Single-File Diffusion of Mixed and Pure Gases by High Field NMR

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Molecules restricted to diffuse through unidimensional channels – channels so narrow that molecules cannot pass each other – may exhibit single-file diffusion (SFD). Here we report the first experimental evidence of SFD in a mixture of different types of diffusing species (Figure 1).

^{13}C NMR diffusometry using high magnetic field (17.6 T) NMR and ultra-high magnetic field gradients (up to 30 T/m) revealed single-file diffusion in dipeptide nanochannels for one-component CO and CH_4 gasses as well as for a gaseous mixture of CO and CH_4.

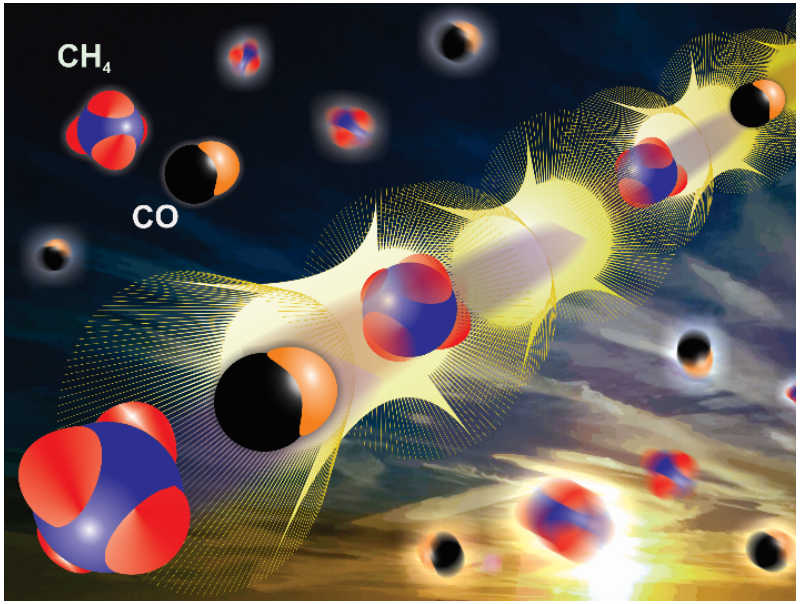

Figure 1. Schematic presentation of SFD in a nanotube.

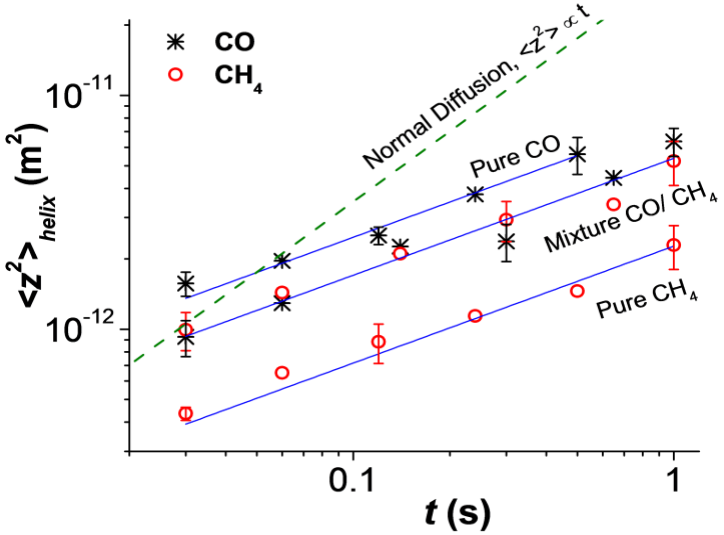

Figure 2. Measured time dependence of the MSD at 298 K.

While CO and CH_4 individually have different SFD mobilities, we demonstrate that both species start exhibiting the same SFD mobility when mixed (Figure 2). *In contrast to the relationship commonly observed for normal diffusion of mixed gasses, the mobility of the mixed gas in the unidimensional channel is only slightly smaller than that of pure CO, and much faster than pure CH_4.*

Recent theoretical and computational studies suggest that induction of single-file conditions in nanoporous membranes and catalysts can lead to a dramatic enhancement of the performance of these systems in separations and catalysis. *Our work utilizes high magnetic fields to pioneer experimental studies of this performance enhancement.*

Facilities: AMRIS (17.6 T NMR spectrometer), University of Florida

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