CO_2 capture with MDEA-DGA blends in a pilot-scale absorption-regeneration plant

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The European Commission has adopted an Industrial Carbon Management Communication to support the 2050 climate neutrality goal, emphasising the importance of carbon capture, storage and utilization (CCSU). Amine scrubbing is recognized as an effective technology for industrial CO_2 capture. However, challenges for implementation are related to high energy demands for regeneration, solvent degradation, equipment corrosion and possible amine aerosol emissions. Advancements in optimising and developing new amine-based solvents can address these challenges and expand the amine scrubbing usage. Methyldiethanolamine (MDEA) emerges as a promising candidate for overcoming these obstacles due to its low corrosion impact, slow degradation rate, low heat of reaction and reduced vapour pressure. However, the primary limitation of MDEA is its slow reaction rate, which can be mitigated by blending it with more reactive amines. Diglycolamine (DGA) is shown to improve absorption efficiency when combined with MDEA significantly. Though simulative studies highlighted the potential of MDEA-DGA blends, there is a lack of experimental results in the open literature.

This study evaluates the CO_2 absorption and regeneration efficiencies of MDEA-DGA blends in a pilot-scale absorption-regeneration plant operating at 1 atm and with a lean solution temperature set at 40 °C. Both the absorption and regeneration columns have a DN100 diameter, each equipped with 3 meters of packing height (Intalox saddles and M250.Y). The lean solution has a total amine content of 50% wt with MDEA content ranging from 35 to 50% and DGA content ranging from 0 to 15% wt. The setup tests different liquid and gas loads (L/G ratios ranging from 20 to 60 kg/kg) at a constant CO_2 concentration of 10% vol in N_2. Fixed a specific MDEA-DGA solution, the energy provided for the regeneration was varied for each L/G ratio investigated. Otherwise, fixed an L/G value, the energy provided was kept constant across all the MDEA-DGA solutions. For instance, when the L/G ratio is 20 kg/kg, the reboiler duty for the regeneration of the rich solution was set to 6.1±0.6 kW. The preliminary findings reveal that adding modest amounts of DGA (5% wt) to MDEA significantly improves CO_2 absorption performance, and increasing DGA up to 15% wt still improves efficiency, albeit with lower yields. However, the regeneration efficiency slightly decreases as the dosage of DGA increases. This research highlights the benefits of integrating DGA into MDEA solutions for CO_2 capture while maintaining operational constraints. The results provide insights for designing efficient systems to support CCSU efforts and help progress toward climate neutrality.

Keywords: *CO_2 Capture Technology (CCT), Amine Scrubbing, MDEA-DGA Blend*