Drilling down to the nanometer depths of leaves for biofuels

July 19 2010

A xylem cell with fluorescent lignocellulose bands as the major feature

(PhysOrg.com) -- By imaging the cell walls of a zinnia leaf down to the nanometer scale, energy researchers have a better idea about how to turn plants into biofuels.

In a paper appearing online in the journal *Plant Physiology*, a team from Lawrence Livermore led by Michael Thelen, in collaboration with researchers from Lawrence Berkeley National Lab and the National Renewable Energy Laboratory, has used four different imaging techniques to systematically drill down deep into the cells of *Zinnia elegans*.

Zinnia is a common garden annual plant with solitary daisy like flower heads on long stems and sandpapery, lace shaped leaves. The leaves of seedlings provide a rich source of single cells that are dark green with chloroplasts and can be cultured in liquid for several days at a time. During the culturing process, the cells change in shape to resemble the tube-like cells that carry water from roots to leaves. Known as xylem, these cells hold the bulk of cellulose and lignin in plants, which are both major targets of recent biofuel research.

Using different microscopy methods, the team was able to visualize single cells in detail, cellular substructures, fine-scale organization of the cell wall, and even chemical composition of single zinnia cells, indicating that they contain an abundance of lignocellulose.

"The basic idea is that cellulose is a polymer of sugars, which if released by enzymes, can be converted into alcohols and other chemicals used in alternative fuel production," Thelen said. "But for this to happen efficiently, we need to find ways to see how this is proceeding at several spatial scales."

To get at the sugars is no easy task. The team had to find ways to overcome the hydrophobic protection of crystalline cellulose provided by lignin in the cell wall. The two polymers, collectively called lignocellulose, are very insoluble, resistant to common chemicals and mechanical breakage, and are a superior substance for providing strength and structure to plants.

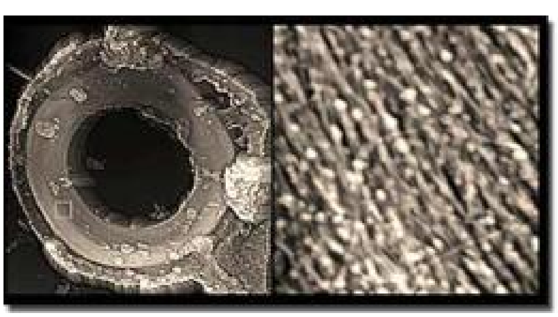

Image showing a substructure of the cell wall (ring), and the detailed organization of lignocellulose in the cell wall.

The detailed three-dimensional molecular cell wall structure of plants remains poorly understood.

"The capability to image plant cell surfaces at the nanometer scale, together with the corresponding chemical composition, could significantly enhance our understanding of cell wall molecular architecture," said Alex Malkin, a member of the LLNL team who is an expert in atomic force microscopy. "A high resolution structural model is crucial for the successful implementation of new approaches for conversion of biomass to liquid fuels."

To make fuels from plant biomass requires a thorough understanding of the organization of cell walls before determining the best methods for cell wall deconstruction into its components. Catherine Lacayo, a postdoctoral scientist working with Thelen and Malkin, has taken the first steps toward a comprehensive approach.

She came up with techniques that reveal the inner structure of cell walls in these single xylem cells, which represent about 70 percent of the cellulose in plants that can be used in fuel processing. "This approach will be useful for evaluating the responses of plant material to various chemical and enzymatic treatments, and could accelerate the current efforts in lignocellulosic biofuel production."

Provided by Lawrence Livermore National Laboratory