Effect of Nano Coatings on Magnesium alloy on their Surface Properties: A Review

Dr. Farook Sayyad
Research Scholar, Mechanical Engineering Department,
Faculty of Engineering,
Lincoln University College,
Malaysia
fbsayyad@gmail.com

Dr. Rohan Senanayake
Professor & Head, Mechanical Engineering Department,
Faculty of Engineering,
Lincoln University College,
Malaysia
drrohan@lincoln.edu.my

Abstract—

Magnesium (Mg) and its alloys have low specificity, specific hardness and electrical protection properties, attractive to the automotive industry, 3C (computer, communications, consumer electronics), military and aviation. Poor corrosion resistance is an important drawback of Mg alloys, limiting their active use. Nanocoating is one of the most effective ways to improve the resistance to poor corrosion quality. In this paper, the procedures for nanocoating the developed Mg alloys are now reviewed and discussed which point to a pathway for the preparation of anti-corrosion coatings by the incorporation of anorganic nano-particles into electroless coatings

Keywords—Coatings, Nanoparticles, Corrosion Resistance, Magnesium Alloy

I. INTRODUCTION

Magnesium and its alloys, with one quarter of the metal weight and only one-third of aluminum and anti-gravity strength beyond this, fulfill an acceptable role as a light weight alloy. Therefore, these alloys have obviously been a weight reduction option in portable microelectronics, telecommunications, aerospace and automotive applications. The magnesium-aluminum system has been in all the widely used magnesium types since these materials were introduced in Germany during its inception. World War.

The advantages of countless nickel learning coatings are: Deeply tested surfaces (e.g. using holes) can be well integrated using the welding process. It does not require current external gas for the compression installation. Unlike the electroplating process that results in excessive formation of aggregates at the edges and corners, electroless plating can produce more elastic binding on the entire surface of the shape complex. An electroless process can produce a coating that fit into the adhesive layer. Electroless process can produce coating which is homogeneous across the coating thickness. Electroless plated coatings are much better than electroplated plating, because the coatings are less porous and provide excellent corrosion protection to steel based substrates. Non-electronic covers can be fitted with airtight, non-commercial, complimentary, and non-conductive components. No complicated jigs or racks needed. There is a flexibility of metallicity and size. Chemical recycling can be monitored automatically and a sophisticated filtering method is not required. Matte, bright or bright lights can be found.

Due to the number of benefits, innumerable covers are widely used in all types of industries. Figure 1 shows the use of the nickel coatings. While it has many benefits, a few important parameters for a electroless plating are shorter lifespan of chemicals and higher costs for waste treatment due to faster chemical recycling.

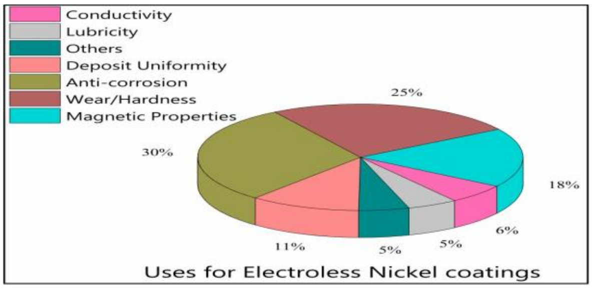


Fig 1. Rrepresenting the use of electroless nickel coatings (Source – home page: www.pfonline.com).

Most of these alloys contain 8-9% aluminum with small amounts of zinc [1, 2]. The addition of several composites such as aluminum, zinc and rare earth has been reported [3-10] to improve corrosion resistance, technically not satisfying the need for several applications. Therefore, the use of a surface engineering method is an appropriate way to promote corrosion resistance. Among the various high-tech techniques available for this purpose, nickel blending is of particular interest to the electronics industry, due to its mobility and many other engineering properties Electroless nickel is known for its durability and durability [11 - 16].

II. CORROSION PROTECTION STRATEGIES FOR MG ALLOYS

A coating method is typically needed to achieve a class A (Class A in automotive industry refers to the glossy, smooth appearance that is required for readily visible, outer surfaces of automobiles) quality of surface finish on Mg parts, as shown in Figure 2 [17].

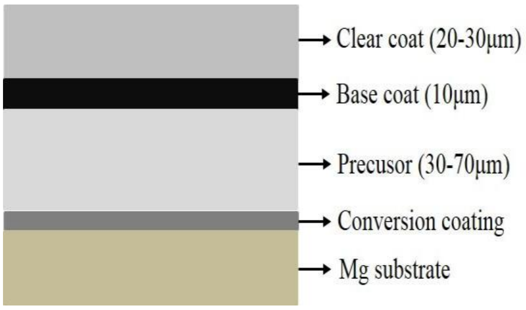


Fig.2. Typical coating system of Mg Alloy [17].

