Effect of Properties and Turgor Pressure on the Indentation Response of Plant Cells

The indentation of plant cells by a conical indenter is modeled. The cell wall is represented as a spherical shell consisting of a relatively stiff thin outer layer and a softer thicker inner layer. The state of the interior of the cell is idealized as a specified turgor pressure. Attention is restricted to axisymmetric deformations, and the wall material is characterized as a viscoelastic solid with different properties for the inner and outer layers. Finite deformation, quasi-static calculations are carried out. The effects of outer layer stiffness, outer layer thickness, turgor pressure, indenter sharpness, cell wall thickness, and loading rate on the indentation hardness are considered. The calculations indicate that the small indenter depth response is dominated by the cell wall material properties, whereas for a sufficiently large indenter depth, the value of the turgor pressure plays a major role. The indentation hardness is found to increase approximately linearly with a measure of indenter sharpness over the range considered. The value of the indentation hardness is affected by the rate of indentation, with a much more rapid decay of the hardness for slow loading, because there is more time for viscous relaxation during indentation.