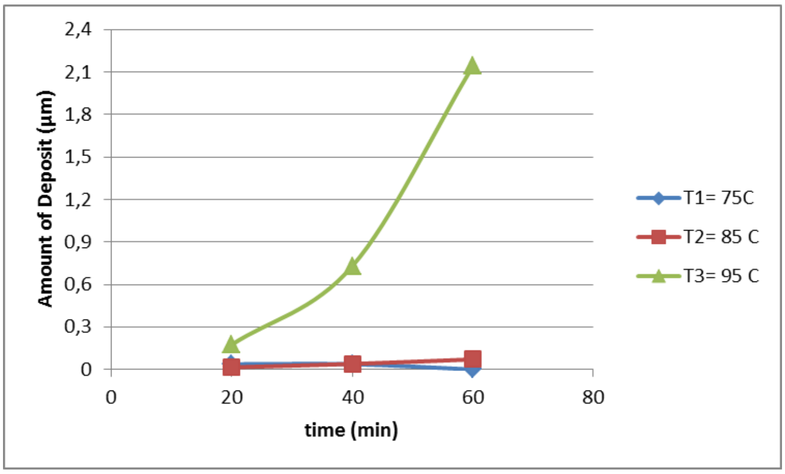


Figure 5. Time effect on amount of deposit in Bath 2 for 800 grit size sandpaper

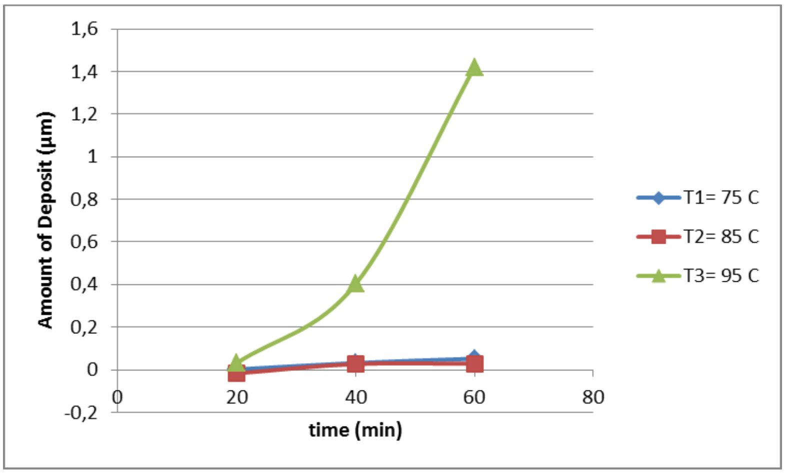


Figure 6. Time effect on amount of deposit in Bath 2 for 1500 grit size sandpaper

The effects of sandpaper size on the amount of deposit are shown in Figures 7-12. Amount of deposit versus sandpaper size graphs are plotted. As sandpaper size and temperature increase, plating amounts are increased for both Bath 1 and Bath 2. When the baths are compared with each other, the best results are obtained in Bath 1 according to the amount of deposit with 1500 grid sandpaper in 95°C in 60 minutes (6.2 µm).

