REDUCING THE IMPACT OF CORROSION USING NANOMATERIAL COATING

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المستخلص:

في هذا البحث تم تقديم مقترح لطلاء الانابيب النفطية باستخدام المواد النانوية لمنع التآكل، وكمثال على هذه الطلاءآت استخدام سبيكة الطلاء $Zn-Ni-Al_2O_3$، حيث تعتبر ذات اهمية كبيرة للطلاء على الفولاذ. تم دراسة تأثير الالومينا على الخصائص التركيبية لسبيكة $Zn-Ni-Al_2O_3$ من اجل تحسين مقاومة السبيكة ضد التآكل والتي سوف تودي الى تحسين الخصائص الميكانيكية للسبيكة.

الكلمات المفتاحية: التقنية النانوية، الجسيمات النانوية، السبائك، الطلاءآت .

ABSTRACT

In this paper, we try to give suggestion to prevent the corrosion of oil pipes using nanomaterials to produce high-performance coatings, for example alloy of Zn-Ni-Al_2O_3 nanocomposite coatings. The study of coating properties of such alloy is very important in order to obtain a high quality coating on mild steel. The effect of alumina nanoparticles on the structural properties of Zn-Ni-Al_2O_3 alloy for improved resistance against corrosion of this alloy coating was investigated. Thus mechanical properties will improve.

Keywords: Nanotechnology, nanoparticles alloys

INTRODUCTION

Nanomaterials are important due to their unique properties that may lead to new and exciting applications [1]. Nanotechnology has a potential applicability in the field of protecting metals against corrosion, which has been attracting a wide attention of researchers. Nanostructure particulates can be adopted to suppress corrosion taking place as a result of the surrounding environment condition. It can use effectively some alternatives to hazardous and toxic compounds such as nanocomposites [2]. As a new technique in nanotechnology applications is nanocoating which is mainly adopted for avoiding and controlling corrosion protection.

According to the fact that the physical, chemical and physicochemical properties are unique and crucial, nanocoating technology has a remarkable contribution in this field. In nanocoating, some specific features can be enhanced due to incorporation of nanoparticles in the coating formulation [3]. The disintegration of metal/alloys surfaces due to specific environmental circumstances is known as corrosion [4]. Corrosion healthy in equipment of big industries such as oil industries as well as the quality of its transmission is an important and basic problem which disregarding of this phenomenon causes to stop production and consequently cost repairing [5]. The improvement of the lifespan and performance of metallic alloys and components through the application of numerous anti-corrosion coatings is highly advantageous [6].

1. **Experimental Details**

Mild steel sheet was used as substrate with 1 mm in thickness and an area of 20 cm^2, also was used as the cathode, while a high purity (99.75%) nickel plate was used as the anode. Substrates must be thoroughly cleaned before deposition, and a variety of procedures exist for this purpose. The compositions bath were (was) $ZnSO_4.7H_2O$, $NiSO_4.6H_2O$ and $NaSO_4$. In the bath, Al_2O_3 concentration were (0, 25, 50 gm. L^{-1}) in order to obtain Zn–Ni electrodeposition, while the processing parameters were; time (20 minute), current density (60 mA/cm^2) and agitation speed 400 rpm. The pH of the bath was adjusted to 3 ± 0.5 using a dilute H_2SO_4 solution. After the bath

preparing, then cathodes immediately immersed in plating bath to deposit nanocomposite coating.

1. RESULTS AND DISCUSSION

3.1 XRD ANALYSIS

Figure 1 shows XRD pattern of Zn–Ni composite coatings for three cases (0, 30, 50 gm. L^{-1}) of concentration of Al_2O_3. The main peak corresponding (330) dominated for all cases with phase structure is single (γ-Ni_5Zn_{21}). The peak broadening suggested the formation of nanocrystals of size and the prominent peak of any one of each spectra confirm that the synthesized particles have a crystalline structure with random crystal orientation. As seen, there are small peaks appear in the XRD pattern. Using Deby-Scherrer formula:

$$D_{hkl}= k \lambda /\beta \cos\theta \quad \ldots\ldots\ldots(1)$$

The average grain size of the prepared samples can be calculated from the prominent peak (330), λ- X-ray wavelength, β- FWHM (full width at half the peak maximum) [7]. The grain size of Zn–Ni coating is larger than the grain size of Zn–Ni–Al_2O_3 coatings. If the concentration of Al_2O_3 increases from 25 to 50 gm. L^{-1}, the grain size decreases from 48 to 29 nm. Smaller grains on the nanometer in the fine structure can increase microhardiness [8].

