NPG Asia Materials research highlight | doi:10.1038/asiamat.2011.21
Published online 07 February 2011

Bioinspired polymers: Driving droplets

Polymer fibers that mimic the structure of spider silk can condense water from moist air and collect the droplets together.

The ability to drive liquid drops in a specific direction is of interest for the development of devices that can collect water from moist air. Moving relatively large drops of liquid — with volumes in the hundreds of microliters — can be achieved by creating surface gradients. This is more difficult to achieve with smaller drops, however, because surface tension effects mean that the droplets experience a much larger resistance to movement. Nature has already conquered this problem — the silk fibers of spider webs are highly efficient at condensing moisture from the air then collecting the droplets of water together.

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Yongmei Zheng from the Beijing University of Aeronautics and Astronautics along with Lei Jiang from the Institute of Chemistry Chinese Academy of Sciences and co-workers have now produced artificial polymer fibers that mimic this effect[1]. “When moisture condenses on a natural spider web, the structure of the silk thread changes to form ‘spindle’ knots periodically along its length,” explains Zheng. “The energy of surface interaction and pressure differences due to the change in surface curvature cooperate to drive the water droplets towards the knots, where they coalesce.”

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To produce a similar structure, the researchers dipped nylon thread into a polymer solution and then drew the thread horizontally. This procedure caused small polymer droplets to form along the length of the thread, forming artificial spindle knots on drying.

Droplets of water on the polymer-knotted nylon behaved similarly to those on spider silk. The conventional explanation for the phenomenon is that the droplet is driven toward a more wettable region of the fiber. Zheng, Jiang and their co-workers, however, showed that on this scale such a mechanism is not the dominant force: changing the polymer to a less wettable type did not reverse the direction of movement.

“We have found that on polymers with a rough surface, droplets always move towards knots, regardless of hydrophobicity,” says Zheng. “On a smooth surface, droplets move away from the knots if the polymer is hydrophobic, and towards them if it is hydrophilic.” These findings may help in the design of smart materials that drive water droplets in a controllable manner.

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Reference

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This research highlight has been approved by the author of the original article and all empirical data contained within has been provided by said author.

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NPG Asia Materials ISSN 1884-4049 (Print) ISSN 1884-4057 (Online)