Correlation between the electrochemical behavior and mechanical properties of Ti-20Zr as a candidate for orthopedic material

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Keywords: Biomaterials, corrosion, electrochemical, orthopedic

ABSTRACT

A combination of titanium with zirconium was evaluated because it has been suggested as a candidate for human body implant material and was primarily developed in response to concerns of potential cytotoxicity and adverse tissue reactions caused by vanadium and aluminum in the actually used biomaterial Ti6Al4V.

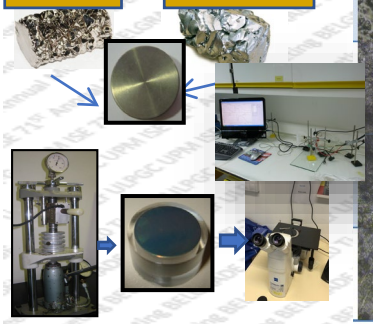
Metallography

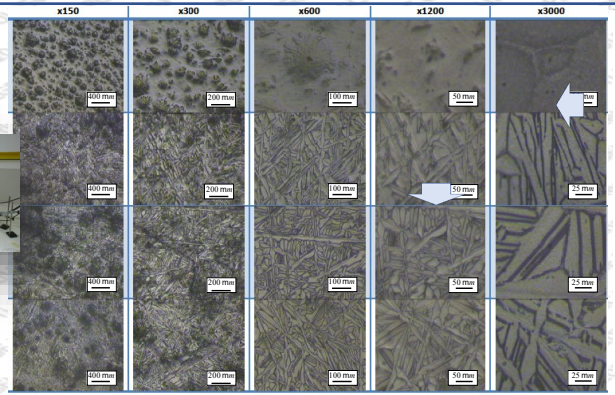
The Ti-20Zr alloy, composed of 80% Titanium and 20% Zirconium, (from R&D CS Bucharest, Romania – Research & Development Consulting and Services) was obtained by vacuum melting.
From metallographical images can be observed that the sample has an alpha-beta structure. The microhardness measurements concluded that the alloy formed a hard layer on its surface which greatly improves the wear resistance. The obtained tensile strength can be considered good in relation with other similar implant materials.

Materials and Methods

Titanio

Zirconium



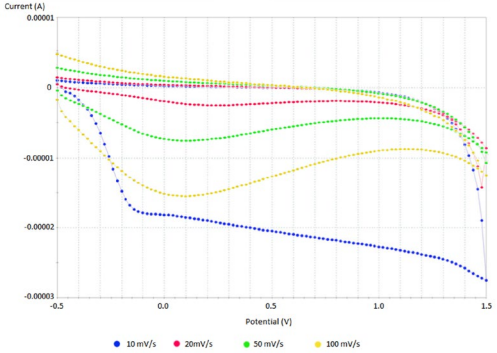


LOAD (gf)	AVERAGE HV	BRINELL HARDNESS	TENSILE STRENGTH (psi)	TENSILE STRENGTH (MPa)
50	234	234	81917	564
100	228	228	80062	552
200	239	239	83877	578

Microhardness

SOFT AND HARD PHASES - Ti-20Zr

LOAD (gf)	PHASE	HARDNESS (HV)	INDENTATION DEPTH (µm)
0.5	SOFT	37.3	0.712
	HARD	50.0	0.615
1	SOFT	66.2	0.756
	HARD	91.3	0.643
2	SOFT	101.5	0.863
	HARD	145.3	0.721
3	SOFT	127.7	0.942
	HARD	197.2	0.758
4	SOFT	149.8	1.000
	HARD	214.8	0.839
5	SOFT	163.7	1.075
	HARD	288.4	0.809
10	SOFT	194.6	1.394
	HARD	242.4	1.249
20	SOFT	201.9	1.935
	HARD	298.4	1.592
50	SOFT	212.8	2.981
	HARD	255.3	2.722
100	SOFT	201.3	4.335
	HARD	256.2	3.842
200	SOFT	210.5	5.990
	HARD	268.8	5.305



The impedance spectra were fitted with two time constants equivalent circuit and the fitting parameters indicate long-term stability of the passive layers in surgical implant conditions.

CONCLUSIONS

The hardness of Ti-20Zr alloy is 20% higher than that of commercially pure Ti, confirming the alloy's superior mechanical strength.
The results were confirmed by mechanical approach, in terms of two-layer model of the oxide film, consisting of a thin barrier type inner layer and a porous outer layer. The pronounced porous outer layer is expected to facilitate the incorporation of mineral ions and to improve the resistance to electrochemical corrosion over the potential of relevance for human body conditions.