

A vacuum set-up for fundamental studies of self- and transport diffusion in porous media

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Diffusion in disordered porous media attracts a lot of attention because of its considerable importance to industrial processes, such as molecular separations, heterogeneous catalysis and oil recovery [1]. In heterogeneous catalysis, the molecules diffuse through the pore network and react on the active sites on the pore walls. The geometrical disorder of porous systems intensely influences molecular transport processes that occur inside the pore network [2]. In mesoporous materials, Knudsen diffusion is often the predominant transport mechanism for gases, where the mean free path of the molecules is much larger than the pore diameter, so that molecule-wall collisions dominate molecular transport.

Despite its practical relevance, direct experimental insight of the effect of fractal surface roughness on Knudsen diffusion in porous media has never been obtained. This may be due to the complexity of real porous media, where effects of pore shape, surface roughness, and pore connectivity are combined. Modeling [2,3] nevertheless suggests significant effects of fractal surface roughness on Knudsen diffusion. Such theoretical results can form the basis for comparison with carefully designed experiments on model pores or porous media to validate the theory.

Here, we propose experiments that emulate processes that occur in disordered mesoporous media, on a macroscopic scale, by using a special designed high-vacuum system and 3D-printed channels to investigate features of complex porous media, such as fractal pores [3]. This set-up allows us to validate Knudsen diffusion theory in complex geometries more directly than has ever been the case. Some preliminary results will be shared, including features of the vacuum set-up, and Knudsen diffusion results in channels of varying geometry, including channels with a 3D-printed fractal surface.

References

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