RECENT RESEARCH ACTIVITIES

Optically transparent cellulose nanofiber nanocomposites via Pickering emulsion method

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CNF-reinforced optically transparent composites of high-performance have been developed a decade ago.[1] The composites were fabricated by impregnating acrylic resin monomer into the CNF-sheet. The CNF-sheet is very stiff due to the hydrogen (H) bonding among the nanofibers and hence, its resin impregnated composite is difficult to mold into a three-dimensionally (3D) curved material. To accomplish 3D-molding with optical transparency, CNF-suspension could be mixed with liquid resin, however, hydrophilic CNF-suspension and hydrophobic acrylic resin are typically immiscible. These drawbacks virtually hinder the fabrication of CNF-reinforced high-performance transparent materials that could be used in many exciting applications, such as contact lenses, substrate for curved displays, microlens arrays and so on.

To overcome above two limitations, a Pickering emulsification process is developed. First, CNF-suspension was mixed with acrylic resin monomer (ABPE-10) at a concentration of 10% CNFs to the resin followed by vigorous agitation in a high-speed blender (37,000 rpm). The obtained emulsion was vacuum-filtered to get a CNFs/resin mat. The mat was then hot-pressed by placing between respective substrates to fabricate planar, 3D-molded, or micro-patterned composites (Fig. 1). The thermal, mechanical and optical properties of the composites were evaluated.

During emulsion formation, numerous resin droplets of 0.3-10 μm in diameter have been produced. The droplets are covered and stabilized by the suspended CNF-network in the emulsion. Interestingly, after vacuum-filtration a CNF/resin mat with self-assembled 'nacre-like' structure has been obtained (Fig. 1). The nacre-like alternating CNF-resin structure reduces the H-bonding between the CNFs and allows to fabricate a lens-shaped transparent material after hot-pressing. The fabricated materials uniquely combines high optical transparency (regular transmittance 82% at 600 nm wavelength), high strength and toughness (15 and 24-times than neat acrylic resin, respectively), and a drastically low thermal expansion (1/24th of the neat acrylic resin) at a CNF content of 14-20%.

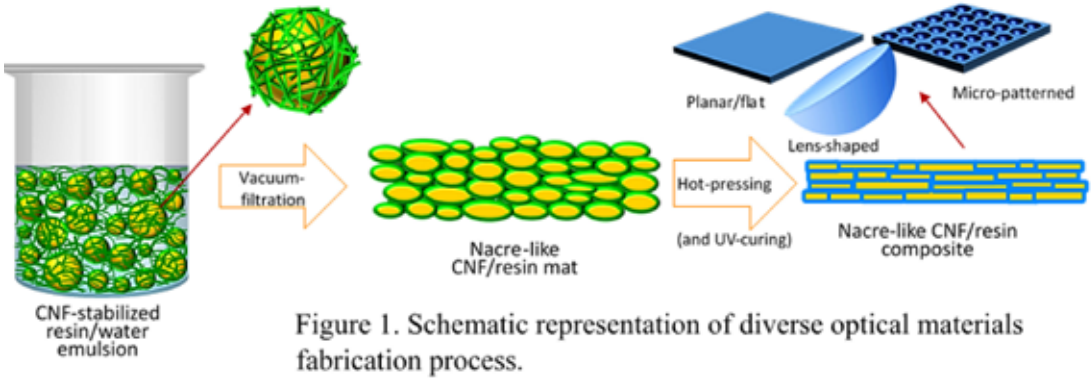

Figure 1. Schematic representation of diverse optical materials fabrication process.

References

[1] Yano H, Sugiyama J, Nakagaito A.N., Nogi M, Matsuura T, Hikita M, Handa K, "Optically transparent composites reinforced with networks of bacterial nanofibers", *Advanced Materials*, vol.17, no.2, 153-155, 2005.