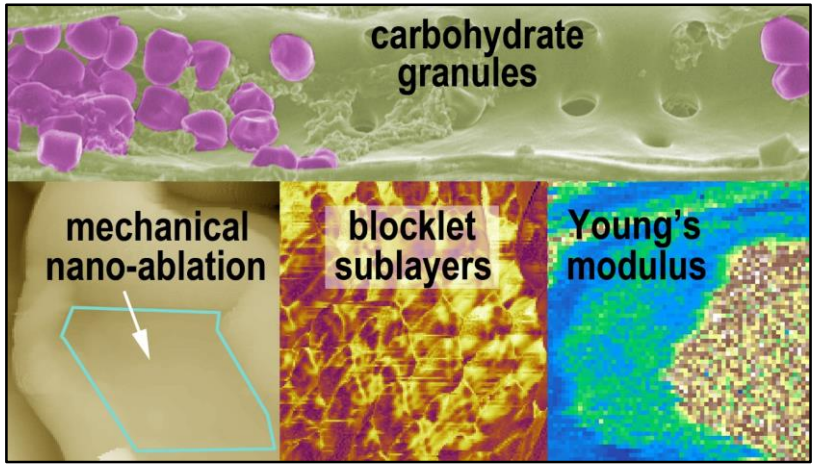
A new technique measures chemistry and nanomechanics of native carbohydrate granules

Background

- Biomass characterization can aid both quantitative biological studies of the ultrastructures of plants and guide development of new treatments for more efficient biofuel production.
- Nondestructive measurements of mechanical and chemical properties of plant cells at the nanoscale, in particular, beyond the immediately accessible top layer of specimen, are challenging.

Approach

- A novel adaptation of existing material characterization techniques was demonstrated by using an atomic force probe to manipulate and displace the top layer of carbohydrate granules in order to expose its inner blocklet sublayers and their arrangements as well as to measure their chemical composition.



Outcome

- We achieved nanometers resolution in observation, geometric recognition, and chemical identification of the starch granules in plant cells in conjunction with quantitative determination of their elasticity and plasticity.
- Demonstration of gentle nanomechanical forces applied to delicate outer layer material of the granules towards nondestructive bio-imaging.

Significance

- The results pave the way to more advanced probe-based operation on soft matter and biological specimens. This can enable quantitative *in situ* biological and chemical characterization of the structural layers within plant cell walls.
- The mechanical properties within plant cells are believed to be linked to their ability to be processed.

Nanomechanics of granules within the ray parenchyma cells of *Populus* xylem, a desirable woody biofuel feedstock. Mechanical nanoablation allows access to the interior of the granules without compromising the inner nanostructure, which is found to comprise of 156 nm blocklets arranged in a semicrystalline organization. These findings demonstrate how spectroscopy and force microscopy facilitate studies of structure–function relationships among starch granules and more complex secondary cell wall features as they relate to plant performance.

R. H. Farahi, A. L. Lereu, A. M. Charrier, U. C. Kalluri, B. H. Davison, and A. Passian, Nanomechanics and Raman Spectroscopy of in Situ Native Carbohydrate Storage Granules for Enhancing Starch Quality and Lignocellulosic Biomass Production." *ACS Omega* (2020) doi: 10.1021/acsomega.9b02849

THE CENTER FOR BIOENERGY INNOVATION

February 2020