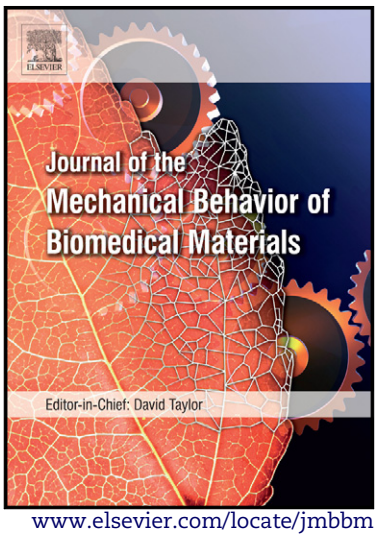


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# A 3-D constitutive model for pressure-dependent phase transformation of porous shape memory alloys

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**Abstract**

Porous shape memory alloys (SMAs) exhibit the interesting characteristics of porous metals together with shape memory effect and pseudo-elasticity of SMAs that make them appropriate for biomedical applications. In this paper, a 3-D phenomenological constitutive model for the pseudo-elastic behavior and shape memory effect of porous SMAs is developed within the framework of irreversible thermodynamics. Comparing to micromechanical and computational models, the proposed model is computationally cost effective and predicts the behavior of porous SMAs under proportional and non-proportional multiaxial loadings. Considering the pressure dependency of phase transformation in porous SMAs, proper internal variables, free energy and limit functions are introduced. With the aim of numerical implementation, time discretization and solution algorithm for the proposed model are also presented. Due to lack of enough experimental data on multiaxial loadings of porous SMAs, we employ a computational simulation method (CSM) together with available experimental data to validate the proposed constitutive model. The method is based on a 3-D finite element model of a representative volume element (RVE) with random pores pattern. Good agreement between the numerical predictions of the model and CSM results is observed for elastic and phase transformation behaviors in various thermomechanical loadings.

*Keywords:* Shape memory alloys, Porous materials, Pressure dependency, Phase transformation, Multiaxial loading



## 1. Introduction

The research on the behavior of smart materials has been rapidly increasing thanks to their innovative applications. Among different types of smart materials, shape memory alloys (SMAs) have two unique features known as pseudo-elasticity and shape memory effect observed both in dense and porous SMAs. NiTi which is the most widely used SMA, exhibits good corrosion resistance and biocompatibility. Therefore, it can be utilized in several applications, e.g., as actuators in different mechanisms and as stents, implants and

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