Molecular Permeation in 2D Silicon Dioxide

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2D silicon dioxide or bilayer silica was discovered in 2010 and since then has been thoroughly characterized in a supported form by surface-sensitive techniques. It is composed of corner-sharing [SiO_4] tetrahedra that organize into either a hexagonal lattice or a vitreous network of four- to nine-membered rings. Unlike graphene and similar single-layer structures, the pores in bilayer silica appear large enough for the translocation of small molecules. In this work, we for the first time isolate free-standing sheets of 2D SiO_2 and carry out direct mass transfer experiments [1-3]. The material preparation is done by atomic layer deposition (ALD), and sensitive gas permeation measurements are combined with quantitative adsorption studies. It is shown that regular gases do not permeate through the vitreous polymorph whereas vaporous substances like water readily cross its natural openings. The passage of the vapors is understood in terms of the surface-mediated flow, and the membrane selectivity is demonstrated to depend on the strength of gas-surface interactions. As illustrated in Figure 1, bilayer silica further enables size exclusion for chemically alike species which is associated with distinct energy barriers for entering the structure. Thus, 2D silicon dioxide proves to be an inherently open material with a high areal density of well-defined pores.

References

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Figures

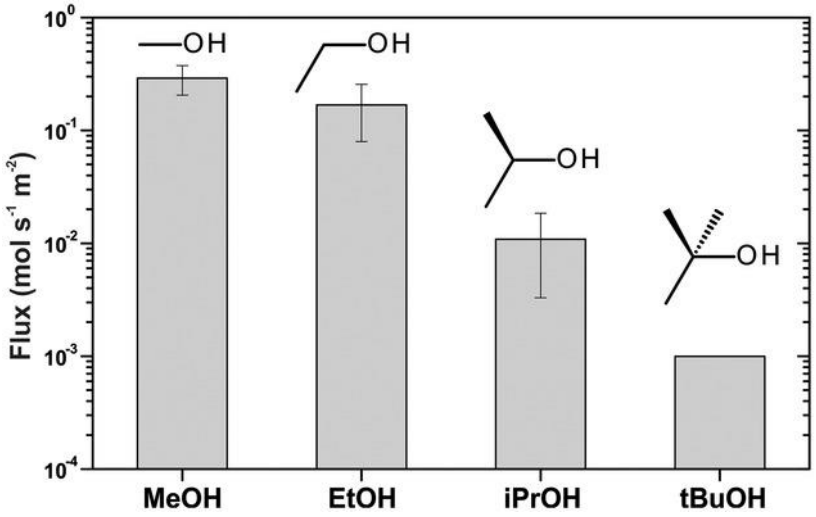

Figure 1: Transmembrane flux of alcohol molecules in vitreous bilayer silica. Adopted from ref. [1].