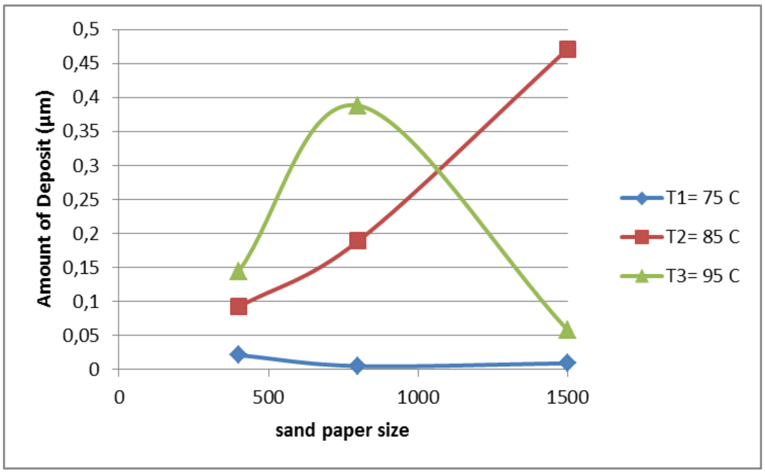


Figure 7. Sandpaper size effect on amount of deposit in Bath 1 for 20 min**.**

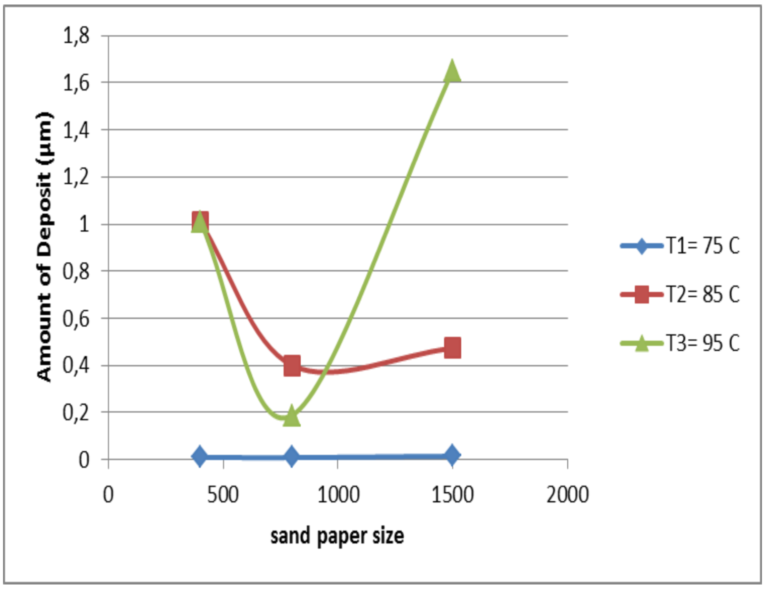


Figure 8. Sandpaper size effect on amount of deposit in Bath 1 for 40 min.

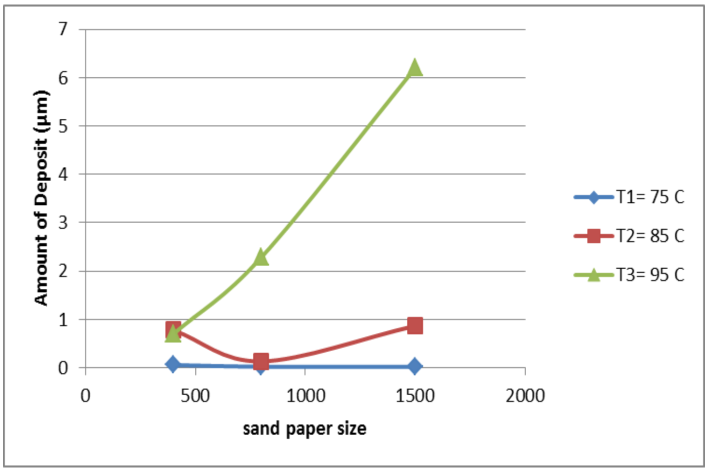


Figure 9. Sandpaper size effect on amount of deposit in Bath 1 for 60 min.

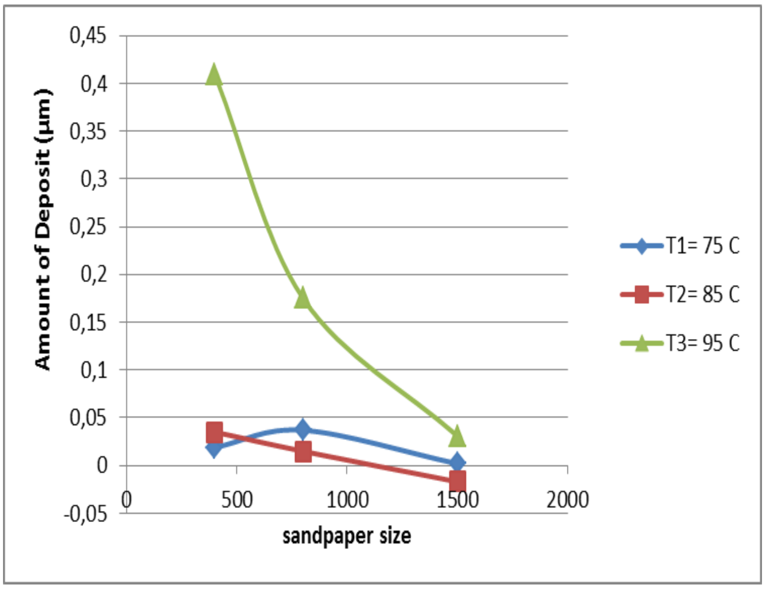


Figure 10. Sandpaper size effect on amount of deposit in Bath 2 for 20 min.

