Cellulose Nanocrystals for Security Applications: Embedding Non-Optical Signatures Provided by Nanoparticles into Cellulose Nanocrystal Chiral Nematic Films

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The recent increase in counterfeited documents, banknotes, and medications impacts society, calling for irreproducible security technologies. Nature mimicking materials, which combine multiple properties in a single material, are well-suited for security applications. Aqueous suspensions of Cellulose Nanocrystals (CNC), extracted from cellulose, self-assemble into chiral nematic structures creating, upon drying, free-standing films. They exhibit unique optical properties: structural color, iridescence, and light polarization for covert and overt encryption. Quantifying the CNC films' electrical properties, novel research, adds additional forensic encryption. It was hypothesized that combining CNC with sub 50nm nanoparticles yields composite materials that retain CNC optical properties and have influenceable electrical features, creating materials with unique optical and electrical signatures. The experiment created new, CNC-based composite materials with various nanoparticles: copper, aluminum, cobalt, iron, carbon single-walled nanotubes, graphene, titanium dioxide, titanium carbide, fluorescent rhodamine, and gold. All composite films retained CNC unique optical properties. Adding nanoparticles uniquely influenced the structural color and iridescence, both measured with a custom-designed setup for a Fiber Spectrometer. The film morphology, examined using Polarized Optical and Scanning Electron Microscopy, was uniform with evenly dispersed nanoparticles. The nanoparticles influenced films' resistivity and dielectric constant, measured with custom-built plates and electrodes connected to specialized meters. CNC-based composite films with nanoparticle-dependent properties are suitable as a new class of anti-counterfeiting materials with multi-dimensional security levels.

Awards Won:

Intel ISEF Best of Category Award of $5,000

SPIE, the international society for optics and photonics: First Award of $2,000

National Security Agency Research Directorate : Honorable Mention "Science of Security"