Capillary flow is harnessed for the first time

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Capillary flow is a common phenomenon inherent in everyday tasks, from wiping up spills to watering plants. Credit: KTH Royal Institute of Technology

You may never have heard of the capillary effect, but it's something you deal with every time you wipe up a spill or put flowers in water. Wouter van der Wijngaart has spent most of his life contemplating this phenomenon, which enables liquid to flow through narrow spaces like the fibres of a cloth, or upwards through the stems of flowers, without help from gravity or other forces.

Now, for the first time, he and a team of scientists, from KTH Royal Institute of Technology in Sweden, have found a way to fully control capillary action, and they've designed a device that harnesses it for possible use in biotech applications such as biomolecular analysis and body fluid handling.

"Capillarity is a very common phenomenon that we now have dissected into its details and turned into an engineering device, that is, a simple pump which we fully control," says van der Wijngaart, a professor at KTH.

Capillary flow is independent of gravity. In fact, it actually acts in opposition to gravity. "I have been tinkering about capillarity since I was 14, when we learned about it at school and I raised questions that my teachers couldn't answer," van der Wijngaart says. "I wondered why water flowing against gravity couldn't be used to create a perpetuum mobile (a motion that continues infinitely), and today I ask my students each year to explain this."

The phenomenon is an interplay between two kinds of forces, cohesion and adhesion. Cohesion is the attraction between similar types of particles, such as water molecules. And adhesion is the attraction between different kinds of particles, such as water and the fibres of a towel. When adhesion is stronger than cohesion, capillary action occurs.

The rate of capillary flow is still affected by the viscosity of a fluid and the geometry and surface energy of the surfaces of the channels through which it flows. Yet, after five years of study, the researchers have managed to make these variations negligible. In a series of three publications, they first showed how to make the flow constant in time;

then independent of viscosity; and, finally, independent of the surface energy.

Reporting in Microsystems & Nanoengineering, the researchers tested pumps of their new design with a variety of sample liquids, including water, different samples of whole blood, different samples of urine, isopropanol, mineral oil and glycerol. The capillary filling speeds of these liquids vary by more than a factor 1000 when imbibed by a standard constant cross-section glass capillary, van der Wijngaart says.

By contrast, the new pump design resulted in flow rates in a virtually constant range with a variation less than 8%, the researchers report.

More information: Weijin Guo et al. Capillary pumping independent of the liquid surface energy and viscosity, *Microsystems & Nanoengineering* (2018). DOI: 10.1038/s41378-018-0002-9

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