Going With The Flow

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As our technology shrinks ever smaller, commercial manufacturing and biological and medical research follows suit. Sometime in the relatively near future, asserts Joel Koplik, a professor at the City College of the City University of New York, there will be a need for new techniques that allow commercial and research interests to control liquids at the nanoscale.

Along with colleagues Marek Cieplak from the Polish Academy of Physics in Warsaw and Jayanth R. Banavar at Penn State, Koplik is working on ways that the manipulation of fluids on the smallest workable scale could be managed.

Koplik and his colleagues have developed a simulation that shows how fluids can be contained without using the obvious method — small, closed nanotubes. *Physical Review Letters* published a portion of their work on March 23. Koplik believes that these tubes are not only unnecessary, but also impractical: “A closed nanotube is not easy to fabricate, it is easy to clog, and it is hard to control anything inside of it. Instead of having liquid confined by walls, have it controlled in other ways.”

The other way Koplik, Cieplak, and Banavar envision is the use of chemically patterned solids to contain the flow of water. Their system involves a solid that has a specific chemical pattern. This chemical pattern looks like a complex highway, with “roads” that branch out from a main “thoroughfare” and then merge back together or divide into new roads. The patterns are wetting regions. Wetting is a term that describes a portion of the solid that is highly attractive to a liquid or a gas. When one is working on such a small scale, liquids or gases prefer to be near regions of solid that are wetting, while avoiding regions that are not, and gravity is negligible so there is no spillage. The wetting regions are so attractive, explains Koplik, “that it is possible to make fluids flow at the nanoscale without spilling by applying body forces, like electrical or centrifugal forces.”

Now that it appears possible to create fluid containment in this manner, new questions crop up, mainly: How does one control the fluid motion in better detail? Answering this question is Koplik’s main interest. “Right now,” he tells *PhysOrg.com*, “the fluid chooses a branch to follow spontaneously. The idea is to be able to make it go a particular direction.” He is also working on ways to perhaps split the flow that some of the fluid follows one brand at the “fork in the road” and some of it follows another brand. But there is a catch: “You want to be able to ideally control how much goes down one side and down the other. It’s not just a matter of some going here and some going there. You want to have control of the relative volumes.”

Another issue Koplik and his colleagues need to address are the different properties of different liquids. One problem Koplik sees is the desire for the fluid manipulated at the nanoscale to be water, which is the preferred liquid in biological and medical settings. However, water is quite volatile and nanoscale volumes of it are likely to evaporate at room temperature, limiting its usefulness at the nanoscale. He is pursuing the idea of having water on a wetting region, surrounded by another, less volatile, liquid to prevent evaporation. The extra effort needed in fabrication may be compensated for by better flow control.

If Koplik and his peers can figure out how to harness the system they have discovered, the opportunities in science and technology are numerous. Applications including microscopic fluid analysis and chemical detection in "labs on chips" would be possible. Additionally, Koplik points out the advantages of being able to efficiently move molecules around. And in biological and medical research, controlling fluid flow at the nanoscale can mean a better detection of pathogens.

"This is on the verge of being commercially viable," explains Koplik. "We are trying to anticipate the direction things are going, which is smaller and smaller. We're trying to develop techniques and theories so that when the commercial community wants to go there, they can."

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