High Resolution Characterization of Biomass

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Project Goals: The BioEnergy Science Center (BESC) is focused on the fundamental understanding and elimination of biomass recalcitrance. BESC's approach to improve accessibility to the sugars within biomass involves 1) designing plant cell walls for rapid deconstruction and 2) developing multitalented microbes for converting plant biomass into biofuels in a single step (consolidated bioprocessing). BESC researchers in characterization, modeling, and data management areas are engaged in 1) applying advanced technologies to analyze chemical and structural changes within biomass and 2) storing, tracking, analyzing and integrating data and understanding across the Center.

BESC has developed a method to provide chemical information about biomass at the scale of tens of nanometers. When employing absorption spectroscopy as a means for obtaining chemical information from samples in bulk form, one is faced with an inherent limitation on the spatial resolution. This lack of resolution, which is caused by the classical diffraction limitation of the excitation and detection in conjunction with the delocalized nature of the nonradiative decay, has hindered studies that require spectral information on sub-wavelength scale or more importantly simultaneous spectral and topographic information. An important example of such studies is the understanding of the plant cell wall organization at the nanoscale. In order to overcome recalcitrance so as to reach higher levels of efficiency for biofuel production that would make lignocellulosic biomass a viable option for the next generation of sustainable energy solutions, it is essential to study the cell spatio-chemically. In an effort to achieve this and thus extend the capabilities of the variety of existing analytical tools available to characterize biomass, we introduced Mode Synthesizing Atomic Force Microscopy (MSAFM), and further proposed to augment it with spectroscopic capabilities. The resulting system aims to nano mechanically reduce the effects of both the diffraction limitation and the nonlocalized energy landscape of the sample on the resolution with which chemical and morphological information can be obtained. Preliminary results show that it is possible to probe the various spatio-chemical properties of biomass and furthermore reach subsurface information. The extension of MSAFM into a hybrid photonic-MSAFM (hp-MSAFM) and the capitalization of the rich underlying dynamics (such as the recently discovered virtual resonance) can provide chemical information of biomass. The results include localized spectroscopic measurements performed with the MSAFM probe, using a quantum cascade laser (QCL) and broadband sources (FTIR) of infrared radiation. We will demonstrate that MSAFM can also be used to provide chemical mapping of biomass at a given wavelength, and will present our results on *Populus* stem cross section samples subjected to a sequence of chemical treatments (from Soxhlet extraction to acid treatment).

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