CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
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Project Number
S1916

Project Title
A Novel Water Source: Biomimicry Study of Torrey Pine Needles for Moisture Harvesting (A Second Year Study)

Abstract

Objectives/Goals
Torrey Pine (TP) trees are well known for their ability to efficiently harvest fog and survive under drought conditions. The mechanisms for moisture harvesting have not been revealed. This study is focused on learning its surface properties and structure in a microscopic level. The results of this study may be utilized with biomimicry to develop a material or device for water harvesting.

Methods/Materials
Most of my important findings were generated from inexpensive tools purchased from Amazon: Portable Digital Microscope 800x Magnification; Home Ultrasonic humidifier; Electronic Milligram scale; Spray bottle and dyes. I used unconventional testing methods such as time resolved video analysis to study water uptake. Using differential weight analysis, the noises in my experiments were filtered when collecting water harvesting data. An FEI SEM and Keyence 3D Digital Microscope were used to observe the microstructure.

Results
A TP needle surface has alternating ridges and valleys. Ridges on a needle are hydrophilic. Valleys contain rows of stomata, which is highly hydrophobic. A micro-pattern of alternating hydrophilic and hydrophobic stripes was identified for TP needles.With two rough surfaces and one smooth surface, I found out the water drops can be absorbed by both needle surfaces directly! This was captured in a video under a microscope. A water droplet absorbing time ranged from several seconds to 2 minutes. Needle tip orientation plays an important role in moisture harvesting. TP needles harvest 2x more water than Jeffrey Pine needles with the needle tip-up orientation.

Conclusions/Discussion
For the first time a micro-pattern of alternating hydrophilic and hydrophobic stripes on TP needle ridges and needle valleys was identified and plotted! It reminded me of the hydrophilic and hydrophobic pattern on the darkling beetle's shell, which hydrates the beetle with condensed dew collected in the dessert. A water uptake effect was observed on TP needle surfaces through video recordings. I also concluded that stomata don't contribute to moisture harvesting. The needles in the tip-up orientation harvest 50% more moisture than the tip-down orientation.

Summary Statement
I explored how the surface structures and surface properties contribute to the moisture harvesting ability of the Torrey Pine needles in order to biomimicry a material or device for efficient water collecting.

Help Received
I am very thankful to my project mentor Dr. Pao Chau from Torrey Pines Docent Society. His curiosity for nature and dedicated working ethic, despite in retirement, has inspired me so much; I would also like to thank Dr. Liu who sponsored my access to an SEM in a UCSD lab. Also, thank you to ASML, who