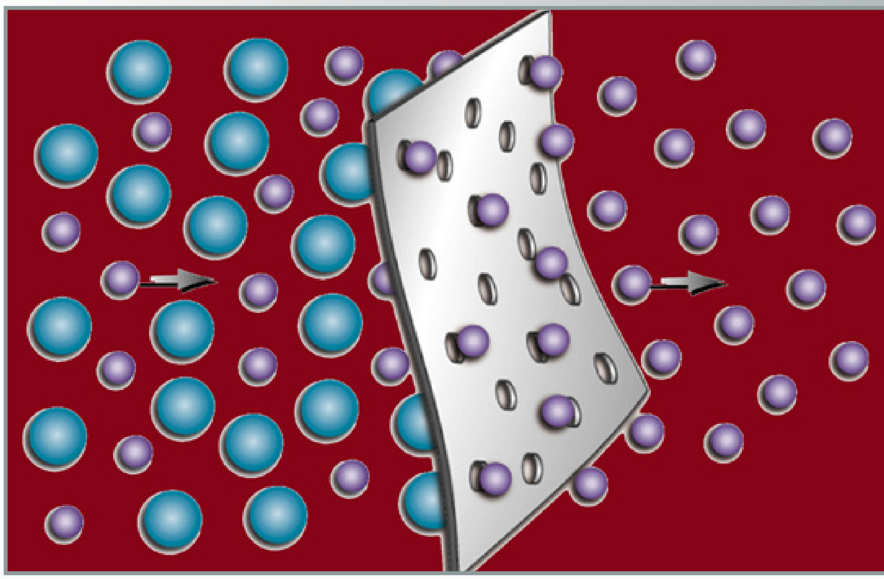
Novel Nanopore Membrane Technology Recovers Energy from Industrial Effluents

UT-B ID 200902330



Technology Summary

A vast amount of energy is wasted in the United States from the exhaust/effluent streams of an estimated 163,000 commercial and industrial boilers. Much of this energy could be recovered by sieving the streams through inorganic membranes featuring nano-sized pore technology. The estimated savings by 2030 for energy recovered from <1000 bark boilers and paper machine exhaust hoods is about 1.3 tera-Btu. A cumulative savings of 360 tera-Btu could be recovered from heat currently lost to the environment, if the technology was implemented throughout the United States.

Researchers at ORNL have developed an inorganic membrane fabrication technology that would permit the recovery of such previously wasted energy from relatively low temperature (<100°C) exhaust/effluent streams. The process involves removing moisture from the exhaust streams and recovering the latent heat when water condenses in the membrane. The heat recovered could serve to preheat the boiler feed water, thus providing an energy savings.

The membrane developed by the researchers at ORNL features pore diameters as small as 0.5 nm to 20,000 nm, and testing has shown effectiveness at many scales. The support structure and layer for the membrane can be made of a variety of metals and ceramics. Thin ceramic separation layers, for example, allow a high flow of gases through the small pore membranes (<100 nm). Porous metal layers applied to tubular porous stainless steel supports yield filters with pore sizes from 0.05 to 1 µm. Their mechanical, thermal, and chemical stability can be tailored by a choice of materials.

As gases and effluent are transported via molecular diffusion, these membranes separate constituents from the flow by Knudsen diffusion, molecular sieving, capillary condensation, surface flow, or a combination of these transport mechanisms. The key to the design is permeance and separation factors: a balance between the volumetric flow rate per unit surface, per unit of transmembrane pressure, and the ratio of flow of two gases in a binary gas mix.

The membranes have shown effectiveness in using molecular sieving to separate hydrogen from coal-derived synthesis gas and from refinery gases. They can separate carbon dioxide, a component of many gas streams, including synthesis gas and flue gas, by Knudsen diffusion, molecular sieving, surface flow, or a combination of these. Carbon dioxide can be separated from the gas stream as the permeate or as the rejected component, by choosing a membrane with the proper pore size and operating temperature.

Advantages

The inorganic membranes can improve energy recovery from low temperature, moist industrial process streams. Metallic-based membranes are capable of performing in exhaust streams containing particulates and gaseous contaminants. Membranes can be operated at high temperatures and pressures. Materials can be selected to provide long life in corrosive environments. Boiler efficiency can be improved from 87% to 94%.

Potential Applications

Potential applications are in gas separation, water purification, energy and water recovery from industrial process streams, and solid oxide fuel cells.

Patent

Application in preparation

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