Unprecedented glycan nanocompartments sustain plant vessel wall patterning and xylem robustness

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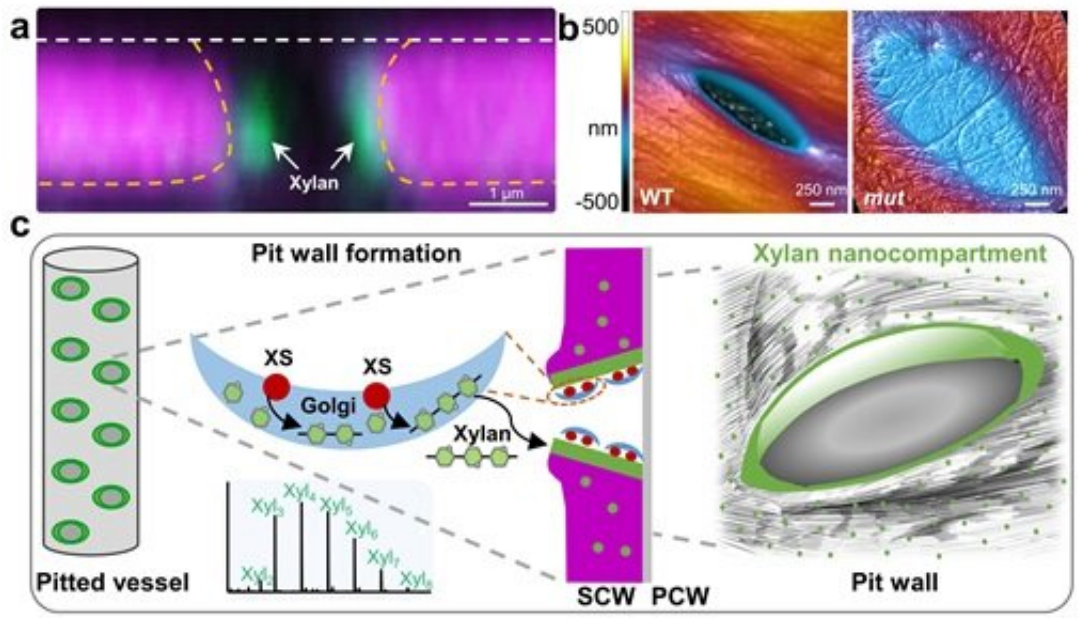

Xylan-based nanocompartments govern vessel wall patterning. a, Z-plane of a pit in wild-type xylem vessel wall probed using xylan-recognized antibodies (green). b, AFM images of vessel walls, showing disorganized cellulosic nanofibrils in the mutant. c, Model for xylan nanocluster formation in pitted vessel cells by xylan synthase. The embedded figure is mass spectrography of the reaction products catalyzed by IRX10 without an acceptor substrate. Credit: IGDB

Researchers led by Prof. Zhou Yihua from the Institute of Genetics and Developmental Biology (IGDB) of the Chinese Academy of Sciences

(CAS) recently reported an identification of unprecedented xylan nanocompartments at the pit borders of xylem vessels in rice and Arabidopsis using super-resolution confocal microscopy.

All living organisms can self-organize into a highly efficient operation system, whose robustness is maintained by compartmentalization of cells to various specialized subcellular structures. For example, lipid bilayers and proteins usually form micro- and nanocompartments via clustering and phase separation. Saccharides are an important class of biomacromolecules that are capable of compartmentalization. Due to the difficulties in probing sugar molecules, very few saccharide-based structures have been characterized. Our knowledge about nanoscale glycan compartments with specific functions is fairly scarce.

In plants, more than two-thirds of carbon dioxide fixed by photosynthesis are converted into structural polysaccharides to construct cell walls surrounding every plant cell, thereby forming tissues, organs and individual plantlets. Xylem vessels of plant vasculature display notable cell wall compartments, such as annular/spiral patterns (protoxylem) and reticulate/pitted patterns (metaxylem). However, how the extracellular polysaccharides self-organize into nanocompartments is unknown.

In this study, the researchers revealed that the nanocompartments are produced by the activities of IRREGULAR XYLEM (IRX)10 and five homologues of the glycosyltransferase 47 family. Rice IRX10, a major member contributing to xylan synthesis in vessels, can mediate xylan chain elongation and initiate the generation of xylooligomers without an acceptor, indicating a de novo synthetic machinery.

Furthermore, atomic force microscopy revealed the nanoscale wall topography around pit boundaries sustained by the xylan nanoclusters. Surprisingly, disruption of the xylan nanostructure leads to abnormal and

fused pits with improperly packed cellulosic nanofibrils, resulting in reticulate-like patterns that compromise vessel robustness.

Moreover, through investigating the vessel pit size and growth traits in 42 core rice accessions, the pit size was correlated with agronomic traits, such as plant height.

Hence, using multiple cutting-edge approaches, the researchers outlined a mechanism of how xylans are synthesized, how they are assembled into nanocompartments and how the nanocompartments sustain cell wall pit patterning to support efficient water transportation throughout the plant body.

The xylan nanostructures at pit boundary are analogous to merrow edges of buttonholes preventing thread release; its role is to sustain cell wall coherence, which deepens understanding of cell wall patterning established from a cytosolic-based perspective. More miraculous polysaccharide-based nanostructures are expected. Furthermore, the discovery of a de novo xylan synthase opens new avenues for rational manipulation of this polymer.

In summary, this study bridges the knowledge gap between polysaccharide synthesis and functional structures, evoking rethinking of diverse physiologic processes in plants and providing new perspectives for precision design of crops.

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More information: Hang Wang et al, Xylan-based nanocompartments orchestrate plant vessel wall patterning, *Nature Plants* (2022). DOI: 10.1038/s41477-022-01113-1