In the coating process, the first step is external surface treatment (e.g. chemical conversion to change or dumping, etc.), aimed at extracting the milling and compressing the oil and improving the corrosion resistance and the adhesive paint. Afterwards an E-coat such as the pre-coating is used to improve corrosion resistance and improve mechanical strength against mechanical damage, followed by a final topcoat containing a base coat and a clear coat to ensure the rigidity of the system and to give the coat a shocking effect. In most cases, before applying the surface treatment, the Mg components must go through the cleaning process and the activation process, as shown in Figure 3.

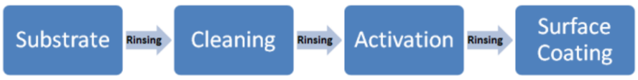


Fig.3. Schematic procedure of surface processing

The cleansing method includes mechanical (e.g., polishing, grinding) and chemical (e.g. alkaline degreasing, organic solvent cleaning) cleaning methods, which combine microscopically and that remove most of the oils, lubricants, impurities, oxide or hydroxide layers from the previous to produce or build processes respectively. Subsequently, the activation process (usually the fatty acid Mg alloys) is used to continue to provide homo native and free Mg oxide for subsequent surface treatment. Detailed information on the surface preparation of Mg alloy prior to cooking has been described [18] and standard procedures can be obtained from Standard ATSM D 2651.

With regard to surface adhesion, various methods have been developed for Mg alloys. Based on data from the web of science using complementary terms such as "convergence of SHI and magnesium blends", the published value of surface composites since 1990 is shown in Figure 4.

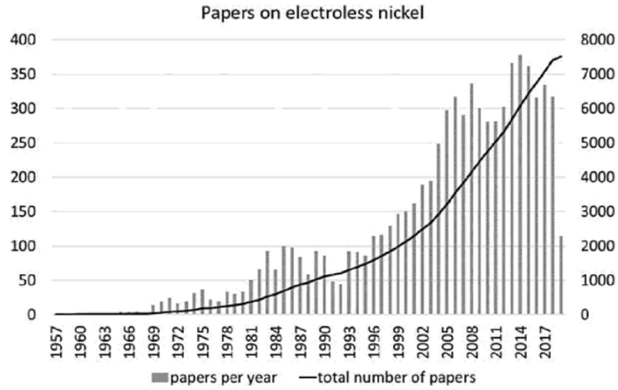


Fig 4. Number of publications of different surface coatings on Mg alloys since 1990

It seems that anodizing & MAO, the chemical synthesis of chemical modifications, and the placement of chemicals in chemistry are drawing the attention of the researcher. In addition, the incorporation of ion, organic coating and coating (including electroless coating and electrochemical coating) for the most part of those published publications. In addition, according to a review of the corrosion protection of Mg alloys based on patents [19], chemical bonding, anodizing, plastering, and organic blending were represented as the most widely used methods to improve the corrosion resistance of Mg alloys. Therefore, the focus of the next section will be on these four types of cover and their use in vehicles. Other procedures such as removal of the vapor core, and other emerging methods such as cold spraying will also be briefly introduced.

Coating processes with chemical and electrochemical properties are widely used in Mg alloys. Physical Vapor Deposition (PVD) [20-30], Electroplating [31], Anodic oxidation [32], Micro arc oxidation [33] and Chemical Vapor Deposition (CVD) [34] are separated by this process. These processes can be performed at room temperature or at low temperatures and therefore do not significantly alter the mechanical properties of Mg alloys, which is a major advantage of the process. In addition, some of them can be deposited in Mg alloy rich materials of complex shapes [34] and can be seen in colors. However, procedural allegations are often difficult. For example, in the electroplating process, e.g. In one of the widely used procedures, the optimal installation solution is to say that it differs depending on the combination of the underlying Mg alloy components and the binding material, which limits the performance of the loading condition. In addition, the preparation time for bathing with Mg alloys is usually shorter due to their high repeatability.

The coating processes in the form of thermal energy are widely used for surface modification of Mg alloys. These procedures are generally used in the development of surgical dressings. Plasma spraying [35, 36] and Arc spraying [37] are separated in this process. In these processes, the metallological proximity between the bottom layer and the implant surface is obtained at high temperatures and even a decrease in solubility can occur, which may affect the mechanical properties of the Mg alloy components. Therefore, these processes are not the best way to improve the corrosion resistance of Mg alloys.

