Nanocellulose and Its Application for Smart Actuators and Optics

Jaehwan Kim[1*], Pooja S. Panicker[1], Dickens O. Agumba[1], Mohammad Latif[1], Samia Adil[1], Duc Hoa Pham[1], Yangxiaozhe Jiang[1], Jong Min Song[1]

[1]Creative Research Center for Nanocellulose Future Composites, Inha University, Incheon 22212, Republic of Korea

[*]Corresponding author (Tel: +82-32-874-7325; E-mail: jaehwan@inha.ac.kr)

Abstract

The use of renewable materials is essential in future technologies. Renewable materials maintain our resources from the environment, which we can overcome the degradation of natural environmental services and diminished productivity. Cellulose is one of nature's most abundant materials, the main chemical components of wood and plants. It is a renewable material that recycles nature by composting within a short time. Nanocellulose, nano-sized cellulose, has its unique characteristics- high strength, elastic modulus, optical transparency, low thermal expansion coefficient, and low density. Nanocellulose can be divided into cellulose nanocrystal (CNC) and cellulose nanofiber (CNF). CNC has remarkable advantages such as high mechanical strength, biocompatibility, nanoscale dimension and renewability. CNF is a decorative element of nanocellulose well-known for its high aspect ratio, mechanical properties, and flexibility. When nanocellulose is blended in polymers, it increases dielectric properties, which is very promising for smart actuators and optics.

This presentation first reviews nanocellulose isolation methods, characterizations, and properties. And recent advancements of nanocellulose for smart actuators are illustrated, including soft actuators, speakers, haptic devices, and energy harvesters. Ionic and piezoelectric behaviors of nanocellulose were applied to soft actuators and piezoelectric paper speakers. Hybrid actuating materials incorporate ionic liquids, carbon nanotubes, and titanium dioxide with nanocellulose, which show robust actuator performance. Soft gel actuators were demonstrated using ionic and nonionic hydrogels. Vibration energy harvesting devices were made by adopting the piezoelectric behavior of nanocellulose. Flexible and biocompatible triboelectric nanogenerators were demonstrated using nanocellulose composites blended with allicin. An electrically tunable lens was developed by blending CNC in polyurethane, which can produce 10% strain under 3 V/μm electric field. Since nanocellulose is renewable, biocompatible and has high mechanical properties, various environmentally friendly actuators and devices are possible.

Keywords: Nanocellulose, Smart materials, Actuators, Optics, Renewability