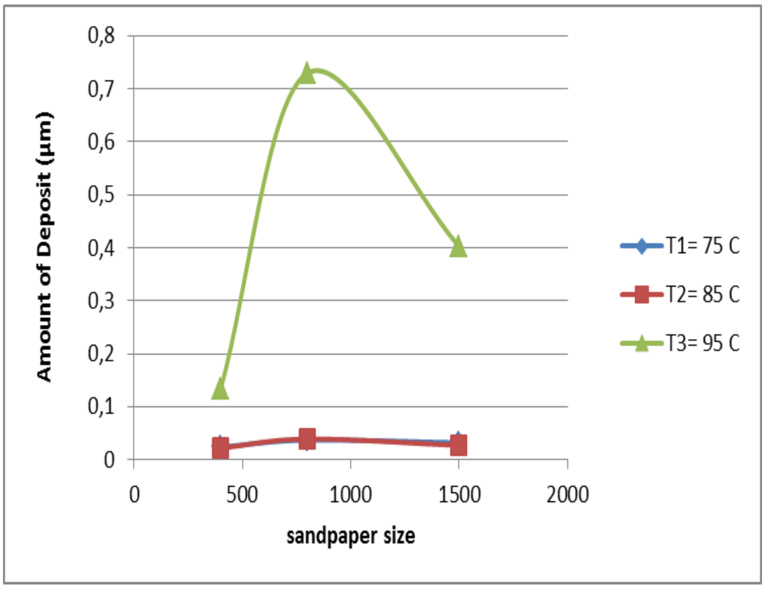


Figure 11. Sandpaper size effect on amount of deposit in Bath 2 for 40 min.

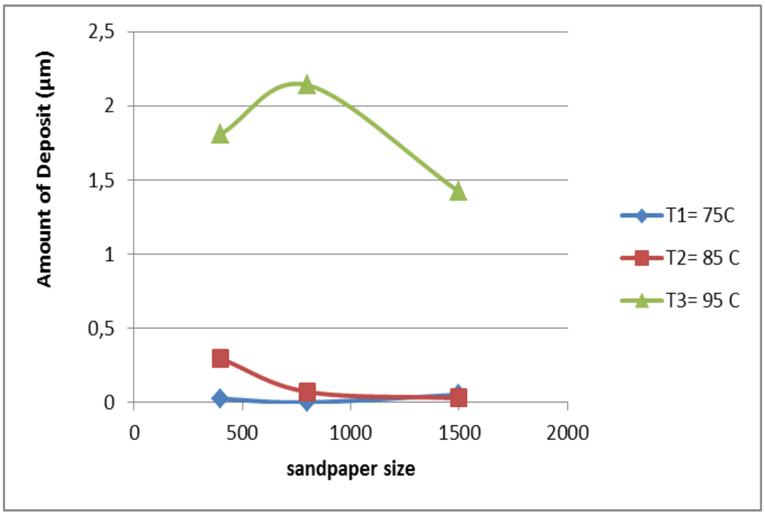


Figure 12. Sandpaper size effect on amount of deposit in Bath 2 for 60 min.

After X-Ray analysis was performed, two of the samples that gave the best plating results in X-Ray analysis, were analyzed in XRD and SEM. The results of XRD analyses are obtained as expected and stated in Figures 13, 14 and SEM analyses are shown in Figure 15. The samples were analyzed in XRD (Figures 13, 14). These results were obtained from samples grounded with 1500 grit sandpaper. Broad peaks suggest an amorphous structure of the nickel coating on the sample and thus the as plated layer is ductile at 2Theta = 20º and 2Theta = 45º in the Figures 13 and 14, respectively. It was confirmed that the formed Ni nanoparticles was sufficient as catalyst for nickel electroless plating (Tang XJ et al. 2009).

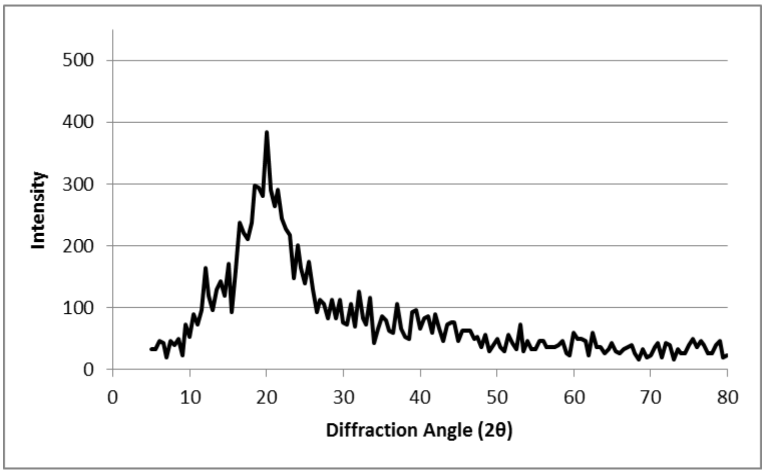


Figure 13. XRD Pattern of Electroless Deposition Ni Layer in Bath 1 with 1500 grit size sandpaper at 60 minutes.

