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# Piperazine-promoted aqueous-ammonia-based CO<sub>2</sub> capture: process optimisation and modification

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## Abstract

Aqueous NH<sub>3</sub>-based CO<sub>2</sub> capture has received much attention as a promising technology for its ability to reduce CO<sub>2</sub> emissions from fossil-fuel based power stations, due to its low energy requirement for absorbent regeneration. However, the low reaction rate of NH<sub>3</sub> with CO<sub>2</sub> leads to larger equipment sizes, and thus higher capital investments than other amine systems. This paper seeks the possibility of reducing the size of CO<sub>2</sub> absorption equipment while maintaining the regeneration energy to a level comparable with or below that of the NH<sub>3</sub> system – by adding piperazine (PZ) as a promoter to the aqueous NH<sub>3</sub> solution. Using a rigorous, rate-based model in Aspen Plus, we conducted a detailed investigation into the technical performance of PZ-promoted NH<sub>3</sub>-based CO<sub>2</sub> capture. A sensitivity study was performed to optimise process parameters, such as PZ concentration, CO<sub>2</sub> lean loading and stripper pressure, aimed at reducing the regeneration duty and total equivalent electrical work. Process modifications, i.e. rich split and advanced flash stripper, were then implemented to further reduce the energy consumption. With the addition of 0.25 mol PZ/kg H<sub>2</sub>O into NH<sub>3</sub> solution, the absorber column height was reduced by 35% compared with the reference case without PZ. The advanced flash stripper greatly improved the energy performance the PZ-promoted NH<sub>3</sub> process, achieving a competitive regeneration duty of 1.97 MJ/kg CO<sub>2</sub> and total equivalent work of 0.192 MWh/t CO<sub>2</sub>, a 20% and 7% reduction compared with monoethanolamine (MEA) and PZ-based flash stripper processes, respectively. The PZ-promoted NH<sub>3</sub> process greatly advances NH<sub>3</sub>-based CO<sub>2</sub> capture and has the potential to be employed in commercial application.

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