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ORIGINAL PAPER

Dynamic mechanical characterization of PC/MWCNT composites under variable temperature conditions

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Abstract A dynamic mechanical analysis has been performed on composite materials of polycarbonates (PC) and multi-walled carbon nanotubes (MWCNT) for evaluation of their mechanical hardness and storage modulus under the combined effects of variable loading frequencies and temperature conditions. The PC-based engineering machine components that are subjected to variable external loads and temperature conditions are not durable owing to the viscoelastic properties of PC. Composites of PC with MWCNT (2, 5 and 10 wt%) were fabricated and their mechanical characterization tests revealed that with increase in MWCNT composition both storage modulus and hardness enhanced significantly in comparison to pure PC. For 10 wt% PC/MWCNT composite, the average storage modulus increased in the range of 40–92%, while the average hardness was enhanced in a range of 88–121% for the combined effect of temperature range of 30–90 °C and loading frequency range of 30–230 Hz. With increase in temperature, the maxima of storage moduli and hardness for these composites shifted toward higher loading frequencies, indicating that these composites can be used for wider loading frequency range. Therefore, the experimental results of this paper have shown that the mechanical properties of PC-based composite materials with minor MWCNT compositions are enhanced significantly and hence can be used for automotive and aerospace engine parts where loading frequencies are high and temperature conditions are variable.

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Keywords Dynamic mechanical analysis · Polycarbonate · Carbon nanotubes · Modulus · Temperature

Introduction

Composites comprising various quantities of MWCNT are being widely fabricated with various polymer-based matrix materials to generate enhanced desirable mechanical properties [1–3]. MWCNT possesses high thermal conductivity of nearly 3000 W/mK and large Young's modulus of nearly 1 TPa [4]. Due to their hollow structure and lower weight, even minor compositions of MWCNT are able to impart sufficient mechanical strength to the composite material.

Polymer-based MWCNT composites have gained much attention over the past decade [2, 5, 6]. To evaluate their mechanical properties, various types of characterization techniques are used. Due to their scope for a wide variety of applications, it becomes imperative to study the composite material behavior under static and oscillating loads under variable temperature conditions.

Dynamic mechanical analyzer (DMA) is one such instrument which is often used to evaluate the storage modulus of the composite under variable frequency of load and variable temperature conditions. Sun et al. [7] used DMA to investigate the tensile mechanical properties of epoxy/single-walled carbon nanotube (SWCNT) composites. It has been reported that composites comprising 1.0 wt% pristine SWCNT in epoxy enhanced the Young's modulus by about 18%, while functionalized SWCNT enhanced the modulus by nearly 25%. Sun et al. have suggested that improved dispersion and prevention of curling of SWCNT can lead to much enhanced mechanical properties of these composites. Zhou et al. [8] used composites of carbon nanofibers (CNF) and epoxy as base material for mechanical characterization