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A Novel Methodology for Online Analysis of Amine Solution Degradation Caused by Fly Ash

Devjyoti Nath[a], Colin Campbell[b], Yuewu Feng[b], Corwyn Bruce[b], Amr Henni[a]*, Wayuta Srisang[b], Brent Jacobs[b], Stavroula Giannaris[b], Dominika Janowczyk[b]

[a] *Faculty of Engineering and Applied Science, University of Regina, Regina, S4S 0A2, Canada*

[b]*The International CCS Knowledge Centre, Regina, S4S 7J7, Canada*

Abstract

Global warming due to the anthropogenic emissions of carbon dioxide (CO_2) is a major worldwide environmental concern. CO_2 capture with an aqueous amine-based solvent is one of the most common and advanced technologies for post-combustion CO_2 capture. Many aqueous amine-based solvents have already been proposed by different researchers to capture CO_2 efficiently from flue gas, however, the technology is still not economical due to high energy requirement for regeneration and operational issues such as solvent degradation. A large number of research studies have been performed investigating oxidative and thermal degradations of amine-based solvent. Although 38% of world energy is derived from coal-fired power plants, research work on the investigation of the impact of fly ash on the amine solvent degradation process in carbon capture plants is still very limited. The accumulation of flue gas contaminants such as NOx, SOx, fly ash, and trace metals in post-combustion CO_2 capture solvents is a major concern, as they contribute to solvent degradation. Fly ash contains various transition metals, depending on the type of coal, and transition metals are known to behave as efficient catalyst for the amine degradation process. The accelerated amine degradation is a serious problem for large-scale applicability, and the potential impact of fly ash is an important consideration for the economic operation of the capture process. The design of modern large-scale plants removing CO_2 from coal-fired power plants must take into consideration the impact on the solvent of fly ash particulate matter entering the absorber. The cost of solvent replacement due to the rapid degradation is a major concern for the feasibility of the whole operation and must be weighed against the costs of flue gas cleanup, including fly ash removal. A very limited number of studies dealing with online analyses of solvents for carbon capture units has been published. The proposed solutions are usually very complex in nature.

This study presents a new online technique to analyse the degradation of aqueous amines (MEA, MDEA and their mixtures) at different concentrations and temperatures. First, the fly ash was fully characterised (Particle size distribution and trace element composition), sieved and then mixed in different amounts with the amine solution at different CO_2 partial pressures. The developed online system included a GC equipped with a liquid sample delivery system. The flow system was equipped with filters to avoid the introduction of large particles into the GC column. A solvent backflush system was used to allow for automated cleaning of the particulate filters. A calibration check sample was run on the GC at least once per day to monitor for calibration drift. In order to study the impacts of fly ash on accelerated degradation, fly ash amounts representing (1 %, 2 %, 10 % and 20) wt.% were used in the experiments. Samples of

the same amine solutions were recirculated for at least a week. The online system was used to asses the degradation of the different amine solutions based on the results obtained before and after contact with different fly ash amounts at different temperatures. Online measurements provided information about CO_2 loading as well as water and amine concentrations which allowed for the estimation of the percentage of amine degraded. The short-term objective is to use the developed online solvent analysis method in our pilot plant before testing it in a commercial size plant. As outlined in the Shand feasibility study, the cost of consumables and OM&A represents 15% of the cost of capturing CO2. Accelerated degradation related to fly ash contamination has been reported to increase the consumables portion of the cost significantly. This materially effects the cost of the CO2 capture. The risk of accelerated degradation has been a barrier to CCS deployment and must be understood. It is believed that the data from these studies will provide valuable information that is necessary for operating cost optimization of the flue gas cleanup, including further particulate removal versus the cost of amine management.

* Corresponding author. Tel.:+1 306 585 4960, *E-mail address:* Amr.Henni@uregina.ca

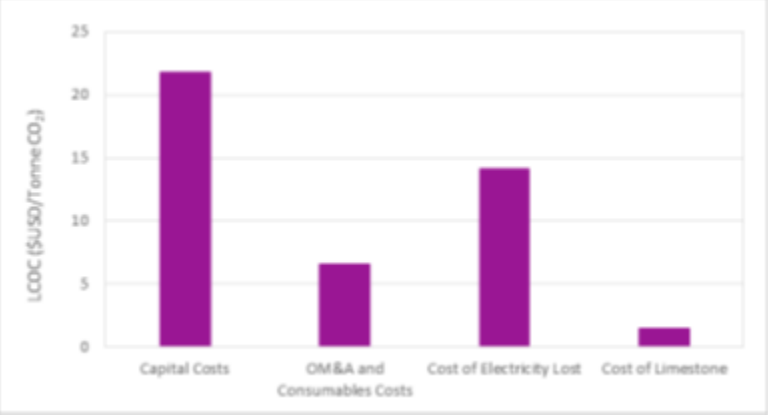

Fig. 1. Break down of Lower levelized Cost of Capture for Shand Plant (The Shand CCS Feasibility Study Public Report, 2018)

Keywords: Carbon capture; Coal-based plant; Flue gases; Amines; Fly ash; Degradation; Online analysis; Gas chromatography.