Efficient Flue Gas CO_2 Capture by a Biomimetic Facilitated Transport Membrane

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Flue gas capture of carbon dioxide (CO_2) is likely to be required within the decade, if not sooner. While there are a number of candidate methods available or under development, with very few exceptions none have either been scaled to the size required and/or are inexpensive enough to avoid significant impact on electricity pricing. The DOE is supporting a large number of different technological approaches, at various stages along the research, development, engineering, pre-pilot and pilot stages, towards demonstration capabilities as a prelude to full-scale implementation. Carbozyme's enzyme catalyzed, hollow fiber, contained liquid membrane permeators is one such technology that is poised to enter pre-pilot demonstration phase.

The Carbozyme technology uses the enzyme carbonic anhydrase to catalyze (facilitate) the conversion of CO_2 to bicarbonate at the feed side of the membrane and then reverses the process on the permeate side allowing the CO_2 to move down its concentration gradient. At the same time the salt filled aqueous solution restricts the movement of nitrogen, oxygen and other gases as these must undergo physical absorption, a process that is slow and that suffers from limited volumetric capacity. The consequence is that the CO_2 is greatly enriched at the permeate side. For example, a process engineering calculation showed that a 13.8% CO_2 feed gas concentration (EPRI case 7C) exits as a 53.5% wet stream from the permeator. After drying the CO_2 concentration is calculated to be 98.3%. Measured laboratory data, using simulated flue gas mixtures, showed that a 15% feed stream yielded a 95% dry stream. These data were further supported by demonstration of comparable CO_2 capture behavior from feed streams derived by combusting methane or propane. The feed gas CO_2 concentrations tested ranged from air to 40%. Thus, any fuel currently combusted can be handled by this design. Long-term studies (1,000h), with deliberate, upset showed the design to be stable and robust. Additional data show that the enzyme is stable in the face of many of the components found in post-scrubbing flue gas. We are currently engaged in determining acceptance criteria to determine if any additional scrubbing may be needed. We have also developed scale-up processes coupled with process engineering studies to project size and cost profiles. The cost of energy of such a system is less than 13% and the per tonne cost of CO_2 captured and compressed to pipeline standards is less than $15.