Pilot plant NO\textsubscript{2} Removal with Aqueous Sulfite

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Abstract

NO\textsubscript{2} impurities in combustion flue gas can initiate oxidation in amine-based post-combustion capture systems and ultimately react with secondary amines to form nitrosamines, further degrading the solvent and creating both environmental and economic impacts. Bench-scale experimental work has been conducted to demonstrate that alkaline SO\textsubscript{2} polishing scrubbers can remove simultaneously NO\textsubscript{2} via the reaction of NO\textsubscript{2} with sulfite, when sulfite oxidation is inhibited via the addition of thiosulfate or other oxidation inhibitors. This technology will be demonstrated with a baseline control experiment at the pilot scale in Summer 2017 using the Pilot Bay 3 Pre-Scrubber at the National Carbon Capture Center (NCCC). Thiosulfate and ethylenediaminetetraacetic acid (EDTA), used to chelate dissolved metals that can further accelerate solvent oxidation, will be added to the Pilot Bay 3 Pre-Scrubber to demonstrate high NO\textsubscript{2} removal and low sulfite oxidation.

The pre-scrubbing system at the NCCC consists of a packed column, buffer tank, and a pump that recirculates sodium hydroxide solution from the buffer tank to the packed column. Flue gas exiting the upstream FGD from the main power generation facility flows through the pre-scrubber, which uses dilute caustic solution to remove a majority of the remaining SO\textsubscript{2} from the flue gas. Concentrated sodium sulfite solution from the buffer tank is blown down to wastewater neutralization, while the cooled flue gas exits the pre-scrubber to a flue gas blower. The pre-scrubber column contains approximately 20 ft of Sulzer structured packing. The typical SO\textsubscript{2} content of the flue gas feed to the pre-scrubber is 30 to 40 ppmv, which is typically scrubbed to about 1 ppmv at the outlet.

During prior baghouse modifications that took place at the E.C. Gaston power plant, the NO\textsubscript{2} concentration entering the pre-scrubber decreased by an order of magnitude. In order to more effectively demonstrate the NO\textsubscript{2} pre-scrubbing technology, modifications are being made at NCCC to inject NO\textsubscript{2} (via a liquid N\textsubscript{2}O\textsubscript{4} cylinder) into the flue gas piping upstream of the pre-scrubber to increase the inlet concentration. In addition to the artificial concentration increase on the inlet to the pre-scrubber, the accuracy of the outlet NO\textsubscript{2} concentration measurement is being improved with the installation of a Rosemount CT5400 Continuous Gas Analyzer, which a lower detection limit of 0.05 ppmv (as compared to 1 ppmv for the previously installed analyzer).

Test objectives include, but are not limited to, the following:

- Measure the rate of sulfite oxidation in the liquid phase and measure the rate of SO\textsubscript{2} absorption from the gas phase.
- Measure the steady state sulfite concentration as a function of thiosulfate and EDTA concentrations.
- Quantify thiosulfate consumption to define the economics of NO\textsubscript{2} scrubbing with sulfite. Thiosulfate will be consumed via oxidation, and also lost to blowdown when caustic is replenished.
- Calculate the NO\textsubscript{2} removal rate in the presence of steady state sulfite concentration in scrubbing solution via liquid and gas-phase measurements.
- Quantify metals present in solution that catalyze oxidation, if any.

The ratio of the rate of sulfite oxidation to the rate of NO\textsubscript{2} absorption during the campaign is of particular importance to evaluating the feasibility of the technology. Although sulfite will be initially added to the pre-scrubber along with thiosulfate and EDTA, the steady-state sulfite concentration is a function of the SO\textsubscript{2} concentration entering the pre-scrubber. Inlet and outlet SO\textsubscript{2}/NO\textsubscript{2} concentrations will be analyzed continuously, while collected solvent samples will be analyzed on-site by iodometric titration, and back at The University of Texas lab via anion chromatography, to determine sulfite and thiosulfate concentrations.