All-Green and Strong Structural Composites Made with Man-Made Nanocellulose Filament and Biobased Resins

Jaehwan Kim*
CRC for Nanocellulose Future Composites, Inha University, Incheon, Republic of Korea

Giseok Park
CRC for Nanocellulose Future Composites, Inha University, Incheon, Republic of Korea

Bogyoung Kim
CRC for Nanocellulose Future Composites, Inha University, Incheon, Republic of Korea

Jieun Lee
CRC for Nanocellulose Future Composites, Inha University, Incheon, Republic of Korea

Abstract:

The bioresource demand for developing high-performance and environmentally friendly composites has recently increased because of net zero emissions and the replacement of petroleum-based materials. Bioresources are attractive candidates for sustainable materials. The enticing hierarchical structure of cellulose has made it possible to fabricate bio-based fibers via wet spinning. Strong and tough nanocellulose filament (NF) has been artificially made by wet spinning the cellulose nanofiber (CNF) suspension. The NF is promising for high-performance and green fiber-reinforced polymer composites (GFRPC) fabricated by developing lignin-based resins with superb physical properties.

A strong, tough, and long filament was made by wet spinning CNF suspension followed by coagulation, washing, drying, and stretching. The CNF suspension was wet spun in a citric acid solution to get NF. To prepare GFRPC, bio-based high-strength resins were synthesized from low-cost and abundant sustainable resources of starch, citric acid, and lignin. Lignin-based resins are synthesized by directly blending lignin with other additives, and by synthesizing bio-based epoxies using vanillin, a lignin derivative, via esterification. By integrating the resins into NF mats through hand-layup, hot-pressing, and post-curing, all-green composites were conceived with excellent flexural strength and stiffness.

The proposed all-green composite combines the high mechanical strength and stiffness of wet-spun NFs with the rigidity of bio-based resins. Since the developed composites have merits in terms of lightweight, good thermal stability, mechanical and hydrophobic properties, they can be used for automotives, drones, and urban aerial vehicles.

Keywords:

Nanocellulose, lignin, nanocellulose filament, resin, green composites.