Plant-based phononic materials for the manipulation of ultrasonic waves

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Résumé

Plants offer a unique engineering platform to design sustainable and multifunctional materials due, in part, to their natural abundance, self-growing capacity, and functional diversity. While these green and recyclable biobased materials have started to substitute inorganic compounds in many existing technologies, including photonics, robotics, and soft electronics, their use as phononic crystals and ultrasonic metamaterials to manipulate the propagation of acoustic waves has remained less explored. In this work, we investigate the phononic behavior of plant-based materials composed of dehydrated plant cells scaffolds and extracted from onion bulbs. We use laser-generated ultrasonic waves to study the interaction of these structures with high frequency MHz Surface Acoustic Waves (SAWs). By measuring the acoustic dispersion curves in these biocomposites, we reveal the presence of phononic effects such as phononic bandgaps and acoustic band-folding, arising from the geometry of the plant cell walls and the spatial periodicity of the plant tissues, respectively. Our results demonstrate the possibility to manipulate ultrasonic waves with plant structures, calling for new protocols to precisely control the mechanical and/or structural properties in plant tissues, which we anticipate will lead to novel biobased phononic materials that could be used as acoustic RF filters, ultrasonic biosensors, and piezoelectric energy harvesters.

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