ISSN : 0974 - 7486 Volume 12 Issue 6

Materials Science

An Indian Journal

Full Paper

MSAIJ, 12(6), 2015 [213-217]

Effect of gamma radiation on electrochemical corrosion behavior, structural morphology and hardness of silver- palladium dental alloy

Abu Bakr El-Bediwi[2]*, N.K.Radwan[2], S.Abdeen[1], Doaa Al- Ragaei[2]

[1]Zoology Department, Faculty of Science, Mansoura University, (EGYPT)

[2]Metal Physics Lab., Physics Department, Faculty of Science, Mansoura University, (EGYPT)

ABSTRACT

Effect of gamma radiation on electrochemical corrosion behavior, structural morphology and hardness of commercial silver- palladium dental alloy has been investigated. Matrix microstructure of silver- palladium such as crystallinty, crystal size and orientation changed after exposure to gamma radiation which effects on all measured properties. Corrosion potential (E_{Corr}), corrosion current (I_{Corr}), corrosion rate ($Corr_{Rate}$) and Tafel slopes (βc and βa) of silver- palladium alloy changed after exposure to gamma radiation. Corrosion potential of silver- palladium alloy exhibited a negative potential. Also, the cathodic and the anodic polarization curves showed similar corrosion trends after exposure to gamma radiation. Vickers hardness of silver- palladium dental alloy decreased after exposure to gamma radiation.

KEYWORDS

Structure;
Corrosion parameters;
Hardness;
Silver- palladium;
Gamma radiation.

INTRODUCTION

Silver/palladium alloys developed by Heraeus in 1931 have been used for dentistry in applications such as bridges and crowns. Nickel alloys are harder than precious metal alloys; they provide the required rigid support for porcelain and prevent fracture. They have been the preferred choice in long-span bridge restorations or when strength is of main concern[1-3]. Also nickel alloys are subjected to corrosion products, which might lead to soft tissue inflammation and contact dermatitis[4,5]. Ni-Cr wires used for orthodontic bands can influence not only the image quality, but also the diagnostic reliability of MRI of the temporomandibular joint[6]. Hubálková et al[7] described the behavior of dental alloys during the magnetic resonance imaging procedure. Ni-Cr, Co-Cr andSUS304 expressed small amounts of MR defects, but SUS405, Pd-Co-Ni and Sm-Co expressed large defects. The effects of gamma radiation and magnetic resonance imaging on structure, electrochemical corrosion behavior and Vickers hardness value of commercial Co-Cr and Ni- Cr dental alloys were investigated[8-10]. Also the effects of gamma radiation and magnetic resonance imaging on structure, surface roughness and Vickers hardness of commercial titanium biomaterialhave[11]. No more available research covering the effects of gamma radiation on structure and physical properties of silver- palladiumdental alloy. For this reason, the aim of the present study was to investigate the effect of gamma radiation (10, 20 and 30 kGy) on structure morphology, hardnessand electrochemical corrosion behavior of commercial silver-

