Optical Encryption with Cellulose Nanocrystals: Polymer and Amino Resin Cellulose Composites Decorated with Nanoparticles

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The recent increase in counterfeited documents, banknotes, and medications impacts society, calls for new security technologies that are difficult to reproduce. Nature mimicking materials with unique optical properties 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. They are suitable for anti-counterfeit materials but they need to be enhanced. It was hypothesized that combining CNC with nanoparticles and/or polymer/resins yields composite materials that retain CNC optical properties, have controllable color and iridescence, and additional functionality, adding extra levels of security. Adding a resin makes the material water resistant. The experiment created new composite materials: CNC with either polymers/ amino resin or nanoparticles, or novel three-components, including both nanoparticles and polymer/resin. A Fiber Spectrometer measured the film's reflected wavelength, Polarized Optical Microscopy examined nematic structures, and Scanning Electron Microscopy examined morphology. All composite films retained CNC unique optical properties and the guest materials shifted the structural color and reduced iridescence, measured with a custom-designed setup - another novelty. The film morphology was uniform with the guest materials uniformly dispersed. The resin made the films water resistant. The experiment created new composite materials with enhanced, controllable optical properties and potential for further fictionalization, making them suitable for anti-counterfeiting materials.

Awards Won:

First Award of $5,000

Intel ISEF Best of Category Award of $5,000