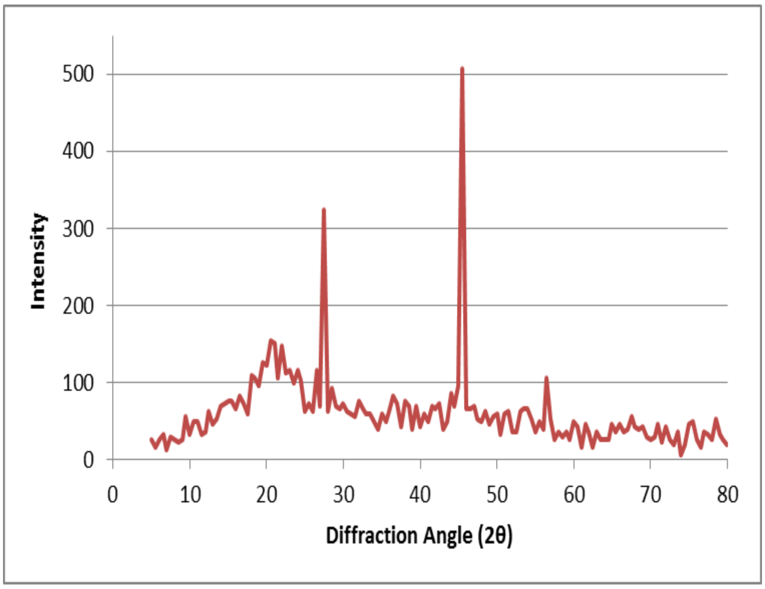
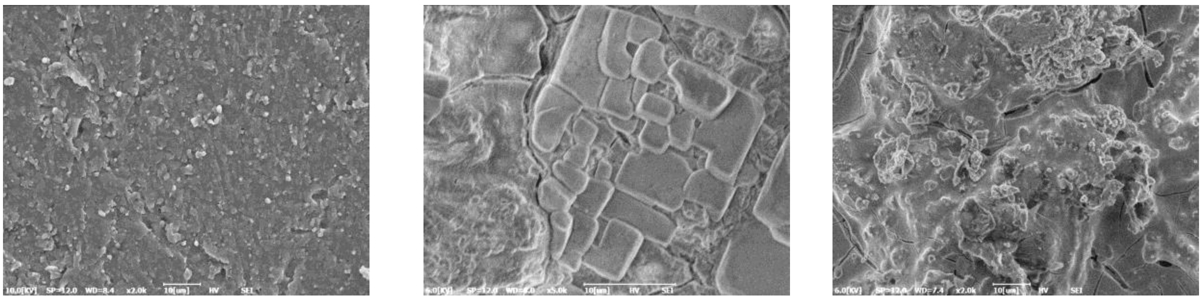


Figure 24. XRD Pattern of Electroless Deposition Ni Layer in Bath 2 with 1500 grit size sandpaper at 60 minutes.

According to the SEM analysis, it is shown in Figure 15 that crystalline material was deposited on the surface of the substrate. The result by SEM-EDS analysis indicated that the plating film consisted of nickel only, and the nickel was homogeneously distributed on the surface of the film.



(1) (2) (3)

Figure 3. SEM photographs 1500 grit ABS samples; (1) the surface of the original plastic specimen and nickel-plated specimen with Bath 1 (2) and Bath 2 (3).

Conclusion

In This Study, Electroless Nickel Plating Technique Was Applied On Acrylonitrile Butadiene Styrene (Abs) Plastic And The Effects Of Two Different Bath Compositions On Plating Were Investigated. It Was Obtained That Nickel Plating On Abs Plastic By Using Two Different Bath Compositions was achieved. The best result was obtained with Bath 1 in 95°C in 60 minutes (6.2 μm).

ABS is a stable resin that didn't leach toxic chemicals. ABS plastics are higher quality plastics with increased strength, rigidity, toughness and temperature and chemical resistance. ABS is made by adding butadiene during the manufacture of acrylonitrile styrene (AS)/styrene acrylonitrile (SAN), resulting in a hard and durable plastic that is stable through a broad range of temperatures.

Electroless nickel plating process was successfully carried out using a palladium-free activation method. This environmental friendly activation process hold promise to reduce both capital and operational costs in large scale manufacturing. Considering safety and environmental concerns, metal plating without hazardous chemicals is a better choice and is strongly in demand now.

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