A variety of combinations of energy-efficient methods have been proposed. In this process, the composite materials exhibit visco-plastic or liquid-like fluid due to the energy provided. According to the classifications summarized in Table 1, the delivery processes in relation to the mechanical energy are divided into 5 groups; “Electric and Chemical + Mechanical”, “Chemical and Heat + Me Me”, “Heat and Heat + Mechanical”, “Mechanical Me Mechan” and “Sound + Vibration and Mechanical”. Here, the group names are shown as "Energy + Energy form". In the present paper, of these 5 groups, the sequential binding processes are selected.

- Physical vapor deposition from the “Electric and Chemical + Mechanical” group
- Explosive cladding from the “Chemical and Heat + Mechanical” group
- Diffusion bonding from the “Heat and Heat + Mechanical” group
- Twin roll casting, Roll bonding, Cold spray and Hot extrusion from the “Mechanical and Mechanical” group
- Friction surfacing and Ultrasonic spot welding from the “Sound + Vibration and Mechanical” group.

Cold spray, twin roll casting and friction surfacing are relatively new methods attracting attention since around 2000, while the diffusion bonding and hot rolling processes have been used for a longtime. The Ultrasonic Spot Welding (USW) is known as a relatively new process. Considering the structural applications of the coated Mg alloys, special attention is paid to microstructure and mechanical properties such as wear resistance, hardness and shear resistance.

III. EFECT OF COATING ON MECHANICAL PROPERTIES

A. *Surface Morphology*

The surface morphology of electroless Ni-P-Al_2O_3 are analyzed under scanning electron microscopy (SEM) to study the morphological changes due to incorporation of second phase nano particles and heat treatment[38]. The effects of heat treatment at different temperatures (200°C/1 hour, 300°C/1 hour, and 400°C/1 hour) are also observed for different composite coatings Figure 5.

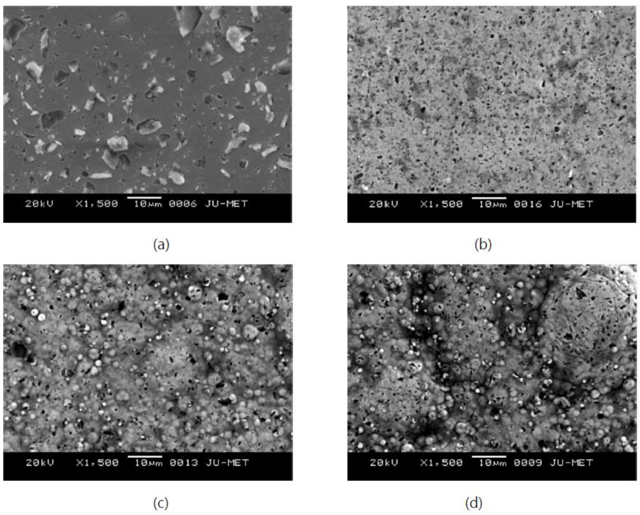


Fig 5. Micrographs of Ni-P-Al_2O_3 composite coatings: (a) as-deposited, (b) heat treated at 200°C, (c) heat treated at 300°C and (d) heat treated at 400°C

The SEM images of the as-plated electroless Ni-B-P alloy and Ni-B-Zn coatings is shown in Figure 6 and Figure 7.

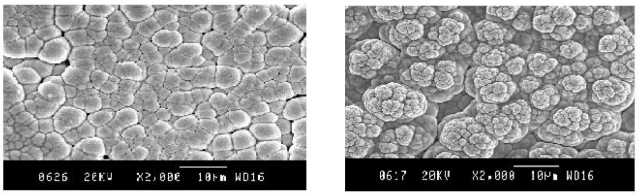


Fig 6. Micrographs of Ni-B-P composite coatings

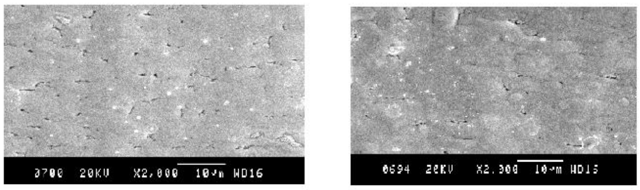


Fig7. Micrographs of Ni-B- Zn composite coatings

B. *Surface Roughness*

Extensive literature review on roughness study of electroless nickel coatings reveals that the center line average roughness (Ra) has been the focus of most of the investigations and is the most common parameter used to study surface topography. In the present paper Ra has been studied for Ni-P-Al_2O_3, Ni-P-TiO_2, and Ni-P coatings. The roughness data for Ni-P-Al_2O_3, Ni-P-TiO_2, and Ni-P[39] coatings is shown in graphical representation in Figure 6.

