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Novel Adsorbent Development for High Pressure CO_2-CH_4 separation in Natural Gas Industry.

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Abstract

Natural gas is not only a source of energy, but it is also an important feedstock for fertiliser, petrochemical, hydrogen and pharmaceutical industries. Production of natural gas involves separation of CO_2 at high pressure. Pressure swing adsorption (PSA) provides potential benefits of compactness, and low energy requirements to improve overall process of natural gas and liquified natural gas (LNG) production. However, high pressure CO_2 separation process is a challenging process as performance of PSA process drops with increase in pressure due to reduction in selectivity and capacity of adsorbents at high pressure. Therefore, there is need to develop low-cost adsorbents with good selectivity, working capacity at high pressure.

The CO2CRC, in collaboration with The University of Melbourne (UoM), developed and tested novel adsorbents suitable for both on-shore and off-shore natural gas/ LNG applications. The test campaigns at CO2CRC's Otway International Test Centre (OITC) have shown encouraging results. The novel adsorbents found suitable up to a pressure of 50 bar and showed better capacity than the commercial adsorbent sorbead.

To further improve the adsorbent for separation of CH_4 and CO_2 at high pressure, a new process recipe to synthesise new improved adsorbent was developed. We synthesized and developed an ultra-stable zeolite from parent material zeolite using the new recipe. The recipe has physical as well as chemical treatment. As a result, CO_2 working capacity and selectivity towards the adsorbent improved significantly. Isotherms of CO_2 and CH_4 were measured at the room temperature of 296.15 K (23°C) using volumetric analyser (3Flex Micrometrics, USA). N2 isotherm was measured at the temperature of 77 K (-196.15°C) with 3Flex for BET (Brunauer–Emmett–Teller) for surface area, pore width distribution and volume. X-ray Powder Diffraction (XRD) Analysis was done to characterise the adsorbent structure and element analysis within the adsorbent samples was conducted using Energy-dispersive X-ray spectroscopy (EDS). The new developed adsorbent presents 3 to 4 times higher CO_2 working capacity than the parent material in the feed pressure of 50 bar and CO_2 concentration of 30 %, being more efficient to be used in pressure swing adsorption process (PSA) for CO_2 capture from natural gas. Thus, the PSA unit can deal with 3 to 4 times flowrates of the same feed gas, compared to the parent zeolite adsorbent, or the size of the PSA unit can be reduced to 1/3 or 1/4, compared with the PSA using the parent material in the same feed flowrate. Compared to the sample HY-Otway tested in OITC CO_2 capture campaign, the new developed have higher CO_2 capacity and selectivity of CO_2 over CH_4. The newly developed adsorbent also has the potential benefits of reduction in CH_4 loss and achieving higher purity.

This paper will also discuss characteristics of novel adsorbent, their potential applications in natural gas/LNG industry and for biogas upgradation and suggested next steps in the development towards commercial application.

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