Triboelectrochemical study of various Nb-Ti-Zr alloys in simulated body environment

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The β phase Ti alloys are under intensive research focus due to their tunable young modulus, excellent tribocorrosion resistance and biocompatibility[1]. Pure Ti has a hexagonal structure (α) and possess a young modulus 4 to 5 times higher than a human bone (20 - 30 MPa). Several elements i.e. Nb, Mo and V can be used to stabilize the β phase of Ti[2]. However, in addition to the β phase, a critical ω phase can also form during quenching which strongly affects the mechanical properties. It is reported that addition of Zr (5-10 wt.%) can significantly discourage the formation of ω phase[3]. Therefore, in this work ternary NbTiZr alloys containing the Nb wt.% (7, 12, 17, 22, 27 and 45) were produce, while the amount of Zr was kept only 5 wt.% in each.

The NbTiZr alloys were prepared by vacuum arc melting and subsequently heat treated at 1000 ^{o}C in a Bridgman furnace for 12 h. The composition of each alloy was examined with Energy dispersive X-ray analysis. To analyze the crystal structure of alloys, X-ray diffraction was undertaken and the suppression of ω phase was clearly observed following the Nb content higher than 22 wt.% in Ti5Zr. All samples were mirror polished and electrochemically tested by mean of open circuit potential, electrochemical impedance spectroscopy and linear sweep voltammetry. To study the semiconducting behavior of the passive oxide, the alloys were anodized via cyclic voltammetry up to 7 V with an incremental step of 1 V. The oxide growth factor, capacitance, permittivity coefficient (ε_r) were evaluated for oxide films grown on various alloys. Finally with the help of Mott Schottky plots the defect concentration in each oxide was determined.

Moreover, it is equally important for an implant material to be tested under tribocorrosion conditions. For this purpose the samples were tested with the techniques namely electrochemical noise method and chronoamperometry under sliding conditions. During the triboexperiments the coefficient of friction (COF) was also recorded. A rise of COF value from (0.1 ± 0.02 to 0.2 ± 0.04) was noted with the increase in Nb content from 7 to 45 wt.%. The microscopic images and wear track profiles were assessed by mean of the light microscope and the profilometer respectively. It was revealed that the wear track volume gets significantly smaller as the Nb content increases. Based on these investigations, it can be concluded that, the ternary TiNbZr alloys containing a percentage of 22 wt.% Nb (or more) and 5 wt.% Zr showed excellent tribocorrosion properties, thus may be considered as potential candidate for further biomedical investigation.

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