Porous Polymer Network
Membranes with Porous Molecular Additives for Post-Combustion CO₂ Capture

This project used novel porous coordination cages (PCCs) for the fabrication of mixed matrix membranes (MMMs) with a porous polymer network (PPN-125) for simulated flue gas separations of CO₂/N₂. Technical difficulties arising from the poor mechanical stability of the developed membranes and solubility of porous molecular additives in select solvents required for membrane manufacturing required an adjustment of the project plan. To address issues with the mechanical stability of the porous polymer membranes, the team utilized poly (ethylene glycol) diacrylate (PEGDA), a flexible polymer as matrix. To address the issues of the porous additives, the team produced several new porous molecular compounds as well as sending several amine-tethered microparticulate porous polymers to NETL for assessment as additives in membrane testing.

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Project Description:
Three steps were taken to achieve the strategy proposed by this project. Using porous coordination cages (PCCs) as molecular porous additives and porous polymer matrix, the team produced mixed matrix membranes (MMMs) with high permeability and selectivity. Step 1: The team prepared PCCs with high solubilities to allow the formation of homogeneous MMMs. Numerous PPCs were investigated for their solubility and workability of homogeneous MMM fabrications. Step 2: The team fabricated homogeneous MMMs based on selected PCCs and matrix (PPN-125 & flexible polymer matrix, PPN=porous polymer network). Poly (ethylene glycol) diacrylate (PEGDA) was selected out as the most potential matrix candidate. Step 3: The team tested the MMMs’ CO₂/N₂ separation performance.

Project Funding:
$203,000

Project Duration:
09/05/2018 – 05/31/2020

Technology Line:
Carbon Capture
Accomplishments:
Though many efforts were attempted on the fabrication of MMMs based on PPN-125 and cages, the poor mechanical property of PPN-125 introduced inevitable cracks to the MMMs. In this case, a more flexible polymer, PEGDA was utilized as the matrix and achieved excellent CO$_2$/N$_2$ separation performance after the combination with PCCs, especially with CO$_2$ selective PCCs, like UMC-1. With an increased loading ratio of UMC-1, the MMMs, based on PEGDA and UMC-1, presented improved separation performance.

NETL Collaboration:
During the project period, the researchers actively participated in the collaboration with NETL in many aspects. Regular UCFER project update meetings were held with NETL and discussions with NETL experts moved the project toward success. Aside from regular meetings and frequent communications, the team also shipped many functional porous materials to NETL, including modified ZIF-8, PPN-125, PCC-20c. Moreover, NETL helped a great deal in the gas separation testing.

Relevant Presentations: