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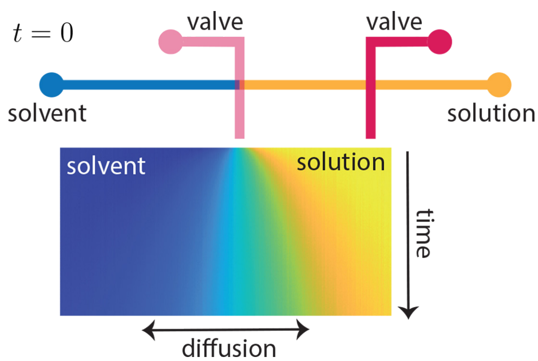
Controlling valves to trigger interdiffusion between two liquids and prevent convection enables monitoring of concentration gradient with time.



Diffusion is often the rate-limiting step in many chemical processes and thus a key element of their modeling and optimization. In complex fluids, measurements of diffusion, especially at high concentrations, are lacking, despite being relevant for important processes like thin film drying.

Unwanted flows, such as free convection, can interfere with and mask diffusion. Nguyen et al. developed a microfluidic chip that combines multilayer soft lithography and pneumatic microvalve technology to measure diffusion while preventing convection.

The device begins by opening a valve between water and a solution, triggering their interdiffusion. Another microvalve in the channel closes and suppresses convection. At that point, the microfluidic channel contains an initially steep concentration gradient between of two liquids. Monitoring the temporal relaxation of this gradient allows the measurement of the diffusion coefficient under diffusive transport conditions.

"This device allows the measurement of diffusion coefficients 'under the eye of a microscope', in quasi-ideal experimental conditions," said author Jean-Baptiste Salmon. "Despite the precise control of the conditions brought by the microfluidic dimensions, our approach also reveals the inevitable presence of interfacial-driven transport phenomena (diffusiophoresis and diffusioosmosis)."

The team believes the device could be used to better characterize these two concentration gradient-induced effects, which encompass, respectively, the spontaneous motion of particles and the flow of solution relative to a surface.

"We also plan to exploit the partial vaporization of water through the soft matrix of the chip to pre-concentrate liquid mixtures, and thus be able to study the diffusion in highly concentrated, or even nearly solid, complex fluids," said Salmon.

Source: "Microfluidic free interface diffusion: Measurement of diffusion coefficients and evidence of interfacial-driven transport phenomena," by Hoang-Thanh Nguyen, Anne Bouchaudy, and Jean-Baptiste Salmon, *Physics of Fluids* (2022). The article can be accessed at https://doi.org/10.1063/5.0092280.