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## Research paper

# Mechanical and biodegradable properties of porous titanium filled with poly-L-lactic acid by modified in situ polymerization technique

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## ABSTRACT

Porous titanium (pTi) can possess a low Young's modulus equal to that of human bone, depending on its porosity. However, the mechanical strength of pTi deteriorates greatly with increasing porosity. On the other hand, certain medical polymers exhibit biofunctionalities, which are not possessed intrinsically by metallic materials. Therefore, a biodegradable medical polymer, poly-L-lactic acid (PLLA), was used to fill in the pTi pores using a modified in-situ polymerization technique. The mechanical and biodegradable properties of pTi filled with PLLA (pTi/PLLA) as fabricated by this technique and the effects of the PLLA filling were evaluated in this study.

The pTi pores are almost completely filled with PLLA by the developed process (i.e., technique). The tensile strength and tensile Young's modulus of pTi barely changes with the PLLA filling. However, the PLLA filling improves the compressive 0.2% proof stress of pTi having any porosity and increases the compressive Young's modulus of pTi having relatively high porosity. This difference between the tensile and compressive properties of pTi/PLLA is considered to be caused by the differing resistances of PLLA in the pores to tensile and compressive deformations. The PLLA filled into the pTi pores degrades during immersion in Hanks' solution at 310 K. The weight loss due to PLLA degradation increases with increasing immersion time. However, the rate of weight loss of pTi/PLLA during immersion decreases with increasing immersion time. Hydroxyapatite formation is observed on the surface of pTi/PLLA after immersion for  $\geq 8$  weeks. The decrease in the weight-loss rate may be caused by weight gain due to hydroxyapatite formation and/or the decrease in contact area with Hanks' solution caused by its formation on the surface of pTi/PLLA.

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## 1. Introduction

For biomedical titanium alloys, a low Young's modulus similar to that of cortical bones (10–30 GPa) is an important

property to prevent the stress shielding effect (Niinomi, 2008). Therefore, lowering the Young's modulus of titanium alloys was investigated; new  $\beta$ -type alloys with a bcc lattice and possessing Young's moduli of around 40–60 GPa have been developed in the past two decades (e.g., Ahmed et al., 1996;

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