Trapping butterfly wings' qualities

4 January 2012, By Katharine Gammon

Credit: jikatu via flickr

Butterflies have inspired humans since the time of ancient Egypt, but now they're also inspiring researchers to look toward nature to help create the next generation of waterproof materials for electronics and sensors.

A team of researchers from the United States and South Korea looked to the eye-catching blue wings of the male mountain swallowtail butterfly when they wanted a natural model for making better materials. The wings shed water easily because of tiny structures that trap air and create a cushion between water and wing which allows water to roll easily off the surface. Because of the unique structure of the wing with miniscule hills and valleys, the surface tension of the water droplet is higher than the tension between the water and the wing -- enabling droplets to push off cleanly from the wings.

Engineers have long sought to create similarly water-repellent surfaces, but past attempts at artificial air traps tended to lose their contents over time due to external perturbations. In Australia, where the mountain swallowtail lives, the butterfly can be spotted at a distance of hundreds of meters away as sudden bright blue flashes.

"Mimicking biological surfaces in nature is an important part in a variety of practical applications," said Sang Ho Yun, a researcher in materials physics at the Royal Institute of Technology, in Kista, Sweden and the lead author of the new study, which will be published in an upcoming issue of the journal Applied Physics Letters.

To create a new material, the researchers used a unique etching process to carve out tiny bumps and grooves on a wafer of silicon that trap both air and light, making a surface that eschewed water even under harsh conditions. They used many layers of silicon to trap air, and the intricate structure of pores, cones, bumps, and grooves also succeeded in catching light, almost perfectly absorbing wavelengths just above the visible range.

"Owing to the simple fabrication technique, the present approach will certainly expand to generating other biomimetic surfaces on various organic and inorganic materials," said Yun.

According to Yun, the unique structure can be used as a model structure for studying other surfaces that could be made water-resistant for a long period of time. The biologically inspired surface could find uses in infrared imaging detectors, chemical sensors, and devices that combine electrical and optical components.

Other researchers have also found inspiration in the tiny bumps and brilliant colors of butterfly wings. According to Di Zhang, Director of State Key Lab of Metal Matrix Composites at Shanghai Jiao Tong University in China, most of the interest in butterfly wing scales comes from the tiny subtle microstructure. His group works on replicating the optical structure of the wings to create improved solar cells with a better ability to absorb light and convert it to electricity.

Zhang said that the etching process used by the other team is a very effective way to mimic the wings' natural structure in the lab.

"Moreover, they may have found the key structure parameters which have an influenced on the hydrophobicity," Zhang said, adding that those structures can help to create both waterproof and self-cleaning materials.

Other researchers point out that there are more ways to take cues from the natural world. According to Glen McHale, a professor of materials physics at Nottingham Trent University in Nottingham, U.K., some diving insects have sparse, rigid waterproof hairs to create a kind of shell for underwater breathing, and then have a denser set of hairs to prevent drowning if the first layer is penetrated -- and the new material takes a similar approach with its grooves and ridges.

McHale adds that butterflies are a good model for biomimicry experts because they are large enough to fly in the rain, while smaller insects hurry for cover. Their wing surfaces are covered in overlapping scales so they do not retain water and become heavy. Several recent studies have shed light on the inner workings of those scales in nature: they typically bend, but do not collapse, under the pressure of a water droplet. The scales can also shoot water in a particular direction, but removing them by damage or mutation will reduce the lifespan of the insects.

Provided by Inside Science News Service
APA citation: Trapping butterfly wings' qualities (2012, January 4) retrieved 29 October 2020 from https://phys.org/news/2012-01-butterfly-wings-qualities.html