

Preparation and Evaluation of Carbonated Titanium-Diboride Titanium Composite Materials

Using Spark Plasma Sintering Method, and Its Application to Biomaterials

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ABSTRACT

The medical devices, such as artificial joints used in joint surgery and dental implants used as a treatment for missing teeth, implanted in the body have strict requirements for their mechanical properties and biocompatibility. Currently, titanium and titanium alloys are widely used as medical components and implant materials due to their high corrosion resistance, light weight, and high strength. They also have unique properties, such as Osseointegration where bones tissues directly adhere to the implant, observed at the optical microscopy level, and excellent biocompatibility. However, there is a need for further improvement due to issues such as wear particle generation and accompanying inflammatory reactions. Recently, titanium carbide-tungsten carbide (TiC-TiB₂) composite materials have gained attention due to their excellent properties such as high hardness, low density, high corrosion resistance, and superior thermal shock resistance and stability at high temperatures. Previous studies have also investigated the biocompatibility of TiB₂ and TiC as reinforcing materials to improve the mechanical properties of titanium and showed favorable cell growth rates and biocompatibility. However, the mechanical properties greatly depend on the substrate material and there is a possibility of having excessive properties. Also, TiC and TiB₂ are difficult to sinter, making fabrication and processing difficult. Therefore, their use is limited and there has been no medical application yet. In this study, a discharge plasma sintering method, which can sinter difficult-to-sinter materials at relatively low temperatures and short time, was used to fabricate materials with various composition ratios and sintering conditions. The aim was to apply the TiC-TiB₂ composite material as a biocompatible material.

As a result, the sintered body of the TiC-TiB₂ composite material obtained by discharge plasma sintering did not undergo any dissolution or precipitation during the sintering process, and no solid-state reaction occurred at sintering temperatures from 1800°C to 2000°C with a TiB₂ mole ratio of 25% to 75%. Furthermore, the sintered body was confirmed to be composed of two phases, a dense gray phase of TiB₂ and a thin gray phase of TiC, and it was suggested that the size of each crystal grain increases as the ratio of TiB₂ increases and that the growth of TiB₂ can be controlled by changes in composition.

With regards to biocompatibility, cell proliferation and cell adhesion were confirmed to have comparable properties to titanium, and it was confirmed that biocompatibility was not inferior to titanium.