Biomimicking Torrey Pine Needles: Atmospheric Moisture Harvesting through Hydrophilic and Hydrophobic Micro-Patterns

Tianshi, Emily (School: The Cambridge School)

There are 1.1 billion people who lack access to freshwater globally. Harvesting moisture from the air is an innovative way to alleviate the freshwater crisis. Torrey Pine tree needles are well known for their ability to harvest water from fog. This study is focused on learning their surface structures and properties at a microscopic level, identifying the characteristics that contribute to efficient harvesting, and developing an efficient moisture harvesting material or device. Torrey Pine needle surfaces contain an alternating hydrophilic/hydrophobic micro-pattern. I hypothesized that such micro-patterns increase water droplet mobility and improve the moisture harvesting rate compared to homogeneous hydrophilic surfaces. The micro-patterns were fabricated using hydrophobic toner laser printed on hydrophilic transparency film. Dividing a hydrophilic surface with vertical hydrophobic lines increased the moisture harvesting rate by as high as 2.6 times compared to a homogeneous hydrophilic control. The periodic hydrophobic lines were observed to reshape the water droplets by repelling them from expanding horizontally. Droplets can only extend in a vertical orientation, which helps them drip down quickly. In contrast, water droplets attracted to the homogeneous surface and expanded in all directions. Water droplet mobility tests indicated that it is easier for a droplet to roll off the micro-pattern than a purely hydrophilic surface. For a given droplet size, the critical roll-off angle is on average 22° less than that of a homogeneous surface. At a given angle, the critical mass on the micro-pattern is smaller than a homogeneous surface. Aside from these three ways to demonstrate my hypothesis, I also interpreted the results with a theoretical equation.

Awards Won:

Second Award of $1,500