INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Development of Novel CO_2-Selective Thin-film Mixed Matrix Membrane: Role of Amine Carrier and Filler Material on the Membrane Behaviour

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SHORT ABSTRACT

The main objective of the present work is to study the CO_2 separation from fossil fuel combusted power plants using CO_2-selective thin-film composite dense polymeric and mixed matrix membrane containing different combinations of amine carriers and inorganic as well as hybrid fillers. The primary focus is to achieve CO_2-selective membrane by facilitated transport mechanism having impressively high CO_2 permeability along with high CO_2/N_2 selectivity at temperature and pressure values closely resembling the actual industrial flue gas conditions. Poly (vinyl alcohol) (PVA) was used as base polymeric material due to its excellent hydrophilic nature and good film-forming ability. Thermal stability of PVA has been improved by using formaldehyde (HCHO) as cross-linking agent. Poly (ethylene glycol) (PEG) was used as the polymer blend. Various combinations of amines acting as fixed and mobile carriers such as polyethyleneimine (PEI), triethylenetetramine (TETA) and piperazine glycinate (PG) were utilized to improve the CO_2 transport property. Silica prepared by Stober's process and zeolitic imidazolate framework-8 (ZIF-8) metal-organic framework (MOF) was used as filler material. The filler particles were further functionalized by amine functional groups such as 3-aminopropyltrimethoxysilane (3-APTMS) and polyethyleneimine (PEI) and utilized for gas separation studies. Different combinations of amine carriers and functionalized and unfunctionalized filler materials were introduced into the polymer hydrogel in the preparation of CO_2-selective polymer and mixed matrix membranes.

Characterization studies such as TGA, FTIR, XRD, FETEM, FESEM and XPS were done for the active layer which was found to be optically transparent to visible light and mechanically stable to be handled. The TGA curve analysed

the sample weight loss in percentage (%) with temperature. The FTIR analysis confirmed the functional groups present in the sample. The X-ray diffraction pattern for all the amine doped membranes obtained by XRD analysis displayed a semi-crystalline structure with peaks at 2Θ angles of 20°. The FETEM and FESEM analysis determined the surface morphology of the membrane surface and the XPS analysis validated the quantitative and qualitative nature of the chemical state of the membrane surface. Gas stream containing 20 % CO_2 and 80 % N_2 by volume was utilized to study the transport properties (CO_2 and N_2 permeance and CO_2/N_2 selectivity) across the membrane. The effect of temperature (60 to 110 ºC), and sweep side water flow rate (0.0 to 0.075 ml/min) on the performance of the membranes were analysed. Several membranes have been synthesized for the gas permeation. The cross-linked PVA/PG/ZIF-8 mixed matrix membrane having a constant active layer thickness of 4 μm showed optimum performance with CO_2 permeance of 109 GPU and CO_2/N_2 selectivity of 385 at temperature of 100 °C, feed/sweep water flow rate of 0.03/0.05 ml/min and feed/sweep absolute pressure of 2.5/1.2 atm, respectively. Both polymer and mixed matrix membranes showcased promising potential for CO_2 separation from flue gas streams thus showing huge scope for large-scale CO_2 capture studies.