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Identifying Ti-Cu-based alloys for biomedical applications

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Abstract

Titanium alloys are widely-used in biomedicine for dental and orthopedic prosthesis implants, because of their good mechanical strength, biocompatibility and corrosion resistance. This work identified and made Ti-based alloys with similar phase proportions as Ti-6Al-4V, using Thermo-Calc. Beta-stabilisers are preferred as substitutional elements for Al and V since they give the good mechanical strength, biocompatible and corrosion resistance. For antibacterial properties, copper additions were made. Initially, calculations were done on phase proportions of chosen compositions, so that the two-phase proportions of Ti-6Al-4V were mimicked and different Cu additions were also calculated to determine how much Ti_2Cu would be formed.

Compositions with good phase proportions were selected for further work: Ti-6Ta-1.5Zr, Ti-6Ta-1.5Zr-0.2Ru, Ti-6Ta-1.5Zr-5Cu and Ti-6Ta-1.5Zr-0.2Ru-5Cu. Chemical analysis was done using SEM-EDX before etching; micrographs were obtained after etching with Kroll's reagent. X-ray diffraction, corrosion tests and hardness measurements were done on unetched samples. Microstructural and EDX analyses showed that Ti-6Ta-1.5Zr and Ti-6Ta-1.5Zr-0.2Ru alloys were two-phase. The Cu-containing alloys: Ti-6Ta-1.5Zr-5Cu and Ti-6Ta-1.5Zr-0.2Ru-5Cu had plate-like acicular α' martensite and retained β phase, with Ti_2Cu. The Ti-6Ta-1.5Zr alloy with coarse laths had low hardness, while Ti-6Ta-1.5Zr-0.2Ru and Ti-6Ta-1.5Zr-5Cu with fine laths had higher hardnesses, and Ti-6Ta-1.5Zr-0.2Ru-5Cu with plate-like phases had the highest hardness. In corrosion tests, the OCP vs time scans showed increasing passivation, while the potentiodynamic scans showed typical active-passive behaviour, shifting to the passive region, agreeing with OCP profiles. The OCP values did not reach stable potentials in a reasonable time, attributed to the α' metastable phase. The corrosion current densities of the alloys were similar. Corrosion rates were low and those of the Cu-containing alloys were similar to Ti-6Al-4V. The best alloys were Ti-6Ta-1.5Zr-5Cu and Ti-6Ta-1.5Zr-0.2Ru-5Cu, with the target phases α, β and Ti_2Cu and hardnesses comparable to reported Ti-6Al-4V and Ti-Cu alloys.