Applications of Cellulose Nanocrystals in Modern Electrical and Electronics Engineering

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Cellulose nanocrystals (CNCs) are crystalline materials derived from cellulose found in plant fibers. Renewable and biodegradable CNCs exhibit some great promising properties, such as high tensile strength and stiffness for mechanical applications, high piezoelectric response for energy conversion, and high electrical insulation for power system. These properties make CNCs promising candidates for various applications in electronic and electrical engineering. However, the properties of a CNC-based material is not only dependent on the properties of CNC, but also the connectivity and orientation of CNCs in the material. The latter is strongly dependent on the processes used to prepare the CNCs and CNC-based materials.

In this presentation, applications of CNCs in electrical and electronics engineering are reviewed. These applications can be simply classified into 1) energy storage, 2) energy conversion, 3) energy supply, 4) sensors including chemical, physical, and biological sensors. In the review, special attention was given to the microstructure and surface chemistry of individual CNC and the morphology and orientation of CNC in CNC-based materials. For energy storage, CNC-based materials can be used in the development of high-performance battery and dielectric capacitor. In batteries and dielectric capacitors, CNCs enhance mechanical reinforcement, ionic conductivity, and stability, while providing high dielectric constant and low dielectric loss for improved energy storage efficiency and reliability. Regarding the energy conversion, the high piezoelectric coefficient of CNCs makes the CNC-based materials a great candidate for converting mechanical energy from environmental into electric energy to be used in wearable electronics and wireless/remote devices. CNCs' piezoelectric properties allow energy harvesting from activities like walking or typing to power small devices, reducing reliance on traditional batteries. Sensors are the backbone of all automatic devices/systems. Chemical, physical, and biological sensors have been developed based on the usage of CNC-based materials. Finally, the pros and cons of these sensors are also discussed, highlighting CNCs' sensitivity, selectivity, and potential for miniaturization and integration into smart systems.

Keywords: cellulose nanocrystal, dielectric material, energy storage, piezoelectric material, sensors.