Mechanics of polymer-clay nanocomposites

The mechanics of nanocomposites is critical in the design of nanomaterials with desirable properties. In this paper, the mechanics of polymer-clay nanocomposites is studied using a designed polymer and solution nanocomposite synthesis. A copolymer latex, with function groups that strongly interact with the surface of the clay nanoplatelet and glass-transition temperature lower than room temperature, was synthesized. Uniformly dispersed nanocomposites were then generated using water as the intercalation agent through the solution process. The chain mobility in the nanocomposites is greatly reduced as studied by dynamic mechanical thermal analysis (DMTA) and dielectric thermal analysis (DETA). The modulus of the composite increases significantly. The modulus enhancement strongly relates to the volume of the added clay as well as the volume of the constrained polymer. This modulus enhancement follows a power law with the content of the clay and is modeled well by Mooney's equation for this soft-polymer-based nanocomposite. Modeling suggests that the nanocomposite modulus enhancement is determined by the high aspect ratio of the intercalated clay and the strong interfacial strength, in the form of the Einstein coefficient, K, when the modulus of the matrix phase is much lower than that of the clay, i.e., E-f/E-m > 100. This study also indicates that the structure of clay nanocomposites with strong interfacial interactions is analogous to that of semicrystalline polymers. In the case of polymer-clay nanocomposites, the intercalated clay phase serves as an unmeltable crystalline phase that results in improvement in mechanical and thermal properties.