

Membrane Technologies for Recovery of Volatile Organic Compounds

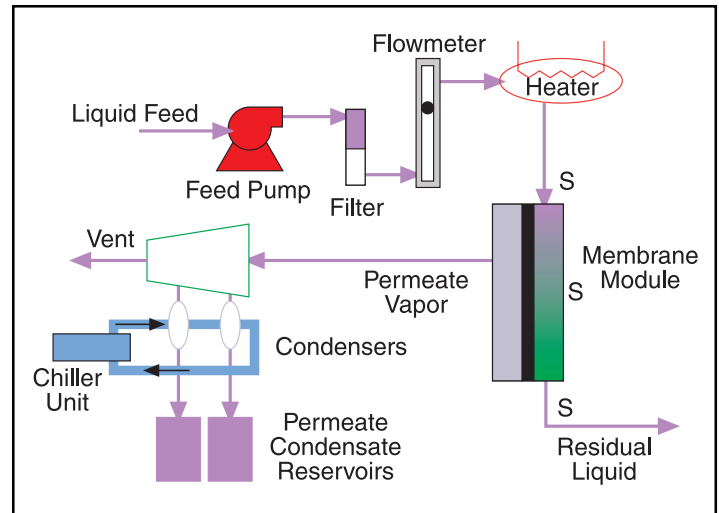
National Risk Management Research Laboratory,
Sustainable Technologies Division,
Clean Processes and Products Branch

Purpose & Goals:

- Investigate and verify a specific application of pervaporation pertaining to aquifer/soil remediation
- Generation of reusable, non-contaminated isopropyl alcohol (IPA) and surfactant “carriers”
- Solvent reclamation and reuse

Background:

Pervaporation is a process in which a liquid stream containing two or more components is placed in contact with one side of a non-porous polymeric membrane while a vacuum or gas purge is applied to the other side. The components in the liquid stream sorb into the membrane, permeate through the membrane, and evaporate into the vapor phase (hence the word pervaporate). The vapor, referred to as “the permeate”, is then condensed. Due to different diffusion rates through the membrane, a component at low concentration in the feed can be highly enriched in the permeate. Concentration factors range from the single digits to over 1,000, depending on the compounds, the membrane, and process conditions.



Membrane Materials:

- Silicone Rubber
- Ceramic Supported Polymers
- PEBA

Membrane Types:

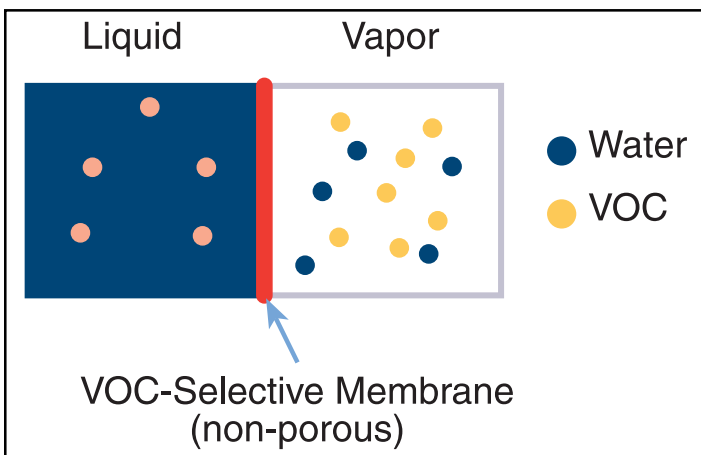
- Flat Sheet
- Hollow-fiber
- Spiral Wound

Applicable Aqueous Wastestreams:

- Groundwaters
- Lagoon Waters
- Leachates
- Rinseates
- Surfactant - VOC Solutions
- Industrial Process Streams

Typical VOC Contaminants:

