Article

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Dynamic mechanical analysis of nylon 6 fiber-reinforced acrylonitrile butadiene rubber composites

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Abstract

Dynamic mechanical properties of polymeric materials are of direct relevance to a range of unique polymer applications. The aim of the study is to investigate the dynamic mechanical properties of composites of short nylon 6 fiber with acrylonitrile butadiene rubber (NBR). The storage modulus (G′), loss modulus (G″), and the damping factor (tan δ) have been analyzed with reference to the effects of fiber loading, curing systems, and bonding agents over a range of temperature and at varying frequencies. The storage modulus increases with increment in fiber loading, whereas loss modulus and damping factor decrease. The glass transition temperature shifts to higher temperature upon increment in fiber loading. Dicumyl peroxide (DCP)–cured composites show higher storage modulus and lower damping than the corresponding sulfur-cured one. The addition of hexa-resorcinol and phthalic anhydride as bonding agents enhances the dynamic mechanical properties of the composites. The experimental results have been evaluated by comparing with Einstein, Guth, and Nielsen models.

Keywords

Nylon 6, acrylonitrile butadiene rubber, composites, dynamical mechanical analysis, storage modulus, loss modulus, damping

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Introduction

Rubbers show both elastic and damping behavior because of their visco-elastic nature. When they are deformed by a sinusoidal stress, the resulting strain will also be sinusoidal but will be out of phase with the applied stress. Dynamic losses are usually associated with specific mechanisms of molecular or structural motion in polymeric materials. The damping in the system can be measured from the tangent of the phase angle or loss tangent (tan δ) which is defined as $\tan\delta = G''/G'$ where G′ is the storage modulus due to stored elastic energy in the materials and G″ is the loss modulus due to viscous dissipation. The method that has been used to investigate the storage modulus, loss modulus, and loss tangent is dynamical mechanical analysis (DMA).

In DMA, the response of a given material to an oscillatory deformation is measured as a function of temperature. This technique has widely been employed for investigating the visco-elastic behavior, stiffness (modulus), damping (energy dissipation) characteristics, phase transitions, and the interfacial adhesion of polymer composites as they are deformed under periodic stresses.[1–2] It is particularly useful because of its non-destructive nature unlike other static mechanical testing methods.

Polymers at the transition region from glassy to rubbery state have great potential for vibration damping. The intensity and breadth of the damping factor (tan δ) peak and the value of the loss modulus generally determine the damping capacity of a polymer at that particular temperature. For fiber-reinforced polymer composites, the dynamic mechanical properties depend on the type of fiber, length of the fiber, orientation of fiber, fiber loading (phr), fiber dispersion in matrix, and interaction between fiber and matrix.[3–4]

Several researchers have studied the dynamic mechanical properties of rubber composites. Malas et al. studied the reinforcing effect of expanded graphite (EG) and modified EG (MEG) with and without carbon black (CB) on the properties of emulsion polymerized styrene butadiene rubber (SBR) vulcanizates.[5] Flaifel et al. carried out the thermal conductivity and

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