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PREPARATION AND ENHANCEMENT OF Co.28Cr.6Mo DENTAL IMPLANT ALLOYS BY AL_2O_3 NANOWIRES

A.R.H. Wetaify

College of Engineering, University of Al-Muthanna, Samawa, Iraq, ah.ra34@mu.edu.iq

Abstract- Cobalt-Chrome-Molybdenum alloys is one of important alloys which used in dental implants especially in complete dentures and partial dentures, due to good mechanical properties and biocompatibility. (Co.28Cr.6Mo/Al_2O_3) nanocomposite material was prepared by powder metallurgy technique to be used in dental implant applications. X-ray Diffraction examination agree with (J.C.P.D.S.) card in the peaks 2θ = 44.72°, 67.197° and JCPDS card (06-0694) and (J.C.P.D.S.) card (07-0050) at 2θ= 53.33° , and 2θ= 75.31°. Microhardness was increased by Al_2O_3 was increased from 8.5 Kg/mm^2 for Co.28Cr.6Mo alloys to 14 Kg/mm^2 at 3% Al_2O_3 NWs. Tensile strength of (CoCrMo/Al_2O_3) was increased compared with (CoCrMo) alloys which is due to presence. The oriented of nanowires and very small wire sizes can understanding yield influence of tensile strength. Fracture toughness increase from ≈78 MPa mm$^{1/2}$ to ≈ 100 MPa mm$^{1/2}$ with increasing in Al_2O_3 nanowires percentage. Scanning electron microscope image showed combination in composition of Co.28Cr.6Mo and refining of microstructure.

Keywords: CoCrMo Alloys, Nanocomposite Materials, Dental Implants and Al_2O_3 Nanowires.

1. INTRODUCTION

Cobalt-chromium-molybdenum alloys have superior corrosion resistance, non-magnetic behavior, high strength and biocompatibility. These alloys are used in a variety of applications, including replacement of knees, elbows, heart valves, bone plates, nails, pins and rods, prosthetics for hips, ankles, fingers, shoulders, and dental implants. These alloys are made by melting and casting method due to complication in shapes of the surgical implantations, as well as to remove any porosity residues in Co.28Cr.6Mo, but the fatigue resistance is poor [1]. Cast cobalt-chromium-molybdenum alloys have been suggested in surgical implants in many studies.

First implant this alloy shows a good combination of fatigue resistance, mechanical strength and biocompatibility as well as possesses good hot workability. Dental prosthetics require biological integrity, biocompatibility and mechanical integrity [2]. Therefore, the alloy that contains (cobalt chromium molybdenum) has exceptional composition and good tribological properties for such application. Therefore (cobalt chromium molybdenum) alloy has been generally used in fabrication complete and partial dentures, and implantation overlays in dentists [3]. To obtain the requirements for prosthetic dentistry and orthodontic appliances and to determine the composition (chemical composition) that requirement to improve fatigue property, hardness, wear resistance, and tensile strength [4]. In current research evaluated chemical composition and improvement hardness, tensile strength, fracture toughness, microstructure of (cobalt chromium molybdenum) alloys manufactured by adding Al_2O_3 nanowires.

2. EXPERIMENTAL PROCEDURE

This procedure includes the preparation of nanocomposite (Co.28Cr.6Mo/Al_2O_3) samples and the mechanical and physical exam to evaluate the behavior of these materials samples, microstructure. The following table represents basic materials powder are used (Table 1).

Table 1. Materials used in this work

Material Powder	size
Co.28Cr.6Mo	D = 3 μm
Al_2O_3	L= 3 μm, D = 45 nm

2.1. Preparation of (Co.28Cr.6Mo/Al_2O_3) Nanocomposite

Nanocomposite of (Co.28Cr.6Mo/Al_2O_3) has been prepared by powder metallurgy by mixing of (Co.28Cr.6Mo) powder and Alumina nanowire (Al_2O_3 NWs) using mixture in speed 120 rpm for (3 hours), After that pressed the samples under (150) MPa in (750 °C) for five hours.