1.2 SURFACE MORPHOLOGY

Figure 2 shows the images of the atomic force microscope in two dimensions and three dimensions with different concentrations of Al_2O_3, (0, 25 and 50 gm/l). It can be concluded from the images, the greater amount of Al_2O_3 will lead to increased refinement of crystal size, this may be due to incorporation of Al_2O_3 nanoparticles in the Zn–Ni coating.
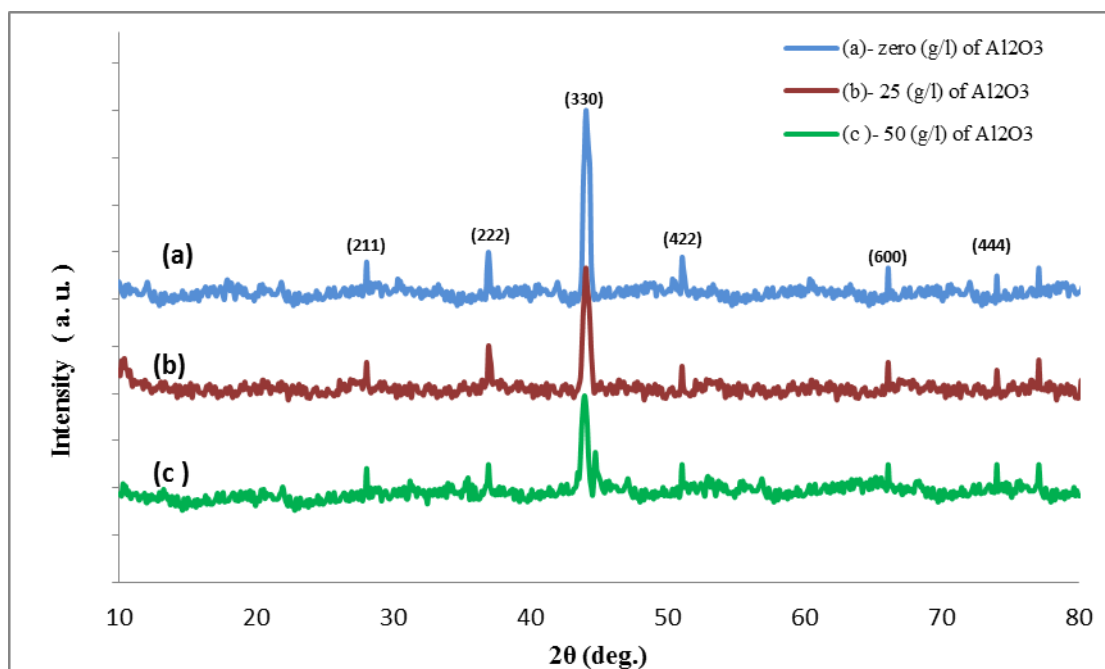

