On the nanoscale, particles flow in unexpected ways

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Researchers studying how fluids travel through nanoscale channels were surprised to discover that the fluids don't flow equally well in all directions. Contrary to the behavior in the macroscale world, the researchers discovered that methyl alcohol, when it was placed in a network of nanoscale channels in a mineral known as a zeolite, diffused 1,000 times faster in one direction than another. This is the first known evidence of such highly unequal diffusion of molecules in a nanoporous material. This highly lopsided flow occurred despite the fact that the diameters of the respective channels are quite similar. In the mineral, two types of nanoscale channels are present: 8-ring and 10-ring channels. The numbers refers to the relative size of the pores in the material, though they are extremely close in size with only subtle differences in geometry. The methyl alcohol molecules were stored initially inside an optical cell.

At the beginning of the experiment, the pressure in the surrounding atmosphere is increased instantaneously and kept constant for the rest of the experiment. The methanol molecules then enter the zeolite voluntarily since they naturally prefer to be in the zeolite than in the gas phase. Once inside the mineral, the researchers measured the particle concentration at various points along the pores. From these profiles, they were able to calculate the particle flux (number of particles that cross a certain area in a certain time) and observed the highly biased flow.

Earlier research reported that the diffusivity of a guest molecule inside a pore network is extremely sensitive to the ratio of the pore window and molecule diameter, particularly if both quantities are close to each other, as was the case with the zeolite channels and the methyl alcohol atoms. The researchers in this study speculate that since the 8-ring window is slightly smaller than the 10-ring window, a smaller diffusivity (and therefore a smaller flux) might be expected. Another reason might be the different pore geometry (straight in the case of the 10-ring channels versus windows and cavities in the 8-ring channels).

Presented in the AIP's *Journal of Chemical Physics*, this apparently counterintuitive discovery has far-reaching implications for the understanding, development, and exploitation of novel microscopic materials, including nanotubes and "intelligent" cell membranes for purposeful drug delivery, the functionality of which is based on an extreme direction dependence of molecular mobilities.

More information: "Micro-imaging of transient guest profiles in nano-channels" by F. Hibbe et al. is accepted for publication in the *Journal of Chemical Physics*.

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