2.2. Examinations and Characterization

2.2.1. X-Ray Diffraction Examination

The conformation of the samples (cobalt chromium molybdenum) alloy was exanimated by x-ray diffraction. atoms interact creating waves of scattered x-ray that reinforces each other in certain directions. The x-ray Diffraction tester apparatus is XRD type Lab x, XRD-6000 Shimadzu.

2.2.2. Microhardness (HV)

Vickers tester method was used according to (A.S.T.M.) (E92-82) to compute the micro-hardness of (cobalt chromium molybdenum) and its composite with Al_2O_3 nanowires, for many points on sample surface using load of 1 Kg for of 20 sec using a diamond pyramid 136°.

2.2.3. Tensile Properties

The tensile properties were achieved by universal testing machine (Model w.d.w-101) according to A.S.T.M. (D 95-85) at the room temperature for the (cobalt chromium molybdenum) and composite with Al_2O_3 nanowires, with computer controlled (maximum load of 100 KN).

2.3.4. Fracture Toughness

Fracture toughness machine tester (impact tester) was used to calculating fracture toughness. The samples of (60×10×10) millimeter dimensions were notched to a depth of 3 mm at the middle of samples, so as to make an area of stress concentrations.

2.3.5. Scanning Electron Microscope (SEM)

Crystalline structure and Morphology, of (cobalt chromium molybdenum) and composite with Al_2O_3 nanowires samples were examined by scanning microscope (MI.RA3 TE. SCAN).

3. RESULTS AND DISCUSSIONS

Figure 1 displays X.R.D. analysis Composite of (cobalt chromium molybdenum) / Al_2O_3 alloy used in the present work. XRD pattern was agreed with J.C.P.D.S. cards (46-1212) the main peaks located at $2\theta = 44.72°$, 67.197° and J.C.P.D.S. card (06-0694), $2\theta = 53.33°$ and $2\theta = 75.31°$ agreed with J.C.P.D.S. cards (07-0050) [5].

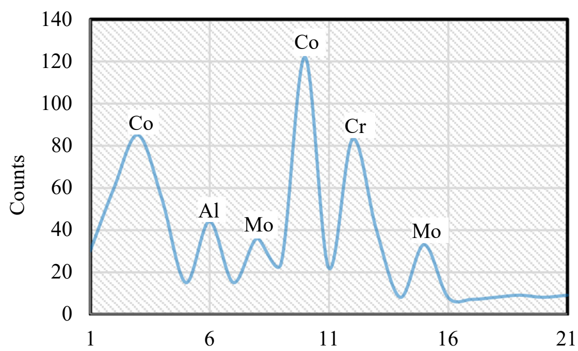

Figure 1. X-Ray diffraction of CoCrMo/Al_2O_3 [illegible]s

3.1. Microhardness

Figure 2 illustrations that the microhardness of (cobalt chromium molybdenum) was increased by the increasing in Al_2O_3 nanowires. Al_2O_3 nanowires are subsisted the vacancies then receiving good coherent or bonding [5-8] between Al_2O_3 and Co.28Cr.6Mo alloy, the increasing was reached to 14 Kg/mm^2 when 3% of Al_2O_3 nanowires was added, the significant increasing can be seen in microhardness of Co.28Cr.6Mo/Al_2O_3 composites and their increment reached to ≈13.8 Kg/mm^2 at 3% NWs. The increasing of microhardness was also observed by Sang-Hak Lee, et al. [5].

