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Abstract

Aqueous NH_3-based CO_2 capture has received much attention as a promising technology for its ability to reduce CO_2 emissions from fossil-fuel based power stations, due to its low energy requirement for absorbent regeneration. However, the low reaction rate of NH_3 with CO_2 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_2 absorption equipment while maintaining the regeneration energy to a level comparable with or below that of the NH_3 system – by adding piperazine (PZ) as a promoter to the aqueous NH_3 solution. Using a rigorous, rate-based model in Aspen Plus, we conducted a detailed investigation into the technical performance of PZ-promoted NH_3-based CO_2 capture. A sensitivity study was performed to optimise process parameters, such as PZ concentration, CO_2 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_2O into NH_3 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_3 process, achieving a competitive regeneration duty of 1.97 MJ/kg CO_2 and total equivalent work of 0.192 MWh/t CO_2, a 20% and 7% reduction compared with monoethanolamine (MEA) and PZ-based flash stripper processes, respectively. The PZ-promoted NH_3 process greatly advances NH_3-based CO_2 capture and has the potential to be employed in commercial application.

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