Material Modeling of Polylactide

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Abstract: Computational modeling of stents can provide insight into critical locations (high stress/strain regions), help with design iterations/optimization, and reduce the need for bench-top testing. This study focuses on the developmental efforts to create a material model that can capture the mechanical response of poly-L-lactide (PLLA), the backbone of Abbott Vascular's ABSORB Bioresorbable Vascular Scaffold (BVS). PLLA is an anisotropic, viscoplastic material. Its material behavior maybe affected by temperature, environment, and processing; thereby, introducing substantial challenges in modeling its response. A new test protocol was developed for performing material characterization experiments that can capture the anisotropic material response using a dog-bone shaped specimen. The Parallel Network (PN) model from Veryst Engineering is an advanced modular constitutive model framework. The PN model allows for specific anisotropic and isotropic hyperelastic and viscoplastic components to be combined to capture the experimentally observed response of PLLA. The material model (PN model) was calibrated to experimental data from the dog-bone material testing. A validation experiment (single ring tensile test) was performed and the fidelity of the computational model was tested by comparing its predictions to the single ring tensile test data.

Keywords: Stent, Anisotropy, Viscoelasticity, Viscoplasticity, Polylactide, Constitutive model, Parallel network model, Dog-bone material testing, Calibration, Validation.

1. Introduction

The role of computational modeling in medical devices is becoming increasingly important since it can provide insight into critical locations of the device (high stress/strain regions), help with design iterations/optimization, and reduce the need for bench-top testing; thereby, reducing the cycle time during the development of the device. Modeling of medical devices poses substantial challenges in terms of accurately capturing the material behavior under relevant processing and/or physiological conditions, and modeling of the *in vivo* loading/boundary conditions. Developing a validated computational model in this context is critical to achieving robust model predictions.

This paper focuses on the developmental efforts to create a material model that can capture the mechanical response of poly-L-lactide (PLLA), the backbone of Abbott Vascular's (Santa Clara, CA) ABSORB bioresorbable vascular scaffold (BVS). Polylactide polymers have a long history of use in the medical device industry starting with bioresorbable sutures in 1960s (Amass, 1998). PLLA is a biodegradable, semi-crystalline thermoplastic that is being increasing used in medical devices due to its biodegradability, processability, and biocompatibility (Amass, 1998; Ikada, 1999). PLLA is an anisotropic (processing-dependant), viscoplastic material and its material behavior maybe affected by temperature, environment, and processing (Grabow, 2005; Engelberg,

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