EGU22-5357, updated on 18 Aug 2022
https://doi.org/10.5194/egusphere-egu22-5357
EGU General Assembly 2022

Xylem hydraulic conductivity measurements during flow-controlled experiments suggest the presence of nanobubbles that move with the flow and accumulate at vessel ends

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Commonly, xylem hydraulic conductance is measured by applying a positive pressure (above atmospheric) to push water through a twig. To imitate flow in twig samples under natural conditions, we developed a method that applies a controlled flow rate using suction, similar to transpiration-driven flow in plants.

The setup consists of a syringe pump to control water flow, where a twig is inserted in the flow path and hydraulic conductivity is calculated from measurements using pressure sensors and a flow meter. The syringe pump can be used to generate controlled flow rates in both directions and a series of bypasses can be used to self-calibrate the sensors and reverse flow directions through the twig while the syringe pump is either pushing or pulling. In this way, we were able to compare our suction method with the more conventional pushing method and assess the effect of flow direction on hydraulic conductance measurements. We found a reproducible pattern in measured conductivity values, where measurements using suction resulted in a 50% lower conductivity than when flow was induced by pushing. The direction of flow (root-shoot vs. shoot-root) also had a strong influence, with suction in root-shoot direction resulting in the lowest conductivity measurements, but repeated reversals of flow revealed an intricate pattern of loss and partial restoration of conductivity, implicating the existence of particles that move with the flow and accumulate at the vessel ends.

Here we present the intriguing results and propose an explanation capable of explaining the reproducible patterns in observed conductivity dynamics during the experiments. The explanation involves nanobubbles that shrink and swell depending on the liquid pressure and surface tension, move with the flow and reduce conductivity as they accumulate at vessel ends.