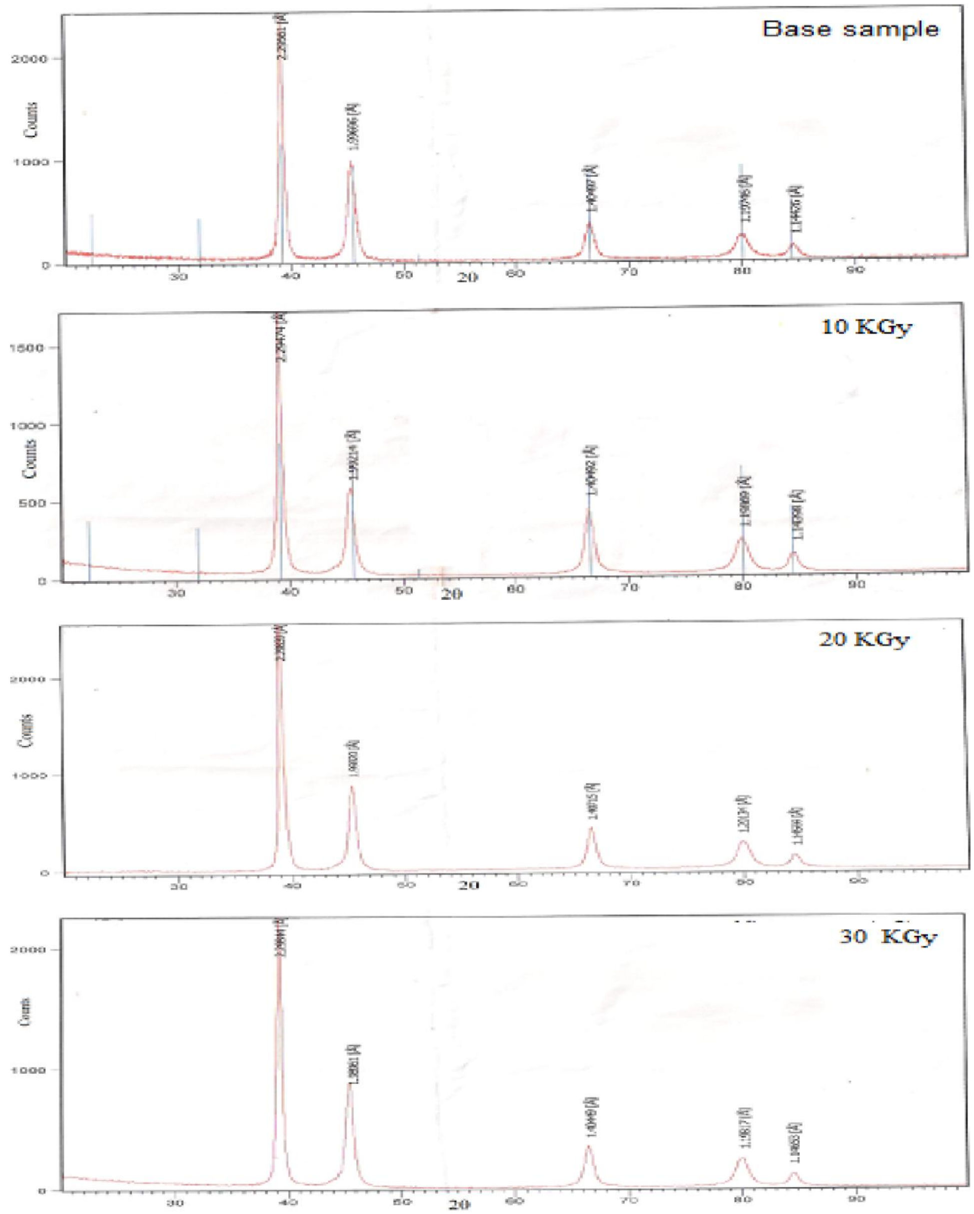

Figure 1: x-ray diffraction patterns of silver-palladium alloy before and after exposure to gamma radiation

palladium dental alloy.

EXPERIMENTAL WORK

The specimens used in the present work are commercial silver- palladium dental alloy. They prepared in convenient shape for all tests such as structure, roughness, Vickers microhardness and electrochemical corrosion behavior. Microstructure of used specimens was performed using a Shimadzu X–ray Diffractometer (Dx–30, Japan). Microhardness test of used specimens were conducted using a digital Vickers microhardness tester, (Model FM–7, Tokyo, Japan), applying a load of 100 gf for 5 seconds via a Vickers diamond pyramid. The roughness of used specimens were measured by using surface roughness measurements device (S.J 201.P). The polarization studies were performed using Gamry Potentiostat/Galvanostat with a Gamry framework system based on ESA 300. The polarization studies were carried out over a potential of +250 to -250 mV with respect to the open circuit potential at a scan rate of 5 mV s^{-1}. The linear Tafel segments of the anodic and cathodic curves were extrapolated to obtain corrosion potential (E_{corr}) and corrosion current density (j_{corr}).

RESULTS AND DISCUSSION

Effect of gamma radiation on microstructure

Effect of gamma radiation on structure and physical properties of dental materials that have been recently developed and introduced to the dental market were not investigated. Figure 1 shows x-ray diffraction patterns of silver- palladium dental alloybefore and after exposure to gamma radiation doses (10, 20 and 30kGy). The details of formed phases (intensity, position and Miller indices) in silver- palladium alloy are shown in TABLE 1. From these results, it obvious that the silver- palladium alloy consists of Ag. Pd face centered cubic phase. The shape of formed phases (intensity, broadness and position) of silver- palladium alloy changed after exposure to gamma radiation. That is because the interaction of high energy gamma radiation with silver- palladium matrix alloy.

Effect of gamma radiation on Vickers hardness

Hardness is a property with a low coefficient of variation when compared with other mechanical properties tested. In general hardness is defined as resistance of material to plastic deformation, usually by indentation. However, the term hardness may also refer to stiffness or resistance to scratching abrasion, or cutting. The microhardness was conducted using a digital Vickers microhardness tester, applying a load of 100 g for 5 s, for silver- palladium alloy. Vickers hardness of silver- palladium alloy before and after exposure to gamma radiation is shown in TABLE 2. Vickers hardness of silver- palladium alloy decreased after exposure to gamma radiation. That is because gamma radiation caused a change in matrix alloymicrostructure which effect on bonding strengthreducing its hardness.

