IEAGHG Information Paper 2018-IP30; 2018 NETL CO_2 Capture Technology Project Review Meeting: Advances in membranes

This event collected the last advances on projects funded by NETL to study further membranes-based carbon capture technologies. Compared to other carbon capture conferences, it is interesting to see that high number of projects in that area. Membranes have been presented over the years as the alternative to chemical absorption which does not depend on steam requirements. Although the experience gained at large scale is limited, developers support their advances on modular systems which could be easily scalable. Capture rate of membranes-based systems is limited, although cheaper capture prices could make them economically convenient.

Regarding the projects presented during this review meeting, the focuses were:

a) development of new materials; b) scale-up and testing and large scale; c) production of membranes; and d) techno-economic analysis (TEA) to demonstrate cost reductions in the solutions proposed, compared with traditional chemical absorption.

For further information, the table below includes a description of the projects presented in the 2018 NETL CO_2 capture project review meeting.

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Project Title	Duration	Coordinator	Info	Website
Sorption enhanced mixed matrix membranes for hydrogen purification and carbon dioxide capture	01/10/2015 – 30/11/2018	State University of New York (SUNY)	This project includes the scale-up of polymer, Pd-based nanomaterials synthesis and the parametric testing (for H_2/CO_2 separation. Tests will be performed in the NCCC facilities	FE0026463
Zeolite membrane reactor for pre-combustion carbon dioxide capture	01/10/2015 – 31/01/2019	Arizona State University	The main objectives are to demonstrate a bench-scale zeolite membrane reactor for WGS reaction of coal gasification gas for hydrogen production (integration with IGCC power plant) and to evaluate the performance and cost-effectiveness for use in 550 MW coal-burning IGCC plant with CO_2 capture. Fabrication was optimized	FE0026435
Energy efficient GO-PEEK hybrid membrane process for post-combustion carbon dioxide capture	01/10/2015 – 30/09/2018	Gas Technology Institute (GTI)	The objective is to combine a conventional gas separation membrane unit and a solvent-based capture process that utilizes a novel hollow fiber membrane contactor unit (third generation PEEK fiber-based), aiming to reduce energy penalty and reach high capture rate (resulting in a 95% CO_2 gas). CO_2/N_2 selectivity is being studied (aiming >90%). Activated MDEA (aMDEA) was tested with simulated fluegas, achieving the aimed mass transfer (>3s^{-1}). 50h testing showed variation of performance and GO-based membranes (GO/EDA/PZ) showed good stability in the presence of fluegas contaminants such as NO_2 and SO_2 (CO_2/N_2 selectivity was greater than 200 h, maintained during 7h). Next step will include the TEA	FE0026383
Bench-scale testing of next generation hollow fiber membrane modules	01/10/2015 – 31/12/2018	American Air Liquide, Inc.	The main focus of the current project is to advance the novel high CO2 permeance PI-2 membrane material to commercial-scale 6inch modules for testing at NCCC (0.3MWe) and in another test facility (0.1MWe). Results are expected to be used for the TEA, aiming to reach a cost reduction of 30% compared to the basis case. Tests show successful conditions at specific testing periods (400 Nm^3/h (6inch)-90Nm^3/h (4inch), 58% permeate purity, 90% CO_2 recovery).	FE0026422
Novel CO2-selective membranes for CO_2 capture <1% CO_2 sources	01/03/2016 – 28/02/2019	Ohio State University	The project includes membrane synthesis, module fabrication, and membrane module testing. Good SW module stability was obtained during the tests (simulated fluegas containing CO_2, N_2, H_2O, O_2, and SO_2 and varying conditions using a 14,000cm^2 membrane). The CO_2/N_2 was around 200 and 500 h of operation were accumulated.	FE0026919
Pilot test of novel electrochemical membrane system for carbon dioxide capture and power generation	01/10/2015 – 31/12/2019	FuelCell Energy, Inc. (FCE)	The project team uses the FCE's patented Combined Electric Power and Carbon Dioxide Separation (CEPACS) system. The CEPACS system is based on an electrochemical membrane (ECM) technology. The driving force for CO_2 separation is electrochemical potential and results in simultaneous power production and CO_2 separation.	FE0026580

