Name(s)

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Project Number

S0324

Project Title

Micro-Pattern Surface Property Design for Atmospheric Moisture Harvesting: Biomimicking Torrey Pine Needles

Abstract

Objectives

Harvesting atmospheric moisture is an innovative way to help solve the world's freshwater shortages. Torrey Pine trees are well known for their moisture harvesting capabilities, but little research has been done to understand their mechanisms. After studying its surface structures and properties at a microscopic level, I identified an alternating hydrophilic and hydrophobic surface micro-pattern on the needles. I hypothesized that this alternating micro-pattern may be more efficient than a purely hydrophilic surface for moisture collecting. My goal was to find an optimized hydrophilic and hydrophobic ratio on the micro-pattern to achieve both a high moisture condensation and droplet transportation rate and understand the mechanisms behind it.

Methods

A Keyence 3D Microscope (VHX) and FEI ESEM (Quanta) were used to observe needle microstructures. To fabricate the micro-patterns, I used a Xerox laser printer (Work Centre 7225) to print hydrophobic toner (PN 006R01453) on hydrophilic transparency films (3M GC3700). To model Torrey Pine needles stomata size (20-40um), I designed vertical hydrophobic lines 40 um wide, with 3, 7, 15, and 31 pixels of hydrophilic area in between the lines. A 100% hydrophilic control was printed next to the pattern samples.

Results

The pattern with a 600um hydrophilic gap between 40 um hydrophobic lines had the highest water collection rate. It collected around 2.6 times more water than the 100% hydrophilic control. The periodic hydrophobic lines reshaped the water droplets by repelling them from expanding in a horizontal direction. The droplets could only extend in the vertical orientation, which helped them overcome the pinning force and transport down quickly.

Conclusions

This study approved the concept of applying a micro-pattern on a material surface to improve its moisture harvesting abilities through increasing the droplet transportation rate. This project has a wide range of applications, including improving current 3rd world country fog collecting devices, clothes or tents that collect moisture for areas with limited resources, self-cleaning solar panels/windows, etc.

Summary Statement

I biomimicked Torrey Pine needles' alternating hydrophilic and hydrophobic surface properties to fabricate a micro-pattern that collects 2.6 times more moisture than a purely hydrophilic surface and demonstrated the theories behind it.

Help Received

My mentor, Dr. Pao Chau from Torrey Pines Docent Society, suggested reference papers to read and reviewed my results. Peter Fellingham, my robotics coach, helped construct my vapor box after I designed a prototype. In previous years, I used an ESEM from UCSD and Keyence 3D Microscope from Cymer