Study and Development of Ti-alloy for Biomedical Applications

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Abstract

Nb, Ta and Zr are the favorable non-toxic alloying elements for titanium alloys for biomedical applications. Low rigidity titanium alloys composed of non-toxic elements are getting much attention. The advantage of low rigidity titanium alloy for the healing of bone fracture and the remodeling of bone is successfully proved by fracture model made in tibia of rabbit. Ni-free super elastic and shape memory titanium alloys for biomedical applications are energetically developed.

Keywords

Titanium alloy; Low rigidity; Super elastic; Shape memory alloy

Introduction

The number of the aged people demanding replacing failed tissue with artificial instruments made of biomaterials is increasing. In particular, the amount of usage of instruments for replacing failed hard tissues such as artificial hip joints, dental implants, etc. is increasing among the aged people. Metallic biomaterials are the most suitable for replacing failed hard tissue up to now. Main metallic biomaterials are stainless steels, Co based alloys, titanium and its alloys. Recently, titanium alloys are getting much attention for biomaterials because they have excellent specific strength and corrosion resistance, no allergic problems and the best biocompatibility among metallic biomaterials.

However, these are basically developed as structural materials mainly for aerospace structures. Therefore, the development of titanium alloys targeted for biomedical applications are highly required. Then the research and development on titanium alloys composed of non-toxic elements were started, and are under development with the increasing continuing in common [1–3]. The titanium alloys composed of non-toxic elements that have been developed in the early stage are mainly α+β type ones. Recently, mechanical biocompatibility of biomaterials is regarded as important factor, and therefore the research and development of β types titanium alloys, which are advantageous from that point, are increasing [1,4,5].

In the aged society, demand for healthcare goods such as wheel chairs, artificial limbs and legs, etc. are also increasing [6,7]. Titanium alloys are also getting much attention in the field of healthcare goods, and the research and development of low cost titanium alloys for healthcare goods [6] are recently started.

Hence the new developments in titanium alloys for biomedical and healthcare goods as stated above are appearing, the selected topics of research and development in titanium alloys for biomedical and healthcare goods including the examples stated above will be described in this paper.

Literature Review

Research and development of titanium alloys for biomedical applications from the beginning were started fairly recently. In that case, the elements, which are judged to be non-toxic and non-allergic through the reported data of cell viability for pure metals [8], polarization

resistance (corrosion resistance) and tissue compatibility of pure metals and representative metallic biomaterials [9], and allergic properties of pure metals [10], are selected as alloying elements for titanium. As a result, Nb, Ta and Zr are selected as the safest alloying elements to titanium. In addition to these elements, Mo and Sn are selected as safer elements for living body. Main metallic biomaterials are stainless steels, Co–Cr system alloys and titanium alloys as stated above.

Shape Memory Alloy for Orthopaedic Applications

Only Ti–Ni has been put into wide practical use as super elastic and shape memory alloy. Formerly, shape memory alloy, Ti–Ni, was tried to apply to implants [11]. However, since Ti–Ni contains a large amount of Ni, which causes allergy at high ratethe usage of Ti–Ni shape memory alloys is restricted. However, Ti–Ni is recently getting much attention for applying to stents or catheters where super elastic characteristics or shape memory effect is very advantageous. However, the risk of metallic allergy is still high in Ti–Ni because Ni content is very high.

Therefore, the research and development of Ni-free super elastic and shape memory titanium alloys composed of non-toxic elements for biomedical applications are increasing.

Conclusion

Titanium and its alloys are well known to have been used for wheel chairs for sports, which are basketball wheel chairs, racing wheel chairs, etc. On the other hand, the usage of titanium and its alloys for general wheel chairs is limited because of the cost. However, the usage of titanium and its alloys are expected to expand because of excellent biocompatibility and sensitivity such as touch feeling.

Although the materials for healthcare are not used in the living body, biocompatibility such as allergic problems, etc. should be considered because the aged people whose immune abilities are in general lowered, are considered to have a lot of chances to use them.

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