Imaging Native Structure of Plant Cell Wall Cellulose Microfibril

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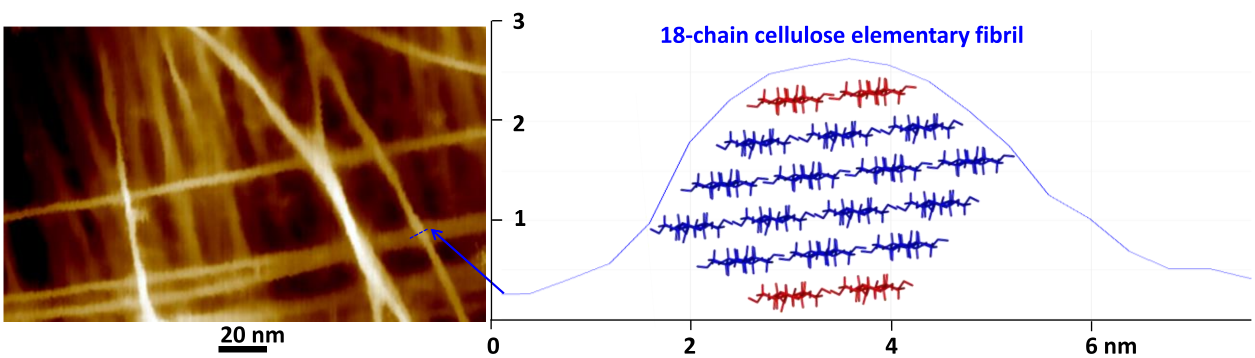
Project Goals: To elucidate the molecular mechanisms that confer resistance to catalytic deconstruction of biomass to sugars by means of developing emerging microscopic techniques in GLBRC to enable real-time imaging capabilities at the cellular and molecular scales, and thereby to provide critical knowledge needed to improve the processes to produce biofuels and bio-products.

Plants provide essential materials of our daily life, such as wood, fibers, and recently feedstock for producing biofuels and biomaterials. Cellulose is central to plant life and the global carbon cycle. Plants use rigid cellulose microfibrils together with non-cellulosic matrix polymers to build cell walls. Cellulose is known to comprise linear β(1,4)-glucan chains that are organized through hydrogen-bonding networks and van der Waals forces, however, in plants the number of chains and how they arrange in the microfibril remains elusive. This study uses atomic force microscopy (AFM) to directly image under water the cell walls from living maize (*Zea mays*) plants, which allows us to precisely measure the near-native structure of the microfibril at the sub-nanometer scale. We find the microfibrils vary in size and arrangement in different wall types or at different developmental stages, but all microfibrils are comprised of a fundamental building block, namely the cellulose elementary fibril (CEF) that has a defined cross-sectional area of 6 nm^2. Based on known crystal structure of cellulose, this CEF is only consistent with an 18 - chain model. We further confirm that this CEF structure widely exists in the cell walls of other monocot and eudicot plant species, suggesting it is likely a result of the conserved cellulose biosynthesis machinery in land plants. Our results provide long-awaited direct measurement of native cellulose structure, which provide new insights into cell wall biosynthesis and plant development, as well as the rational design of cellulose-based biomaterials.



The Great Lakes Bioenergy Research Center is a U.S. Department of Energy Bioenergy Center supported by the DOE Basic Energy Research Office of Science (DE-FC02 -07ER64494).