The minimum shear stress (τ_m) value of silver-palladium alloy before and after exposure to gamma radiation was calculated using the equation[12]:-

$$\tau_m = \frac{1}{2} H_v \left\{ \frac{1}{2}(1-2\nu) + \frac{2}{9}(1+\nu)[2(1+\nu)]^{\frac{1}{2}} \right\}$$

Where ν is Poisson's ratio of the elements in the alloy and then calculated (τ_m) value listed in TABLE 2.

Effect of gamma radiation on electrochemical corrosion behavior

Figure 2 shows electrochemical polarization curves for of silver-palladium alloy in 0.5M HCl before and after exposure to gamma radiation doses (10, 20 and 30 kGy). Fromthis Figure it is obvious that the corrosion potential of the used alloys exhibited a negative potential. Also, the cathodic and theanodic polarization curves showed similar corrosion trends.

TABLE 1 : x-ray diffraction analysis of silver-palladium alloy before and after exposure to gamma radiation

2θ	d Å	Int. %	hkl	FWHM
Base silver-palladium sample				
39.2462	2.29561	100.00	100	0.3542
45.4186	1.99696	39.98	200	0.3149
66.5586	1.40497	14.14	220	0.7872
80.1531	1.19746	9.07	311	0.8659
84.6265	1.14426	4.74	222	0.9600
After exposure to 10 kGy				
39.2947	2.29474	100.00	100	0.1181
45.5346	1.99214	30.39	200	0.2755
66.5616	1.40492	24.14	220	0.4330
80.0539	1.19869	11.12	311	0.8659
84.6527	1.14398	6.17	222	0.8640
After exposure to 20 kGy				
39.1968	2.29839	100.00	100	0.3739
45.3887	1.99820	34.95	200	0.2952
66.4423	1.40715	16.37	220	0.7085
80.8421	1.20134	10.26	311	0.6298
84.4963	1.14569	5.28	222	0.8640
After exposure to 30 kGy				
39.1959	2.29844	100.00	100	0.3739
45.5957	1.98961	34.48	200	0.3739
66.5842	1.40449	14.26	220	0.7872
80.0960	1.19817	9.52	311	0.8659
84.4204	1.14653	4.21	222	0.8640

TABLE 2 : Vickers hardness and (τ_m) of silver-palladium alloy before andafter exposure to gamma radiation

Samples	Hv kg/mm^2	µ kg/mm^2
Untreated	334.6	110.55
10 kGy	321.6	106.28
20 kGy	302.8	99.92
30 kGy	303	99.99

Full Paper

TABLE 3 : E_{Corr}, I_{Corr}, $Corr_{Rate}$and Tafel slopes (βc and βa) of silver-palladium alloy beforeand after exposure to gamma radiation

Samples	E_{Corr} (mV)	I_{Corr} x 10^{-5} (A/cm^2)	$Corr_{Rate}$ (mm/yr)	βa	βc
Untreated	-144.0	7.720	20.87	329.3	172.6
10 kGy	-58.90	25.80	37.59	440.2	436.9
20 kGy	-169.0	7.09	10.32	379.1	119.7
30 kGy	-123.0	3.10	4.52	212.5	172.5