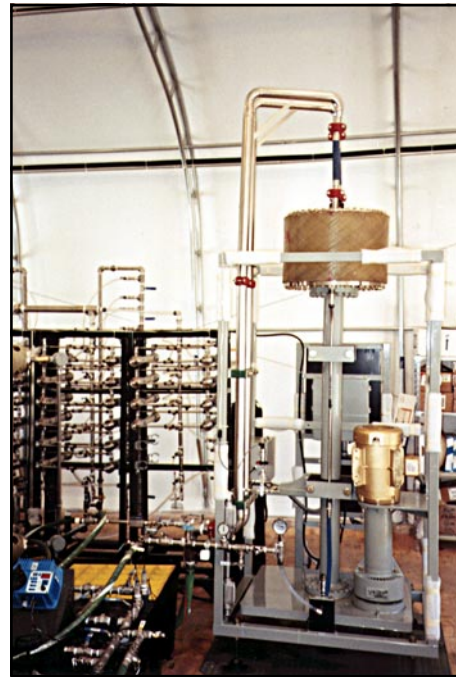
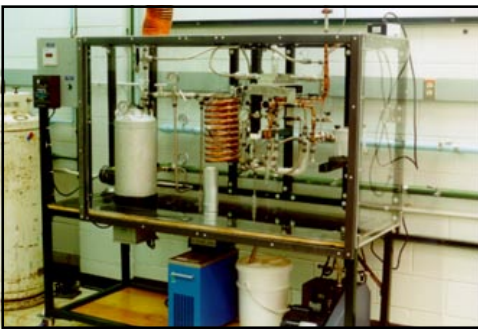
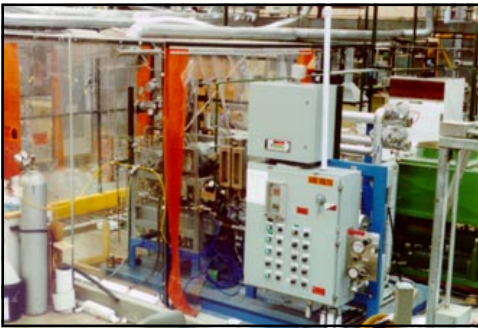
- Carbon Tetrachloride
- Toluene
- Benzene
- Trichloroethylene
- Perchloroethylene
- Methylene Chloride
- Trichloroethylene



Research Objective:

For over seven years, EPA's National Risk Management Research Laboratory (NRMRL) has maintained an active in-house pervaporation research program. Early work dealt with the removal of multiple volatile organic compounds (VOCs) from water using existing and novel membrane materials. During the mid-90s, research focused on recovering VOCs from surfactant solutions, thereby enabling the reuse of the surfactant solutions. EPA demonstrated that trichloroethane and toluene could be removed from surrogate anionic surfactant solutions with no deterioration in performance over several months. In August 1996, 5000 gallons of a surfactant enhanced aquifer remediation (SEAR) solution from Hill Air Force Base in Utah was trucked to Cincinnati, Ohio. The VOC removal performance of the pilot-unit with the actual SEAR solution was comparable to that with the laboratory prepared solution. In 1998, work focused on testing spiral-wound modules, various flow configurations of hollow-fiber modules, and vibratory shear enhanced process (VSEP) membrane stacks.

During spring of 1999, the EPA participated in a DOD-funded demonstration of *in situ* soil flushing and pervaporation treatment technology at Marine Corps Base Camp LeJeune in Jacksonville, North Carolina. Over a two-month period, an aqueous solution of surfactant, isopropyl alcohol, and calcium chloride was injected into a contaminated aquifer to flush dry cleaning solvent (primarily perchloroethylene (PCE)) from the soil for extraction and pervaporation treatment. The pervaporation treatment system (operating continuously for 70 days at one gallon/minute) successfully met the State of North Carolina's 95% removal requirement. Influent PCE concentrations varied from 350 to 1,000 mg/L with an average PCE removal of 99.95% in the absence of surfactant and 95.6% removal in the presence of surfactant. The surfactant and alcohol in the process stream also were recovered and reused using an ultrafiltration and pervaporation system, respectively. The pervaporation treatment system is currently being modified and tested at the T&E Facility with surrogate solutions from the Marine Corps Base Camp LeJeune demonstration site.



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