Controllable Nanometer-sized Valve Using a Zeolite Membrane

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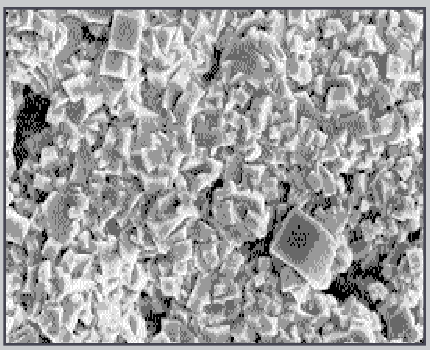
Background

Zeolites are crystalline structures made up of "T-atoms" which are tetrahedrally bonded to each other with oxygen bridges. Because of the regularity of the crystalline structure and the pores with angstrom size dimensions, these crystals, when grown together to form a membrane, can operate as separations devices for gas and liquid mixtures. These membranes have advantages over other types of membranes in that they are highly stable under thermal cycling, high temperatures, and harsh physical and chemical environments which other membranes cannot withstand. (See figure at below, a SEM image of a zeolite membrane grown on a sintered stainless steel support.)



Zeolites can be size and shape selective - more easily allowing straight-chain than branched hydrocarbons to pass through, for example. When used for catalytic reactions, they can be intermediate or product shape selective as well. However, separations using zeolite membranes are not always based simply on size or shape of the diffusing species. When interactions between the surface and the diffusing molecules are important, adsorption or surface diffusion can dominate the transport. In these cases, separations where the larger molecules preferentially pass through the membrane can occur. Additionally, "non-zeolite" pores (pathways through the membrane such as those between crystals or any pathway other than the well-defined zeolite pores) can exist in the membrane. Transport of molecules through these non-zeolite pores can be in series with or in parallel to zeolite pore diffusion.

Technology

A University of Colorado research team led by John Falconer and Richard Noble has developed a polycrystalline MFI zeolite layer, prepared with two types of pores, which behaves as a chemically-activated and chemically-specific nanometer-sized valve. The layer consists of zeolite crystals with ~0.6 nm zeolite pores and larger pores (0.6 – 4 nm) that are spaces between the crystals. Most gas and liquid flow is through these larger pores, which reversibly close and open due to adsorption in and desorption from the zeolite pores respectively. The valve closing is chemically specific and highly sensitive. A combination of vapor- and liquid-feed flow measurements, for both single components and binary mixtures, clearly demonstrated this behavior. This novel zeolite nano-valve has potential for many applications, including separations, chemical sensors, and controlled release of molecules.

Key Documents

Valving and Storage Using Molecular Sieve Membranes. U.S. patent application filed December 14, 2009.