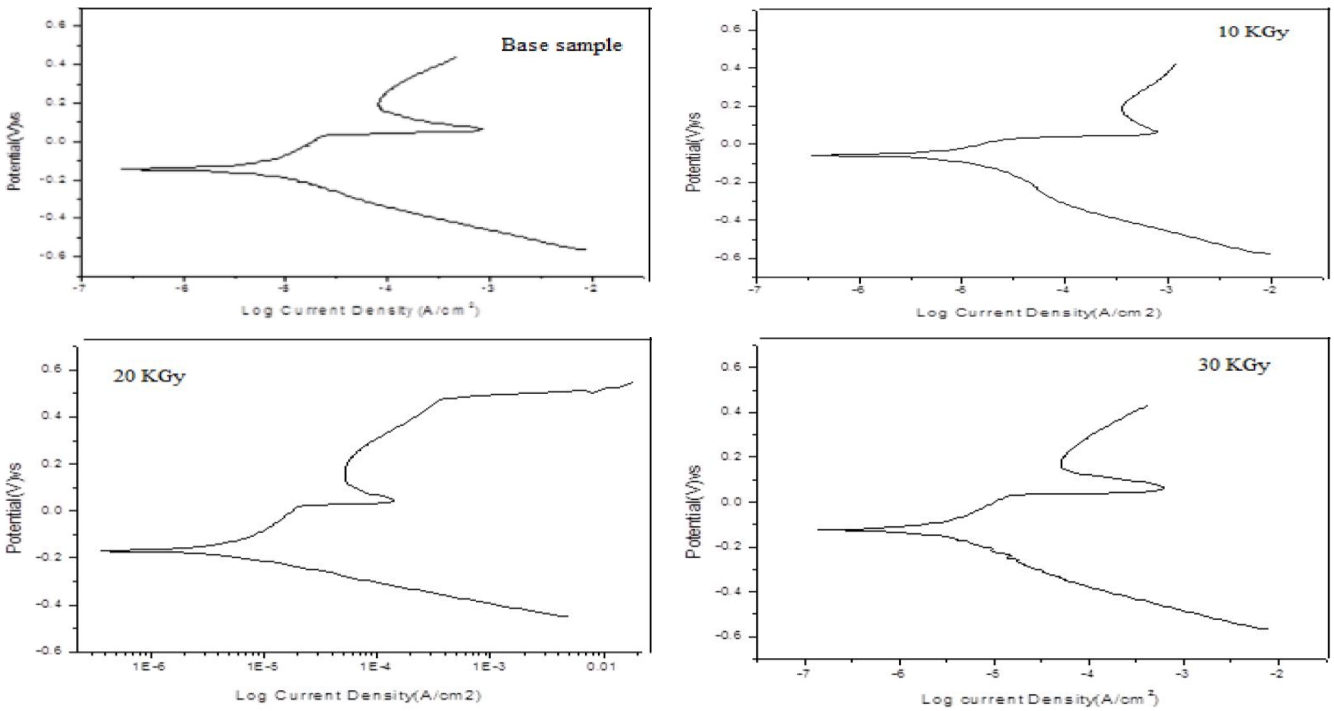

Figure 2 : Electrochemical polarization curves for of silver-palladium alloy in 0.5M HCl before and after exposure to gamma radiation

The corrosion potential (E_{Corr}), corrosion current (I_{Corr}), corrosion rate ($Corr_{Rate}$) and Tafel slopes (βc and βa) of silver-palladium alloy before and after exposure togamma radiation are listed in TABLE 3. Fromthese results, it is found that the corrosion rate and corrosion currentof silver-palladium alloy with 0.5MHCl decreased (except 10 KGy) after exposure to gamma radiation. That is because the interaction of gamma radiation with silver-palladium matrix alloy affected on atoms microsegregation and the reactivity of atoms with HCl solution.

CONCLUSION

1 Silver- palladium alloy consists of Ag. Pd face centered cubic phase. The shape of formed phases (intensity, broadness and position) changed after exposure to gamma radiation.

2 Vickers hardness and minimum shear stress of silver- palladium alloy decreased after exposure to gamma radiation.

3 Corrosion rate of silver-palladium alloy with 0.5M HCl decreased (except 10 KGy) after exposure to gamma radiation.

REFERENCES

[1] G.R.Craig, A.F.Peyton; Restorative Dental Materials, the C.V.Mosby, Saint Louis, 362 **(1975)**.

[2] G.N.B.Smith, P.S.Wright, D.Brown; the Clinical Handling ofDental Materials, IOP Publishing Limited Techno House RedcliffeWay, Bristol, **80**, 128 **(1986)**.

[3] J.N.Anderson; AppliedDentalMaterials, Blackwell Scientific Publications, Oxford, 104 **(1967)**.

[4] I.M.Roitt, T.Lehner; Immunology of Oral Diseases, Blackwell Scientific Publications, Oxford, 208

(1980).
[5] A.Ary´kan; J.Oral Rehabil, **19**, 343 **(1992)**.
[6] W.Wang, B.Jiang, X.Wu, J.J.Sun; Zhongguo Yi Xue Ke Xue Yuan Xue Bao, **32(3)**, 276 **(2010)**.
[7] H.Hubalkova, P.La Serna, I.Linetskiy, T.Dostalova; International Dental Journal, **56**, 135 **(2006)**.
[8] A.El-Bediwi, M.Saad, A.A.El-Fallal, S.El-Khaligy; Radiation Effects & Defects in Solids, **166(3)**, 233 **(2011)**.
[9] A.El-Bediwi, T.El-Helaly, M.Saad, A.El-Fallel; Materials Science (MSAIJ), **8(4)** **(2012)**.
[10] A.El-Bediwi, M.Saad, A.El-Fallel, **164(9)**, 578-583 **(2009)**.
[11] A.El-Bediwi, M.Saad, A.El-Fallel, MSAIJ, **9(10)**, 402-410 **(2013)**.
[12] S.Timoshenko, J.N.Goddier; "Theory of elasticity, 2nd Edition", McGraw-Hill, New York, 277 **(1951)**.