

A Study on the Dynamic Mechanical Properties of Silk Fibre Composites

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First page example

A Study on the Dynamic Mechanical Properties of Silk Fibre Composites

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Abstract. Silk fibre has been popularly used for bio-medical engineering and surgically-operational applications because of its biocompatible and bio-resorbable properties for centuries. Using silk fibre as reinforcement for some bio-polymers to enhance the stiffness of scaffolding and bone implant plates has been developed. However, its dynamic mechanical properties with the biodegradable properties have not yet well understood. In this paper, the dynamic mechanical and thermal properties of degraded and non-degraded silk fibre reinforced Poly(lactic acid) (PLA) composites are discussed.

Introduction

The behavior of viscoelastic material including polymer during the deformation and flow is mainly dependent on temperature as well as time (frequency). This phenomenon is because of the molecular rearrangement of the polymer in order to minimize the localized stresses [1]. Moreover, the molecules of a polymer store a portion of the applied energy elastically and dissipate the rest of it in other dissipative processes (such as damage, heat, sound waves, vibration etc.) under cyclic loading. Therefore, processing the investigation according to the temperatures and the time period is necessary to obtain the description of the material behavior under the loading. The characteristic parameter that reflects such visco-elasticity of a polymer is the tan delta (δ) [2]. Dynamic mechanical analysis (DMA) is a technique in which an oscillating force is applied to a sample to measure its material's deformation response conveniently as a function of temperature, frequency, or time. DMA provides material properties including storage modulus (E'), loss modulus (E''), tan delta ($\tan\delta$) and relaxation processes of polymers, especially the glass transition (T_g). The storage modulus characterizes the elastic behavior of the material, and the loss modulus characterized the viscous behavior. The ratio of energy dissipated to energy stored is the tangent of the phase angle called tan delta. Compared to DSC, weak glass transitions can be easier and more precise determined by DMA due to its approximately one decade higher sensitivity to glass transitions [3].

Material Preparation and Experiments

Biodegradable polymer-PLA as a matrix under investigation in the current study is a neat grade commercialized by Cargill-Dow under the brand name NatureWorks PLA Polymer. Silk fibre with the average fibre diameter of 100 μm was supplied by Ocean Verve Ltd., Hong Kong. The inherent body structure of silkworm is composed of two cores of fibroin which exists in a paired of organ. As mentioned in a previous literature, this layer would affect the bonding between the fibre and polymer-based matrix, and thus worsen the mechanical properties of silk fibre composites [4]. All samples were made by using Hakke MiniLab twin-screw micro-extruder. Before mixing the fibre with PLA, degummed fibre were chopped into 5 mm in length in order to avoid coiling with the