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Thermal Reclaiming of Aqueous Amine Solvents for the Restoration of Solvent Health

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Abstract

Amine scrubbing for post combustion carbon capture is a mature and robust technology essential to the global reduction of CO_2 emissions, especially those from energy production [1]. One of the largest obstacles to broader deployment of amine scrubbing for CO_2 capture is the degradation of solvents. Degradation products pose uncertain environmental and health risks, and their accumulation, along with the accumulation of dissolved metals, is known to further accelerate solvent oxidation [2]. Solvent management strategies include removing these metals and degradation products. One such strategy is thermal reclaiming, which removes non-volatile degradation products and metals from the main solvent. Thermal reclaiming of aqueous amine solvent using single-stage, semi-batch distillation was successfully tested at two pilot-scale campaigns and investigated in a series of bench-scale experiments [3]. The first pilot test of thermal reclaiming occurred at the National Carbon Capture Center with a 1 MWeq boiler flue gas, with reclaiming implemented for 3 days after ~5100 operating hours [3]. A second pilot test of thermal reclaiming occurred at Technology Centre Mongstad (TCM) with 10-12 MWeq flue gas from multiple sources. Two reclaiming campaigns occurred at 1008 and 2185 operating hours for about 3 days each time. Fig. 1 and 2 shows each reclaimer. Of note, the NCCC reclaimer operated under vacuum, while TCM operated around 0.2 - 2 barg. Other key differences include the use of NaOH pretreatment in the TCM reclaimer to help recover more solvent. A key failing of the NCCC testing was a loss of nearly 32% of the working solvent due to reclaiming. It is expected that the loss at TCM from both reclaiming events will amount to around 10% of the working solvent based on initial analysis. Fig. 3 and 4 show a comparison of key degradation species and catalytic metals and their reduction due to thermal reclaiming. Dissolved Fe, a known oxidation catalyst was reduced by 94% and 86% in NCCC and TCM, respectively. NH_3 and other hazardous emissions were successfully managed by reclaiming in both campaigns. One recommendation from this work is to initiate reclaiming when measured emissions near regulatory limits. To support the oxidation mitigation claims based on pilot results and to determine the long-term influence of reclaiming on solvent health, a bench-scale experiment will be conducted in a reactor which cycles between absorber and stripper conditions. The amine will be degraded to similar levels seen at the pilot-scale before the initiation of a reclaiming campaign and then continued operation of the restored solvent. Results from the pilot- and bench-scale experiments will be used to perform a techno-economic analysis of intermittent thermal reclaiming with amine solvents. Important to this analysis, is the disposal costs of the reclaimer bottoms, as NCCC and TCM show very high Cr levels that will likely classify the waste as hazardous in the United States.

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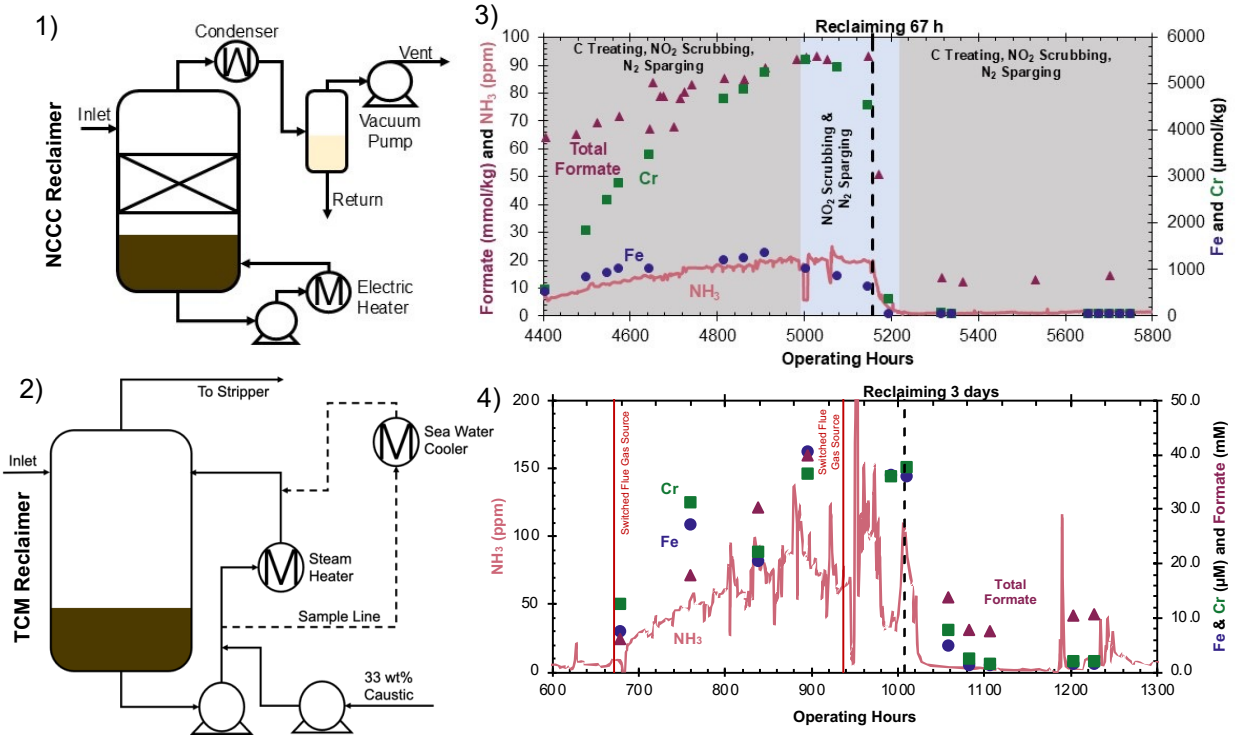

Fig. 1) Process flowsheet of NCCC thermal reclaimer. Fig. 2) Process flowsheet of TCM thermal reclaimer. Fig. 3) NH_3, total formate, Cr, and Fe before and after thermal reclaiming at 5156 h at NCCC. Colored regions represent the other oxidation mitigation strategies tested in this period. Fig. 4) NH_3, total formate, Cr, and Fe before and after thermal reclaiming at 1292 h at TCM. Red lines represent changes in the flue gas source.

Keywords: amine scrubbing, oxidation, emissions, thermal reclaiming

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