From the Figure 6 it is confirmed that mean Ra of Ni-P-Al_2O_3 and Ni-P-TiO_2 composite coatings are higher than mean Ra of Ni-P coating. It means that Ni-P coating has smoother surface as compared to both composite coatings. Out of the three coatings, Ni-P-TiO_2 composite coatings have higher mean Ra value.

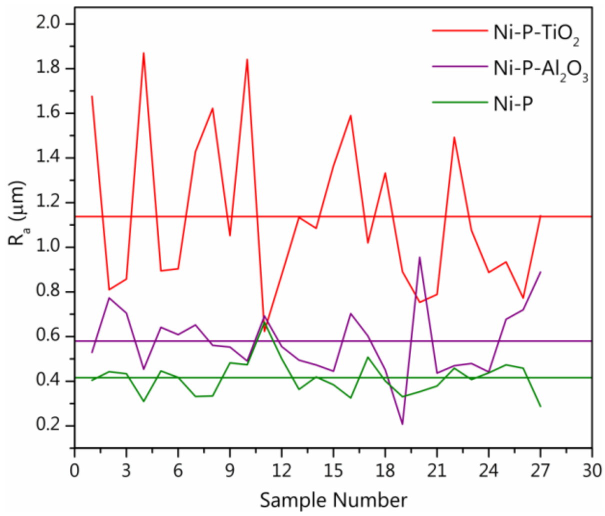


Fig 6. Variation of center line average (Ra)

C. *Surface Hardness*

One of the purposes of applying coating to a surface for any tribological application is related to providing smoothness and hardness to the surface. Hardness of the material controls its wear behavior up to significant extent, as hard material tends to wear out lesser.

In this section, hardness of electroless Ni-P-Al_2O_3 and Ni-P-TiO_2 composite coatings is studied. For both the composite coatings, coating deposition parameters are varied to obtain higher coating hardness. The hardness is measured by using Vicker's technique. For both the coatings, S/N ratio analysis is done with HV0.05 as performance index. As hardness is to be maximized, S/N ratio is calculated using higher-the-better criterion. The hardness values together with S/N ratio values for both composite coatings are shown in Table I.

TABLE I. HARDNESS AND S/N RATIO VALUES FOR NI-P-AL_2O_3 AND NI-P-TIO_2 COATINGS

Sr. No	Ni-P-Al_2O_3 coating		Ni-P-TiO_2 coating	
	Hardness (HV0.05)	S/N ratio	Hardness (HV0.05)	S/N ratio
1	1221	61.73	967	59.71
2	1507	63.56	1258	61.99
3	1226	61.77	1347	62.59
4	1508	63.57	987	59.89
5	1463	63.30	1097	60.80
6	1447	63.39	1460	63.29
7	1251	61.95	1285	62.18
8	1240	61.87	1307	62.33
9	1330	62.48	1302	62.29
10	1207	61.63	1427	63.09

From the Table I it is noted that the heat treatment temperature (parameter D) has the most significant effect on the hardness of both composite coatings. Similarly, concentration of second phase particles (Al_2O_3 and TiO_2) that means parameter C has significant influence on the hardness of the composite coatings.

Figure 8 and Figure 9 shows main effects plots for Ni-P-Al_2O_3 and Ni-P-TiO_2 composite coatings respectively. From the plots, it is confirmed that parameter D has the largest difference between the levels and hence has greatest influence over the hardness of both composite coatings. Similarly, parameter C (TiO_2) has quite a significant influence over the hardness of the coatings. Parameter B (Sodium Hypophosphite) and parameter A (Nickel Sulphate) has the least influence over the hardness of both the composite coatings.

