Carbon capture with monoethanolamine aerosols: safe operation parameters for oxygen-containing flue gas streams

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Abstract

Carbon capture with monoethanolamine (MEA) is a well-researched topic [1]. The current efforts are focused on improving the performance of the chemisorption in terms of CO_2 uptake and mass transfer rate. One approach is to change the classic packed column configuration to alternative reactors. The spray column or spray reactor is a promising alternative because of its advantages such as low pressure drop, reduced investment and operating costs and lower susceptibility to corrosion [2]. Spray columns also allow exceeding the classic aqueous 30 wt% MEA concentration limit that was set due to viscosity. Recently a novel approach of using very high MEA concentrations was reported to increase the mass transfer rate in aerosol reactors. This approach has the advantage of reducing CAPEX and OPEX via smaller absorption reactor size and reduced reboiler heat duty during regeneration [3].

Besides absorption performance, the flammability of MEA in the presence of oxygen is an important property to consider. While flammability properties such as flash point are well-defined for liquids, this is not the case for their aerosol form. Multiple cases are reported in which atomized liquids are ignited below their flash point [4]. In addition, the ignition of aerosols can result in serious incidents such as fires and explosions that have been previously summarized [5]. Many post-combustion gas streams contain oxygen. In combination with the changed flammability of liquids in their aerosol form, the use of aerosol as a reaction medium can have hazardous outcomes. Therefore, addressing the safety is an important requirement. The aim of this work is to address the gap in knowledge on the flammability region of MEA in aerosol form. This is done by determining the safe operation parameters for carbon capture with MEA in an aerosol reactor.

It is suggested and tested in literature that standard dust explosion testing procedures consisting of 20 L spheres can be partially used and adjusted for aerosol flammability tests [4], [5]. In contrast to the classic testing procedures, in this work a flow setup is developed to test the flammability of the MEA aerosol. The effect of the parameters MEA concentration, gas-liquid ratio, oxygen concentration, carbon dioxide concentration and temperature on the MEA flammability are investigated for multiple positions in the aerosol for various nozzles. More specifically, the minimum ignition energy, limiting oxygen concentration and flammability region are determined. In addition, real-time monitoring of the aerosol with a high-speed camera allows to unravel the relation between flammability and aerosol properties such as the mean Sauter diameter, droplet size distribution, droplet velocity and aerosol concentration.

This work provides a safe operation window of carbon capture with MEA for oxygen-containing flue gas streams and offers a continuous flammability testing method for aerosols generated by nozzles.

References

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