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Diffusion of water in palm leaf materials

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Diffusion of water into plant materials is known to degrade their mechanical strength and stiffness, yet simultaneously enhance formability. Hence, the phenomenon is of both fundamental interest, and of importance for manufacture of eco-friendly products, e.g., foodware (plates, bowls). The existing literature on diffusion in plant materials (mainly woods) has focused on diffusion of water vapor (moisture) rather than liquid water. Furthermore, these studies have largely been restricted to estimating the macroscopic diffusion coefficient, using measurements of mass gain, with little focus on elucidating the micro-mechanisms of diffusion. Given the complex hierarchical structure of plant materials, the diffusion process may be expected to be strongly influenced by microstructural components such as fiber, matrix and porosity. Even a qualitative understanding of the role of microstructure in influencing diffusion of water will be of value for predicting the response of plant materials to water permeation, without extensive macroscopic measurements.
Here, we report on measurements of diffusion coefficient of water in areca palm sheath, a model plant material system, also used in eco-friendly foodware. The measurements account for the effects of material swelling and porosity, unlike prior characterization of this diffusion. Using in situ imaging, we show that the permeation of water through the sheath microstructure occurs heterogeneously, being several times faster in the matrix than in the fibers. Furthermore, using digital image correlation (DIC), we map the variation in the local strain during the diffusion process and show that it is significantly higher in regions of greater water penetration. The diffusion coefficient obtained from conventional mass gain measurements is shown to be consistent with the observations from the imaging experiments. The results highlight the critical need to include microstructure parameters, such as porosity and material swelling, to accurately estimate the diffusion coefficient. Implications of the results for diffusion in hierarchically structured materials, foodware manufacturing, and life of foodware products are discussed.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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