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Numerical Modeling of Flow through Phloem Considering Active Loading[1] JIN LIU, TSUN-KAY JACKIE SZE, PRASHANTA DUTTA, Washington State University, Pullman, WA — Transport through phloem is of significant interest in engineering applications including self-powered microfluidic pumps. We present a phloem model, combining protein level mechanics with cellular level fluid transport. Fluid flow and sucrose transport through a petiole sieve tube are simulated using the Nernst-Planck, Navier-Stokes, and continuity equations. Governing equations are solved using the finite volume method with dynamically calculated boundary conditions. Sieve tube cell structure consisting of sieve plates is included in a two dimensional model by computational cell blocking. Sucrose transport is incorporated as a boundary condition through a six-state model, bringing in active loading mechanisms with consideration of physical plant properties. The effects of reaction rates and leaf sucrose concentration are investigated to understand the transport mechanism in petiole sieve tubes. Numerical results show that increasing forward reactions of the proton sucrose transporter significantly promotes the pumping ability. A lower leaf sieve sucrose concentration results in a lower wall inflow velocity, but yields a higher inflow of water due to the active loading mechanism. The overall effect is higher outflow velocity for lower leaf sieve sucrose concentration because the increase in inflow velocity outweighs wall velocity. This new phloem model provides new insights on mechanisms potentially useful for fluidic pumping in self-powered microfluidic pumps.

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