Plant movements and biomimetic actuators

Peter Fratzl, Sebastien Turcaud, John Dunlop, Matt Harrington, Ingo Burgert*
Max Planck Institute of Colloids and Interfaces, Research Campus Golm, Potsdam

The secondary plant cell wall is a composite of cellulose nano-fibrils and a water-swelling matrix containing hemicelluloses and lignin. Recent experiments showed that this swelling capacity helps generating growth stresses, e.g., in conifer branches or in the stem when subjected to loads. A similar mechanism also provides motility to wheat seeds. A simple mechanical model for the cell wall predicts that – depending on the detailed architecture of the cellulose fibrils – swelling may lead either to significant compressive or tensile stresses or to large movements at low stresses. The model reproduces most of the experimental observations in the wood cells and in the awns of wheat seeds. The general principle is based on the modification of the isotropic swelling of a gel by embedded oriented fibres, or on a non-symmetric distribution of swelling elements in an elastic body. More generally, actuation systems in plants provide guidelines for designing material architectures suitable to convert isotropic swelling into complex movements.

*Since October 2011, Professor of wood-based materials at ETH Zürich