Figure 1: X-ray diffraction patterns of Zn–Ni alloy coatings with two different concentrations of Al_2O_3:
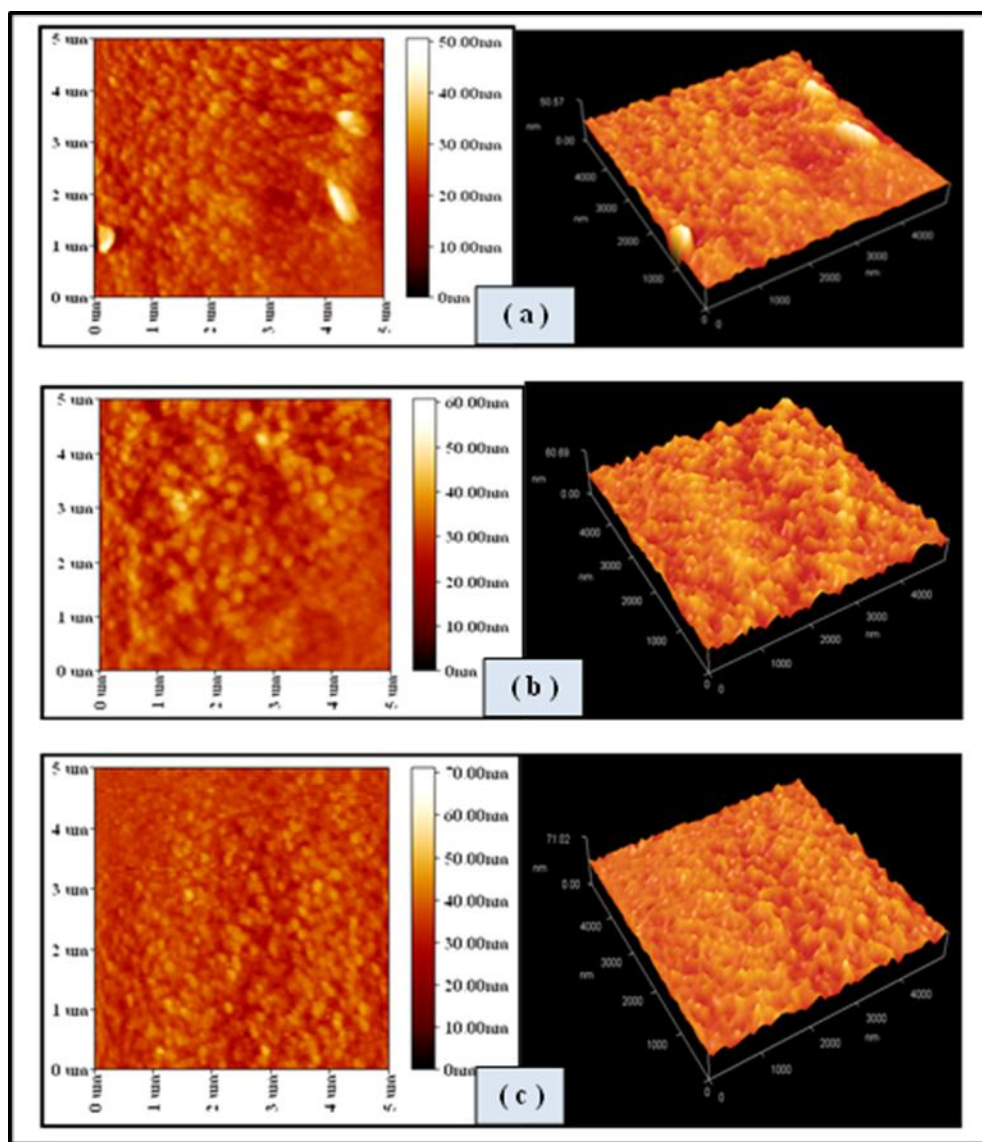(a) Zero (gm/l), (b) 25 (gm/l), and (c) 50 (gm/l).

Figure 2: Two and three dimensions images of Zn–Ni alloy coatings with different concentrations of Al_2O_3: (a)- Zero, (b)- 25 , and (c)- 50 (gm/l).

