A Flexible DLP 3D-printed Coated Microneedle Patch for the Delivery of New Therapeutics to Citrus Stem Tissue

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This work reports the design, fabrication, and testing of a flexible digital light processing (DLP) 3D-printed coated microneedle patch, which is designed for transporting copper-based therapeutics to the stem tissue of Huanglongbing (HLB)-affected trees. HLB has decimated the previously $9 billion citrus industry in Florida, reducing turnover to a mere $3.28 billion as of 2018. HLB is caused by a phloem-limited bacterium “Candidatus Liberibacter asiaticus” (C. las), so any treatment must be delivered to phloem tissue to be effective, demanding the need for an innovative delivery mechanism that is user friendly and can bridge the gap of testing between the lab and the grove. It is hypothesized that a coated microneedle patch will efficiently create penetrations into the stem by which treatments can reach the thin stem phloem. The therapeutic selection criteria were based on 1) the potency, 2) phytotoxicity, 3) the familiarity with the industry, 4) the relative number of regulatory hurdles for EPA registration. Based on the above, metallic copper was selected and used for this study. Copper is formulated in a way that follows sustained release kinetics and can travel through the plant vascular system without causing phytotoxicity. The microneedles were designed to have an optimized surface area for maximizing the formulated copper coating. These needles were subsequently demonstrated in a series of water studies that showed the sustained release of copper over time. Work in progress includes the testing of the device prototype in vitro in lab conditions to optimize parameters required for field environments.