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Frontiers in Nanocrystalline Cellulose and its Applications

Orlando J. Rojas [(1,2,3)*]

(1) North Carolina State University, Department of Forest Biomaterials, Raleigh, North Carolina 27695, United States
(2) North Carolina State University, Dept. Chemical and Biomolecular Engineering, Raleigh, North Carolina 27695, United States
(3) Aalto University, School of Chemical Technology, Department of Forest Products Technology, FI-00076 Aalto, Espoo, Finland

* e-mail de autor de correspondencia: ojrojas@ncsu.edu www4.ncsu.edu/~ojrojas

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We introduce our work related to the application of surface and colloid science in the development of cellulose nanomaterials. These efforts take advantage of the process by which nature assembles fibers in a highly hierarchical structure encompassing a wide range of sizes, from the nano to the meter scales. A number of materials cleaved from the cell wall have been the subject of intensive research, including, nanofibrillar cellulose and cellulose nanocrystals (CNCs), i.e., defect-free, rod-like crystalline residues after acid hydrolysis of cellulose fibers. Interest in CNC originates from its appealing intrinsic properties: nanoscale dimensions, high surface area, unique morphology, low density, chirality and mechanical strength. Directing their assembly back to different hierarchical structures is a quest that can yield useful results in many revolutionary applications. As such, we will discuss the use of non-specific forces to create ultrathin films of nanocellulose at the air-solid interface for applications in nanocoatings, sensors, etc. Assemblies at other interfaces will be introduced as means to produce or stabilize hydrogels, aerogels, and Pickering emulsions. Methods common in biophysics and employed to control the packing density of CNC at the air-liquid and air-solid interfaces will be presented. A convective assembly setup assisted by shear and electric fields will be discussed as a suitable method to produce highly ordered structures. Concepts related to piezoelectric CNC films, organic-inorganic hybrid materials with magnetic and other properties. Overall, the prospects of such novel materials will be explained in light of the unique properties of cellulose and its nanostructured assemblies.