A Molecular Mechanism for Toughening and Strengthening Waterborne Nanocomposites

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An effective, yet simple, method for creating nanocomposite coatings, fibres, and adhesives is to blend an aqueous suspension of carbon nanotubes (CNTs) with either a polymer solution or waterborne colloidal polymer particles (*i.e.* latex). In processing these *waterborne* nanocomposites, there is a wide choice of water-soluble polymers to disperse CNTs in water. Surfactants are frequently used, however, because they are highly effective dispersants. To what extent - or *why* - the choice of dispersant might influence nanocomposite mechanical properties has not been considered. Here, we show that the dispersant can increase the stress transfer between a nanotube and the matrix, which is essential for achieving high stiffness, while still allowing interfacial slippage to increase energy dissipation. We demonstrate that the mechanism of stress transfer is through interfacial friction from molecular entanglements. A high molecular-weight polymer dispersant creates a polymer brush that entangles with the soft matrix. Surfactants and low molecular-weight polymers cannot entangle, therefore yielding far inferior mechanical properties. The dispersant's molecular weight thus provides a means to tune the mechanical and adhesive performance of waterborne nanocomposites.

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