Analytical Formulation of Stress Distribution in Cellulose Nanocomposites

Momeni, K.; Yassar, R.S.

Abstract

Cellulose nanofibers are known to possess aspect ratios larger than 200 and mechanical properties comparable to carbon nanotubes. Combined with other significant properties including low cost, low density, and biocompatibility, cellulose nanofibers are an attractive reinforcement material for nanocomposites. The load transfer between embedded fibers and matrix play a major role in designing nanocomposites with ultimate mechanical properties. In this work, we studied a general case where a simple axial loading exists along the axis of a cellulose fiber embedded in a polymer matrix. Then analytical relation between the applied load, the longitudinal stress along the fiber, and shear stresses along the interface of fiber and matrix was derived. It is shown that the maximum longitudinal stress occurs at the middle of the fiber, while maximum shear stress occurs at the extreme ends. Also, it is shown that the shear stress along the cellulose fibers can be approximated as a linear function of applied load. The derived relationships are useful for design of cellulose-based nanocomposites with enhanced mechanical properties.

Keywords: Analytical Modeling; Nano-structures; Stress Transfer; Cellulose