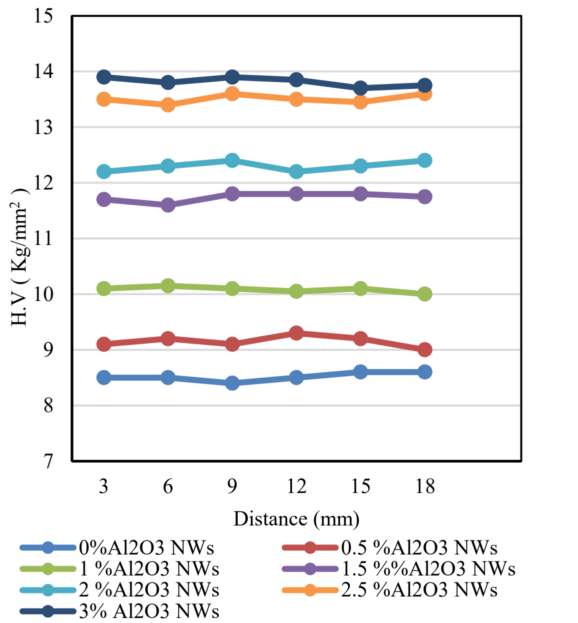

Figure 2. Microhardness of composite Co.28Cr.6Mo/Al_2O_3 nanowires

3.2. Tensile Strength

Figure 3 specifies the stress - strain curves result for CoCrMo alloy and CoCrMo/Al_2O_3 nanowires composite. The data in Figure 3 shows the high tensile strength of CoCrMo/Al_2O_3 nanowires composite related with CoCrMo which is because of the presence of Al_2O_3 nanowires in CoCrMo alloys which act as a nano-fillers. Small sizes of Al_2O_3 nanowires and good distribution and high level of orientations can cause an exclusive effect of surface stresses [9-10]. In fact, at very small wire sizes, a properly oriented wire can experience tensile yield under the exclusive influence of surface stresses, this result is in agreement with the observation with Ahmed [11].

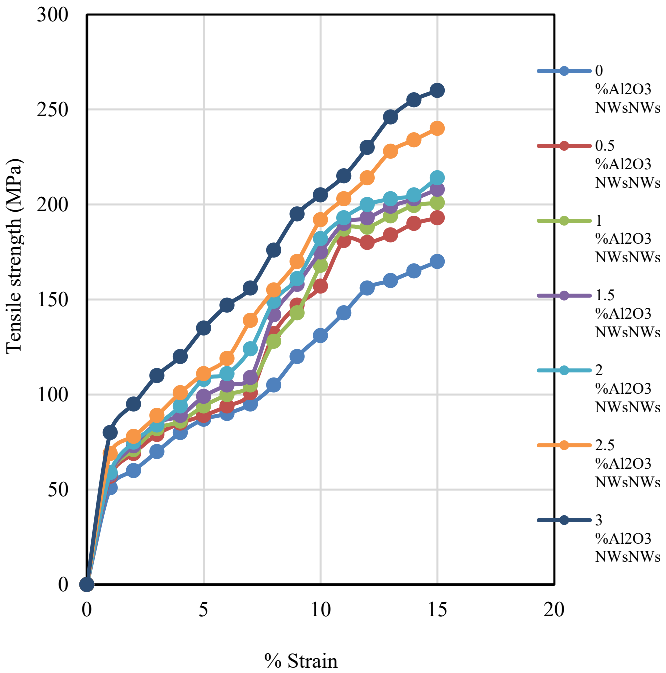

Figure 3. Tensile results of composite Co.28Cr.6Mo/Al_2O_3 nanowires

3.3. Fracture Toughness

Figure 4 illustrates effecting of Al_2O_3 nanowires percentage in fracture toughness of CoCrMo alloys. Fracture toughness was found to increase from 78 $MPa.mm^{1/2}$ to 100 $MPa.mm^{1/2}$ with increasing in Al_2O_3 nanowires addition. This mean there is an enhancement in ductility and internal stress [11-12]. The addition of nanowires improved or prevented the internal cracks, which led to the improvement of the fracture toughness, and this is consistent with Ahmadia [4]

