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# A technology review for regeneration of sulfur rich amine systems

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ABSTRACT

Reducing the capital cost of post combustion $CO_2$ capture by eliminating flue gas desulfurisation (FGD) pre-treatment, requires management of the amines preferential $SO_2$ absorption. Novel technologies such as CS-Cap restrict the impact of $SO_2$ to only a small fraction of the amine inventory resulting in high sulfate burden amines. Traditional thermal reclamation of these spent absorbents has advantages regarding simplicity, but ranks poorly for industrial ecology around PCC. These amines require low energy regeneration technologies compatible with their physico-chemical properties that also maximise the potential for valorising by-products. This review summarises the sulfur chemistry and outlines several amine reclamation processes. It assesses the status of established and novel regeneration technologies for their applicability to high sulfur loaded amines. Should deep sulfur removal be required, a hybrid approach with initial bulk removal (as product) followed by a polishing step to further reduce sulfur is prospective. A preliminary estimation of the relative cost of using standard reclamation methods for treating Sulfur loaded CS-Cap absorbent revealed the cost would increase due to its higher sulfate burden despite comparable treatment volumes. Research gaps are identified which would enable better comparison between the costs of traditional FGD versus higher reclamation costs for combined capture technologies.

## 1. Introduction

Given its wide availability, low cost and high energy density, coal will remain an important global energy source into the near future (MIT, 2007; Takeshita and Yamaji, 2006). In 2015, the Paris Agreement was adopted under the United Nations Framework Convention on Climate Change (UNFCCC). This agreement aims to limit global average temperature increase to below 2 °C above pre-industrial levels. To meet this target with continued coal use, methods for lowering or removing $CO_2$ emissions from coal-fired power stations are required. Recent studies suggest that the 2 °C target will not be achievable without the deployment of large-scale Carbon Capture and Storage (CCS) (Peters et al., 2017; Rogelj et al., 2016; IPCC, 2014).

Currently, the most technologically advanced method for removing $CO_2$ from coal-fired power station flue gas is the amine based post combustion capture process (PCC) (Liu et al., 2017). Major drawbacks of this process include the large infrastructure requirements and parasitic load on generation (resulting in prohibitive costs without offsets or $CO_2$ product sales) (Zhang et al., 2017). This is especially true for coal PCC processes, which have the highest incremental cost relative to a similar plant without $CO_2$ capture (Folger, 2013).

The implementation of amine based PCC technology to power plants requires flue gas pre-treatment to remove reactive acid gases, i.e. $SO_x$ and $NO_x$, prior to $CO_2$ absorption to maintain capture efficiency (Liu et al., 2017). $SO_2$ is the second most abundant acid gas present after $CO_2$ and despite flue gas $SO_2$ concentrations typically 1000 times lower than $CO_2$, it is comparatively more soluble and forms a much stronger acid in aqueous solution. Flue gas $SO_2$ concentrations $< 10$ ppm are recommended (Davidson, 2007) for PCC operation. As $SO_2$ is a stronger acid gas than $CO_2$, its absorption into the basic solutions used for $CO_2$ capture is faster and dominant over $CO_2$ absorption (Beyad et al., 2014). This also means that release of $SO_2$ during amine regeneration does not occur thermally at the same conditions used for $CO_2$ stripping. This leads to accumulation of absorbed $SO_2$ as heat stable salts (HSS) over time, progressively neutralising the capture solution, reducing its capacity to absorb $CO_2$ (Beyad et al., 2014). In an operating amine plant, it is desirable to limit the level of HSS in solution as they can affect operation through reduced capacity, increased corrosion and absorbent foaming. Consequently, flue gas desulfurization (FGD) is an essential requirement for PCC (Adams, 2010).

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