Large pilot testing of the MTR membrane post-combustion CO_2 capture process	01/04/2018 – 31/07/2019	Membrane Technology and Research, Inc.	The focus of this project is on partial capture (50% of the CO_2 is captured) by a two-stage membrane process, from a coal flue gas and using the MTR's high-performance Polaris™ membrane and advanced low-pressure-drop modules. The purity obtained is 75% CO_2 which is purified further after compression and CO_2 condensation. MTR pilot system was completed and running for 6 months. The previous NCCC test (1MWe) used nested module tubes in a single large vessel but that will not be the optimum design for the new configuration. The advanced system could reach a cost of 50.1 \$/t CO_2 captured by "easy changes" and 38.1 \$/t CO_2 captured with more advanced and challenging systems.	FE0031587
Scale-up and testing of advanced polaris membrane CO_2 capture technology	01/08/2018 - 31/07/2021	Membrane Technology and Research, Inc.	The scope is to design, build and operate a system at TCM with the advanced Gen 2 Polaris membranes and modules, optimize integration of compression and CO_2 purification equipment with membranes. Previously, the Gen 1 Polaris was evaluated at NCCC for more than 11,000 h. Parametric testing in NCCC included the Gen 2 Polaris membrane. That confirmed the CO_2/N_2 selectivity (approximately 50) and the increase of CO_2 removal rate compared to the previous model (approximately 28 kb CO_2/h compared to approximately 14 lb/h with Gen 1). The two-step process with CO_2 recycle shows a minimum in the capture cost (at approximately 60% capture rate) and costs are expected to be reduced up to 40\$/t CO_2.	-
Initial engineering design of a post-combustion CO_2 capture system for Duke Energy's East Bend station using membrane-based technology	06/04/2018 – 31/03/2020	Electric Power Research Institute, Inc. (EPRI)	The project is focused in delivering a techno-economic analysis (with 30% accuracy) of retrofitting Duke Energy's EBS, a 600-MWe coal-fired power plant with a capture process that utilizes MTR's second-generation Polaris™ membranes as CO_2 capture system. The analysis will also examine several options for providing the PCC auxiliary power via a CT-based power plant. Once it is optimized, the complete process design can be completed. HAZOP and constructability review will be included.	FE0031589
Bench-scale development of a transformational graphene oxide-based membrane process for post-combustion CO_2 capture		Gas Technology Institute	The project combines technologies developed in previous funded projects: GO-1 (higher selectivity) and GO-2 were developed and tested at lab scale; and the coating. Using simulated gas, it was reached a CO_2/N_2 selectivity of 650. 50-100cm^2 GO membranes will be developed to scale-up up to 1000 cm^2 and to be tested in a continuous running test (approximately 1000h). The target is to achieve a CO_2 permeance >2500 GPU and a CO_2/N_2 selectivity >200. Results will be used to produce the TEA. The GO2 process will be tested at the NCCC with actual fluegas for CO_2 capture with 95% CO_2 purity.	-
Development of a pre-combustion carbon dioxide capture process using high temperature polybenzimidazole hollow-fiber membrane	01/10/2013 – 30/06/2018	SRI International	The main goal of this project is to demonstrate the technical viability of the membrane system in an actual syngas feed stream and utilize the data to evaluate the technical and economic viability. The cost estimation has shown that the CO_2 capture cost for combined process would be < \$40 /t CO_2 captured compared to \$52/t CO_2 captured for IGCC (Selexol). Those membranes can be produced at km lengths with minimal defects.	FE0012965
Development of self-assembly isoporous supports enabling transformational membrane performance for cost effective carbon capture	01/06/2018-31/05/2021	Membrane Technology and Research, Inc.	The objective is to obtain a more cost-effective process (aiming 30\$/t CO_2 captured) by the use of composite membranes within highly regular surface pore structures and improved selective materials with higher permeance/selectivity than the current generation Polaris material. CFD analysis will be included.	-