Mechanical Engineering Thesis Defense

Electrically Assisted Vat Photopolymerization 3D Printing of Bioinspired Hierarchical Structures with Controllable Roughness for Hydrophobicity Enhancement

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Abstract

Biomimetics is a field where natural and biological systems are replicated in a lab. The evolved hierarchical designs of the floating leaves of the water fern Salvinia Molesta are taken as inspiration as they reveal excellent dual scale roughness capability which also presents superhydrophobic properties in the nature. The microscale eggbeater-shaped hairs are coated with microscopic granules and nanoscopic wax crystals (dual-scale roughness) and wrinkled hydrophilic patches are coated with wax crystals which are evenly distributed on the terminal of each hair. The combination of features with diverse wettability, such as wrinkled hydrophilic patches atop superhydrophobic eggbeater hairs, makes such structures unique. The hydrophilic patches bind the air-water interface to the tips of the eggbeater hairs and inhibit air bubble formation. Salvinia effect of several Salvinia species has been extensively researched. Superhydrophobicity is attracting increasing attention for various applications. Salvinia exhibit multiscale roughness because of the unique combination of smooth hydrophilic patches on elastic eggbeater structures decorated with nanoscopic wax crystals. However, how to reproduce such hierarchical structures with controllable surface roughness is challenging for current fabrication approaches, which hinders the applications of these superhydrophobic properties as well as multi-scale roughness on surfaces in engineered products. The objective of this research is to fabricate and study the superhydrophobic structures using electrically assisted Vat Photopolymerization. In this project, an electrically assisted Vat Photopolymerization 3D printing (e-VPP-3DP) process was developed to control the surface roughness of printed eggbeater structures with distribution of multi walled carbon nanotubes (MWCNTs) for multi scale roughness. Vat Photopolymerization (VPP) is a Photopolymerization technique where a Photo Curable resin is used to rapidly produce dense photopolymer parts. A fundamental understanding of e-VPP technique to create superhydrophobic structures was studied to identify the relation between geometric morphology and mechanical enhancements of these structures. The correlation between the material properties for different weight percentage mixtures of MWCNT, printing parameters and the mechanical properties like attaching forces, surface roughness and superhydrophobic nature are also identified with this study on bioinspired hierarchical structures.

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