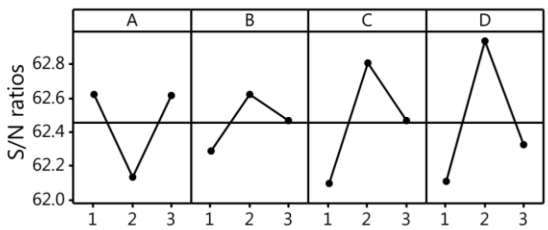


Fig 8. Plot for S/N ratio Ni-P-Al_2O_3 coatings

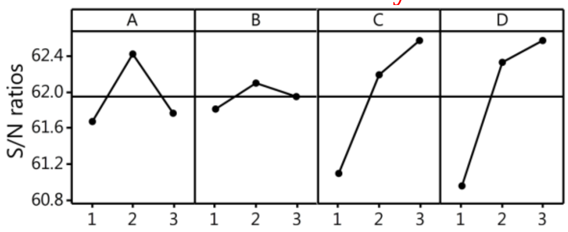


Fig 9. Plot for S/N ratio for Ni-P- TiO_2 coatings

D. *Corrosion Resistance*

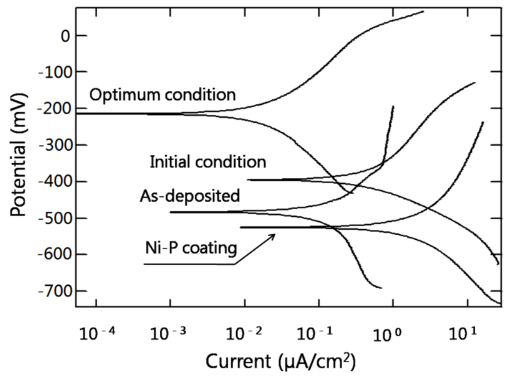
Corrosion is a deteriorating phenomenon of metals, which often reduces the life of products.

The resistance of the coatings towards corrosion is evaluated on the basis of the corrosion parameters obtained from these studies viz. open circuit potential, corrosion current density, charge transfer resistance, double layer capacitance, corrosion rate, etc.

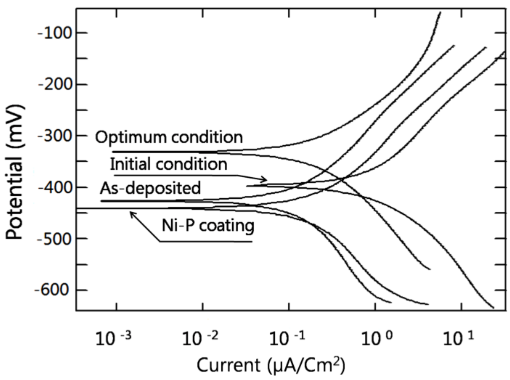
The corrosion behavior of as-plated electroless alloy coatings was evaluated by Potentiodynamic polarization and Electrochemical impedance spectroscopy studies (EIS). It is found that there is a shift in the corrosion potential values of as-plated electroless Ni-B-Zn alloy coatings.

The shift in the corrosion potential values suggests that there is a significant increase in the electrochemical activity for cathodic and anodic reactions.

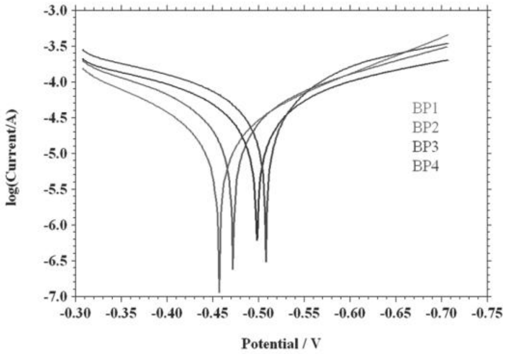
The polarization curves for the composite coatings developed are shown in Figure 10.



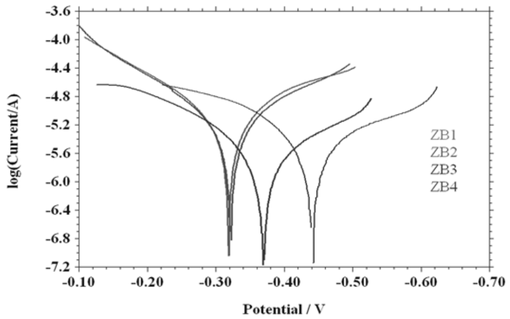
(a) For Ni-P-Al_2O_3 coatings



(b) For Ni-P-TiO_2 coatings



(c) For Ni-B-P Coating



(d) For Ni-B-Zn Coating

Fig 10 . Polarization curves for the composite coatings

IV. Conclusion

In the present review paper, a variety of coating processes for the improvement in mechanical properties of magnesium alloys are introduced, and their advantages and disadvantages are explained. Special attention is directed at the coating processes utilizing a mechanical energy source form. The mechanical properties of the obtained coating and substrate are also briefly mentioned. The effect of coating on mechanical properties like surface finish, hardness and corrosion resistance of various coating on magnesium alloy is studied. It is observed that in each case the optimal combination of parameters yield a significant improvement in the hardness and corrosion resistance properties of the coatings.

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