ABSTRACTS (MASTER THESIS)

Optically transparent materials from cellulose nanofiber (CNF)-stabilized resin-in-water Pickering emulsion

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Introduction

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.

Experimental

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.

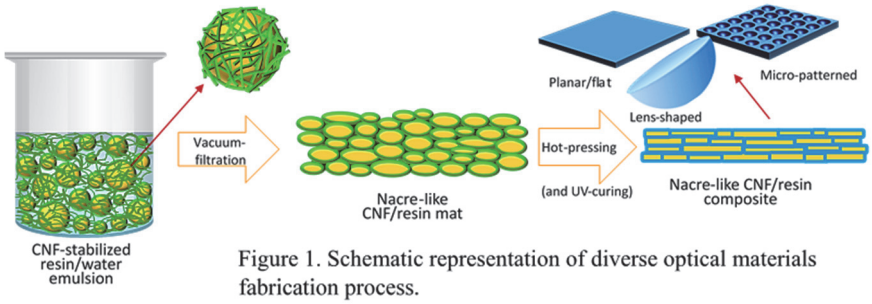

Figure 1. Schematic representation of diverse optical materials fabrication process.

Results and discussion

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 (Fig. 2). 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%.

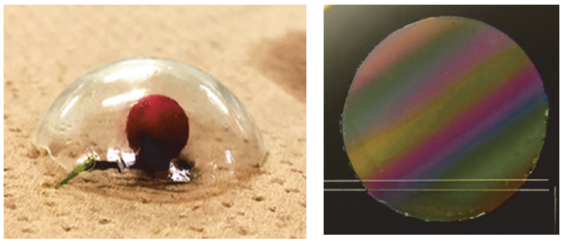

Figure 2. CNF-reinforced lens-like composite (left), and a micro-patterned composite showing beautiful colors (right).

References

[1] Yano, H., Sugiyama, J., Nakagaito, A.N., Nogi, M. et al., *Adv. Mater.*, 17 (2), 153-155, 2005.