Evolution of a Novel Ta-Nb-Ti Multi-Component Alloy for Potential Biomedical Applications

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The modern material class of equiatomic multi-component alloys, especially high-entropy alloys (HEAs) gained tremendous attention in the scientific community over recent years. This can be attributed to two main reasons: Firstly, the new concept of combining several elements (at least 5 principal elements with concentrations between 5 and 35 at. % [1]) in contrast to conventional alloys, mostly containing only two or three elements in addition to the main alloy constituent. This results in a broad variety of possible combinations thus leading to completely novel materials. Secondly, recently developed refractory metal based high-entropy alloys (RHEAs) have shown properties that are superior to the ones of current state-of-the-art alloys, which are based on several unique thermodynamic effects [2–5]. However, besides the outstanding mechanical properties, abrasion resistance and thermal resistance, a vast variety of chemical elements used in RHEAs also belong to the category of biocompatible elements, hence leading to potentially new biomedical materials. In consideration of this background and due to the excellent biocompatibility of the constituents [6], an equiatomic composition of Ta, Nb and Ti as multi-component base alloy was chosen for investigations. The alloy examined was produced using an arc melting furnace under Ar atmosphere, metallographically prepared and investigated respectively. Scanning electron microscopy (SEM) analysis revealed the presence of a dendritic microstructure, with an enrichment of high-melting elements in the dendrites, as well as Ti in the interdendritic regions (verified by means of EDS mappings). Microstructure analysis by means of X-ray diffraction (XRD) showed, that there are two types of body-centered cubic (bcc) crystal structures (Im-3m I: a = 3.287 Å; Im-3m: a = 3.291 Å) present in the as-cast state. To get a better understanding of the microstructure evolution, heat-treatment experiments regarding different temperatures and times were performed. Moreover, the biocompatibility of the novel alloy Ta-Nb-Ti was evaluated by means of cell (f.e. osteoblasts) attachment, as well as monocyte inflammatory response analysis and compared to samples of elemental Ta, Nb, alloy Co-28Cr-6Mo and alloy Ti-6Al-4V. First results indicate competitive osteoblast attachment, as well as comparable expressions of fibrosis markers in comparison to the conventionally used

biomedical materials. In addition, the Ta-Nb-Ti alloy showed reduced inflammatory capacity, indicating a high potential for use as prospective biomedical material.

References

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