VISCOELASTIC RESPONSE OF CARBON NANOTUBE-REINFORCED POLYMERS

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Recent experimental results presented in the literature demonstrate that in some instances substantial improvements in the mechanical behavior of reinforced polymers can be attained through the addition of very small amounts of carbon nanotubes as a reinforcing phase. While this suggests the possibility of new, extremely lightweight carbon nanotube-reinforced polymers (CNRPs) with mechanical properties comparable to those of traditional carbon-fiber composites, a much greater understanding of the interaction between the nanotube inclusions and the polymer must first be developed before such novel materials can be fully utilized.

One of the areas where such an understanding will be critical is in predicting the viscoelastic behavior of CNRPs. Specifically, some experimental results suggest that the presence of nanotubes can change the glass transition temperature (T_g) of the reinforced polymer by as much as 25 C (from 63 to 88 C) [1]. Because there is significantly more surface area per unit volume fraction of inclusion in the case of CNRPs (in comparison to traditional carbon fiber composites), the presence of nanotube reinforcement may drastically impact the viscoelastic response by influencing molecular mobility on the atomic scale. This is significant because the nanotube dimensions are on the order of magnitude of the individual polymer chains, possibly making it necessary in some cases to explicitly account for the molecular interaction between the two phases, an area that would lend itself quite well to the field of computational mechanics. It is anticipated that the nanotube reinforcement will also impact other aspects of viscoelastic behavior (e.g. physical aging and effective equilibrium), although to date experimental tests in these areas have been limited.

To study the impact of nanotube-polymer interaction on the viscoelastic behavior of CNRPs, we will present results of in-house creep testing of both blank and reinforced polymer materials. These experimental results will then be used to identify those aspects of current viscoelastic models that will need to be adapted for use with CNRPs. Preliminary modeling of these results, including both analytical methods and finite element unit cell approaches, will also be presented. The potential of molecular dynamics techniques to clarify impact of nanotube dispersions on inherent polymer properties will be highlighted, and further implications for appropriate computational methods that incorporate nanotube-polymer interactions will be discussed.

References

[1] Gong, X., J. Liu, S. Baskaran, R. Voise, and J. Young, Surfactant-assisted processing of carbon nanotube/polymer composites, *Chemistry of Materials*, v. 12, p. 1049-1052, 2000.