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Characterization of a Smart Nitinol/Silicone Rubber Composite for using in Soft Tissue Replacements

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Abstract

A smart NiTi/Silicone rubber composite can imitate the intelligent behavior of a soft tissue with Compounding shape memory effect of NiTi strips with viscoelasticity behavior of the polymer. In the present investigation NiTi strips were embedded in a flexible HTV silicone host and then studied for composite applications. The interfacial adhesion force between the metallic constituent and the polymeric matrix was measured by pulling-out test. The results show that the samples including two-way shape memory metal had the more bonding forces comparing the one-way shape memory ones. The SEM observations and electrical resistivity (ER) measurements indicated that the curing treatment changes the transition points and the microstructure of the strips. These changes affect the shape memory behavior of the NiTi strips embedded within the composite segments.

Keywords: NiTi/Silicone composite; Medical applications; Curing treatment; Smart material

1. Introduction

Three decades has past of the NiTi shape memory alloy (SMA) industrial/scientific attraction as a smart functional material [1]. Exhibition of shape memory behavior (SME) [2], superelastic (SE) effect [3], corrosion resistance [4] and biocompatibility [5] attract many medical applications [6-11]. Using NiTi alloys in thermal actuators is one of their important applications [9]. The actuators have industrial [12] and also medical [10] uses. In order to manufacturing smart and flexible composites, SMAs actuators are sometimes embedded into a different polymeric Matrix.

Compounding SME of NiTi strips with viscoelasticity behavior of well known biocompatibility of silicone can lead to invention of a smart composite usable for artificial muscles manufacturing [13]. In this application performing two-way SME (TWSME) in the metal strips is necessary. The effect is occurred by different thermomechanical treatments [12-16]. For example, Gyobu and et al. [16] presented that TWSME occurred by constrained ageing. The recent technique was used for inducing the effect.

Most of TWSME induced medical devices that are topics of a lot of articles are functioning in bending [15], so the load sheme that was chosen in this present research was bending. Alloy compositions and the conditions of heat treatment are the key factors influence the property [12].

In the present work, a constrained aged NiTi strip after flat annealing under stress-free condition and an annealed one order to verify the SME of the sample for using in medical implants were investigated before embedding in a silicone matrix. The effect of the compression molding technique used for molding heat vulcanizing silicone composite segments on transformation temperatures also was investigated.

Recently many literatures were published about some parameters affect the functionality of NiTi-polymer smart composites specially adhesion strength in the interface [17-23], but a few about the effect of curing treatment on shape memory properties of the SMA compound [13,24]. Therefore, SME of the samples was studied after the curing treatment.