3.3 MICROHARDNESS OF THE COATING

Using a Vickers hardness tester (HV) and at constant time of 15 second to load of 100 g, the microhardness of coatings were measured and performed in (on) the surface by using a Wolpert Wilson Instruments (model 402UD) [9]. The results obtained from microhardness test of Zn-Ni and Zn–Ni–Al_2O_3 with respect contents of nano-alumina in the composite coatings are (is) shown in figure 3. It is clear that the hardness increase as the alumina concentration increase.
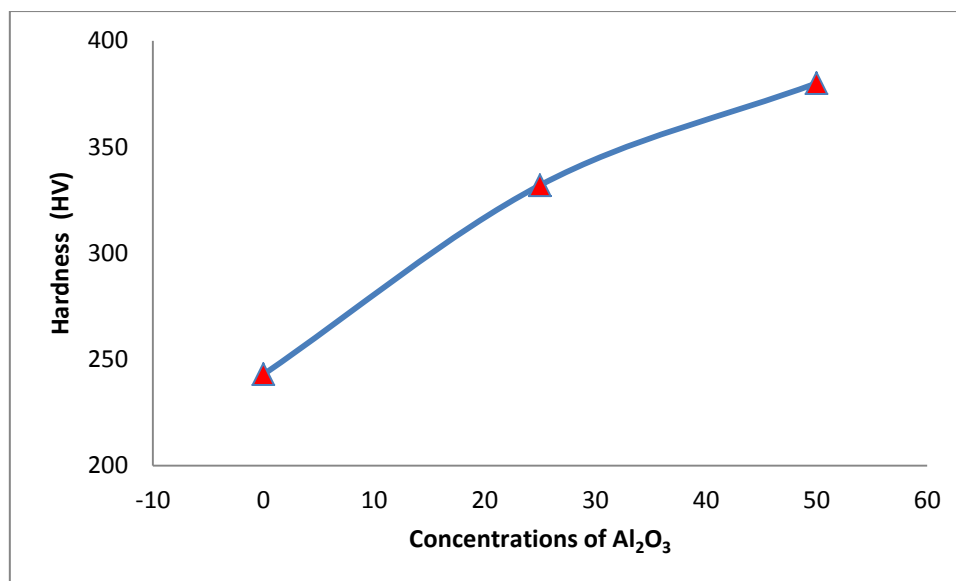
Figure 3: Hardness of Zn-Ni and Zn–Ni–Al$_2$O$_3$ as a function of Concentrations of Al$_2$O$_3$

CONCLUSIONS

The incorporation of Al$_2$O$_3$ nanoparticles with Zn-Ni alloy, lead to improves the structure of Zn–Ni–Al$_2$O$_3$ alloy. The grain size decreases from 48 to 29 nm as the content of Al$_2$O$_3$ increases from 25 to 50 (gm/l) and the surface morphology becomes more refined of crystal size, while hardness increase as the alumina concentration increase.

RFERENCES

[1] V. S. Saji and Joice Thomas," Nanomaterials for corrosion control", Current Science, Vol. 92, No. 1, 10 January (2007).

[2] **R. S. Abdel Hameed**, Abd-Alhakeem H. Abu-Nawwas and H. A. Shehata," Nano-composite as corrosion inhibitors for steel alloys in different corrosive media", Advances in Applied Science Research, 4 (3): 126-129, (2013).

[3] **Mathazhagan, A. and R.** Joseph: Nanotechnology– A new prospective inorganic coating– review, International Journal of Chemical Engineering and Applications, Vol. 2, No. 4, pp. 225 – 237,(2011)

[4] **Heusler, K. E., Landolt, D**., and S. Trasaiti," Electrochemical corrosion nomenclature", Pure & Appl. Chem., Vol. 61, No. 1, pp. 19-22,(1989).

[5] **E. Noveiri and S. Torfi,"** Nano Coating Application for Corrosion Reduction in Oil and Gas

Transmission Pipe: A Case Study in South of Iran", International Conference on Advanced Materials Engineering IPCSIT vol.15 (2011).

[6] **Popoola, A. P. I., Fayomi, O. S. I.,** and O.M Popoola: Comparative Studies of Microstructural, Tribological and Corrosion Properties of Plated Zn and Zn-alloy Coatings, Int. J. Electrochem. Sci., Vol. 7, pp. 4860 – 4870, (2012).

[7] **R. B. Kale, C. D. Lokhande,"** Band gap shift, structural characterization and phase transformation of CdSe thin films from nanocrystalline cubic to nanorod hexagonal on air annealing", Semicond. Sci. Technol. Vol. 20, No.1 (2005).

[8] **M. Diafi, S. Benramache, E. G**. Temam, A. M. Lakhdar and B. Gasmi," Study of Zn-Ni alloy coating modified by nano- Al_2O_3 particales incorporation", Acta Metallurgica Slovaca, Vol. 22, No. 3, pp. 171-180, (2016).

[9] **W. Chen, W. Gao,"** Sol-enhanced electroplating nanostructured Ni-TiO_2 composite coatings- the effect of sol concentration on the mechanical and corrosion properties", Electrochimica Acta, Vol. 55, No. 22, pp. 6865–6871, (2010).