Greenhouse Gas Capture – Recent Results

Sandra E. Kentish[a*], Liang Liu[b], Elaheh Hosseini[a], Moataz El-Okazy [a] ,Forbes McGain[c]

[a] Department of Chemical Engineering, The University of Melbourne, Parkville, Victoria 3010, Australia

[b] CSIRO Mineral Resources, 1 Technology Court, Pullenvale, Queensland, 4069, Australia

[c] Department of Anaesthesia and Intensive Care, Western Health, St. Albans, Victoria 3054, Australia

* Corresponding author: sandraek@unimelb.edu.au

Abstract:

This presentation will give an overview of our recent results in membrane gas separation for the purpose of greenhouse gas reduction.

Approximately 250,000 general anaesthetics are performed in Victoria annually, amongst millions globally. These general anaesthetic gases are expensive and they have high global warming potential (between 130 and 2540 times that of CO_2). Virtually all of the anaesthetic gas breathed in by the patient is later breathed out unaltered to the atmosphere, contributing to global warming. There are thus both financial and environmental drivers to reduce the emissions of anaesthetic gases to the atmosphere.

A number of devices have been developed to capture these gases, so that they do not escape into the atmosphere. However, in most of these devices, the gases are not recovered for reuse. In this work, we present an alternative design, where the anaesthetic gas is retained within the breathing circuit by a membrane, which permeates the lighter gases, namely nitrogen, oxygen and water. We have tested a number of membranes for this purpose and found the optimal design to be a microporous 1,2-bis(triethoxysilyl)ethane (BTESE) membrane prepared by a sol-gel method. This inorganic membrane offers greater size selectivity than can be achieved with a polymeric membrane.

In the more traditional capture of carbon dioxide, solubility selectivity becomes as important as size selectivity and so polymeric membranes predominate. Here, our recent focus has been on perfluoropolymers. While more expensive, these materials have much greater resistance to the impurities that are likely present in biogas and natural gas. We confirm the work of other researchers that these materials also operate close to the upper bound for many gas pairs due to a strongly negative interaction with hydrocarbons. The interactions with CO_2 and with CH_4 can readily be described by both the dual mode sorption model and more sophisticated approaches, such as the Non-equilibrium lattice fluid (NELF) model. These solubility models can then be incorporated into a transport model, allowing the diffusion coefficients to be determined. We compare these diffusion coefficients to those calculated through molecular dynamics simulation. While the two approaches provide comparable data for smaller penetrants, they diverge for larger molecules. This divergence arises from the inability of the molecular dynamics approach to accurately model the larger glassy voids within such polymers.

Keywords: sevoflurane; gas separation; inorganic membrane; perfluoropolymer.