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Structure and mechanics of biological fiber-laden membranes[1] YOGESH KUMAR MURUGESAN, ALEJANDRO REY, Department of Chemical Engineering, McGill University, DAMIANO PASINI, Department of Mechanical Engineering, McGill University — We present a mechanical model of the plant cell wall viewed as anisotropic 2D soft matter, where a dilute dispersion of cellulose fibrils of variable orientations is on a curved deformable viscoelastic membrane. The model integrates the elastic energy of the curved membrane, the nematic fiber orientation energy, and competing curvophilic and curvophobic interactions mediated by the membrane geometry and the fibrils' orientation. The selected membrane geometry is a straight cylinder, whose cross-sectional shape varies from a circle to a super-ellipse as in many plant species, and its size increases as in plant cell wall during growth. Model predictions indicate that due to curvature–orientation couplings, the fiber orientation displays three modes: axial (at large curvature), helical and transverse (at small curvature). The high curvature also promotes the order of the fibrils. The predicted fiber structure is validated with that in the cell wall of tracheids. To gain insight into the role of fiber structure on the elasticity of fiber-laden membranes, the effect of fiber orientation and order on the effective bending modulus of the fiber-laden membrane cross-section is investigated. The structure–property relations for super-elliptical membranes are established.

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