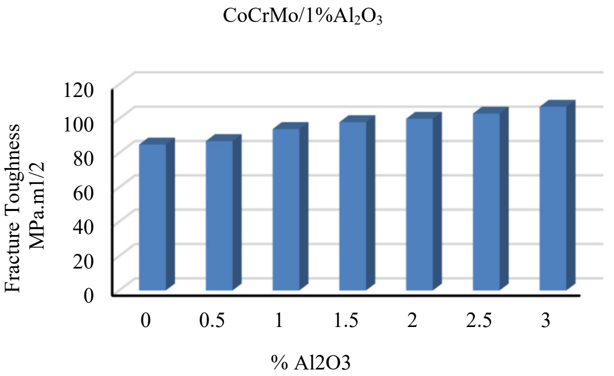

Figure 4. Effect of Al_2O_3 addition on Co.28Cr.6Mo alloys

3.4. Scanning Electron Microscope

Figure 5 shows the SEM images of Co.28Cr.6Mo alloys and its composite of Co.28Cr.6Mo/Al2O3 nanowires. After adding Al_2O_3 nanowires, noted the incidence high combination in microstructure of CoCrMo alloys, lowering the alteration in microstructure and threatened of the spherical shape of partial, nanowires act as a network to link the components in CoCrMo and then the refining of composition can occur [12-13]. After adding nanowires, one can see the occurrence of more incorporation in composition of CoCrMo alloys, reducing the difference in microstructure and disappearing of the spherical particles. increasing the weight percentage of nanowires, the incorporation increases and then the refining of composition can occur as shown in Figure 5. The latter result is in good agreement with the observation which done by R.A. Anaee [13].

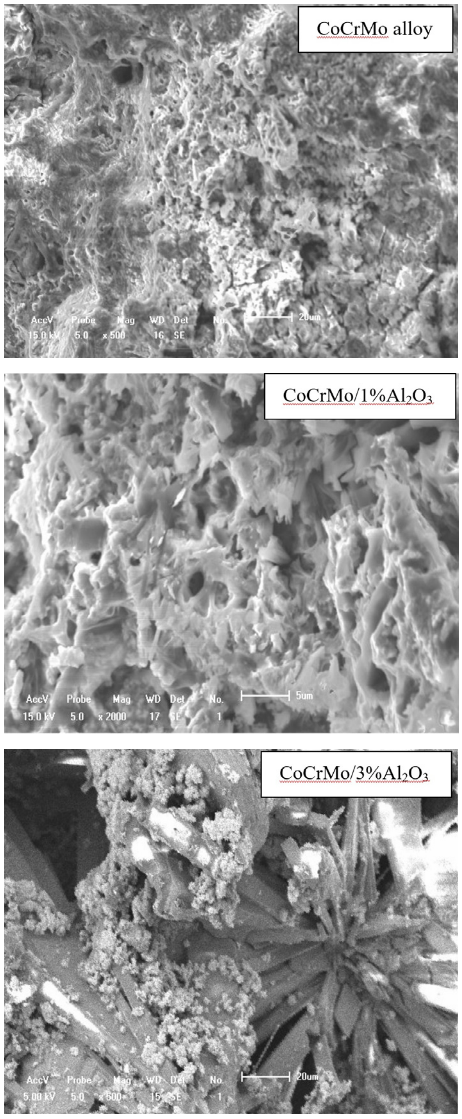

Figure 5. SEM of CoCrMo and its Composite.

4. CONCLUSIONS

X-ray Diffraction examination showed a good agreement with JCPDS card. Microhardness was increased by Al_2O_3 was increased, this increasing was given in to the substated of vacancies in CoCrMo by Al_2O_3 nanowires and receiving high comprehensible and linking between the Co.28Cr.6Mo alloys and Al2O3 nanowires. Tensile properties of CoCrMo/Al_2O_3 composite were increasing related to CoCrMo alloys. An enhancement in internal stress and ductility due to enhancement in fracture toughness and this enhancement was increased by Al_2O_3 was increased. Scanning electron microscope image showed the occurrence of more combination in composition of CoCrMo, disappearing of the spherical particles shape, reducing the difference in and the refining of microstructure morphology.

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BIOGRAPHIES

Name: **Ahmed**
Middle Name: **Rajih Hassan**
Surname: **Wetaify**
Birthday: 27.11.1981
Birth Place: Babylon, Iraq
Bachelor: Materials Science Department, Babylon University, Babylon, Iraq, 2005
Master: Materials Science Department, Babylon University, Babylon, Iraq, 2008
Doctorate: Materials Science Department, Technology University, Baghdad, Iraq, 2017
The Last Scientific Position: Assist. Prof., Chemical Department, Al-Muthanna University, Samawa, Iraq, Since 2008
Research Interests: Nanomaterials, Biomaterials, Composite Materials
Scientific Publications: 17 Papers