INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Development of Thermally Stable and Moisture Responsive CO_2- Selective Carboxymethyl Chitosan Based Membrane

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SHORT ABSTRACT

The primary focus of the thesis is to develop a thermally stable and moisture responsive biopolymer-based membrane for CO_2 separation. Among various biopolymers, chitosan possesses CO_2 transport site as its structure consists of amine group. Moreover, chitosan has very good film forming ability and thermal stability without crosslinking. However, the limited solubility of chitosan in neutral and basic medium drives towards an alteration. Also, the unmodified chitin present in the chitosan solution may hinder the gas permeation through membrane. Therefore, carboxymethyl chitosan (CMC), a water soluble derivative of chitosan has come into picture. The optimum performance of CO_2 separation was obtained for CMC membrane at 80 °C with supplied sweep/feed water flow ratio of 1.67 and feed pressure of 2/1.2 bar (feed/sweep) presenting a significant increase of CO_2 permeance (~35 GPU) and CO_2/N_2 selectivity (~39) as compared to that of chitosan membrane. The membrane showed its thermal stability at the operating temperatures. Hence, CMC membrane was further explored for CO_2 separation application by incorporation of different amines and fillers. In order to increase the amine content in the membrane matrix, piperazine (PZ), a small molecule amine was blended with CMC and utilized for CO_2/N_2 separation. Improved performance of CO_2 separation was obtained for 20 wt. % PZ containing membrane at the same operating conditions as CMC membrane and exhibited more than two times increase in CO_2 permeance (89 GPU) and CO_2/N_2 selectivity (103) as compared to that of pure CMC membrane. The membrane performance was found stable up to 3 days. Then poly (amidoamine) (PAMAM), a large molecule amine was blended with CMC which remarkably enhanced the CO_2/N_2 separation performance than pure CMC membrane. The membrane containing 10 wt. % PAMAM and 90 wt. % CMC showed the overall CO_2 permeance of ~ 101 GPU with the CO_2/N_2 selectivity ~137 on maintenance of

sweep/feed water flow ratio 2.33 at 90 °C. However, the amine blended polymeric membranes possess the drawback of performance stability for a longer duration. Hence, the incorporation of filler was deliberated. Accordingly, multiwall carbon nanotubes (CNTs) were incorporated to CMC matrix which presented the optimum CO_2 permeance of ~ 43 GPU and CO_2/N_2 selectivity ~ 45 at water flow ratio 3 and temperature 80 °C. Although, the CNTs (1 wt. %) loaded CMC membrane showed slight improvement in CO_2 permeance and CO_2/N_2 selectivity as compared to CMC, the membrane stability retained even after 10 days. In a similar experiment, 1 wt. % of hydrotalcite (HT) was incorporated to CMC matrix as filler and the CMC/HT membrane displayed remarkable CO_2 permeance (70 GPU) but inferior CO_2/N_2 selectivity (13) than that of CMC at 90 °C and water flow ratio of 2.33. Well ahead, based on the above-mentioned studies, a goal has set to work on the improvement of CO_2/N_2 selectivity as well as CO_2 permeance simultaneously. In view of that, CMC/PAMAM/HT membrane was fabricated and obtained the significant augmentation of CO_2 permeance up to 123 GPU and CO_2/N_2 selectivity of 67 at 90 °C pertaining a constant water flow ratio of 2.33 (sweep/feed). Hence, among all the tested membranes (CMC, CMC/PZ, CMC/PAMAM, CMC/CNT and CMC/HT), CMC/PAMAM/HT membrane showed the best CO_2 permeance which substantiated the efficiency of the membrane for CO_2 separation application. In this way this work encourages us to envision the utilization of carboxymethyl chitosan-based mixed matrix membranes for CO_2 separation from flue gas.