Testing Methods for Continuous Monitoring of SO_3 and H_2SO_4 at Flue Gas Conditions

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Abstracts

This research is to examine two optical absorption measurement approaches, one in the UV and one in the IR range, for operation at flue gas composition and temperature conditions. Continuous monitoring of flue gas from coal power plants has been a desired technology for decades in order to achieve the ultimate goal of controlling pollutants. Sulfur trioxide (SO_3) is a very unstable compound and easily forms sulfuric acid (H_2SO_4) in the presence of water. Sulfuric acid can then potentially form ammonium bisulfate (ABS) with excess NH_3 from the selective non-catalytic reactor (SNCR). These chemicals can lead to corrosion and air preheater damage in the power plant, with significant repair cost. There are several existing commercial monitoring systems but none of them are real time measurements, or the temperature range is too low, or they require further validation of the system performance. The study has three major goals, first is to experimentally demonstrate that SO_3 and H_2SO_4 are in equilibrium (or at accurately predictable ratios) at typical flue gas conditions; second is to demonstrate the viability of the relatively inexpensive approach of differential optical absorption spectroscopy (DOAS) for continuous measurement of SO_3 in flue gas; and the third is to addition of IR absorption as a possible method for measuring SO_3 and H_2SO_4 gas phase using a unique external cavity quantum cascade laser (EC-QCL). In order to create a reliable real flue gas composition for SO_3, H_2SO_4, H_2O, SO_2, N_2, O_2, an oven is designed with a special catalyst from Haldor Topsoe for converting SO_2 into SO_3. Several valves (3-way valves, check valves, regulators) and inlets are specially designed at different location of the system in order to have a wide range capability of handling different flue gas composition as well as verifying the experiment with different sample gases. For example, being able to inject pure SO3 or nitrogen carrying water vapor permits validation of the optical methods and evaluation of typical background signals. A heated 1-meter gas cell is also used with two opposing 2” diameter windows to conduct optical measurement from one end to the other. The EPA method 8A wet chemistry system for detecting sulfur ions by using liquid chromatography is connected downstream as a final verification for the upstream gas composition (with respect to flow rates) as well as the data acquired from the DOAS/EC-QCL gas analyzers. Chemkin

simulations with plug flow reactor/perfectly stirred reactor (PFR/PSR) modules is used to predict SO_3 and H_2SO_4 equilibrium under different amounts of water concentration. Acquiring a reliable chemical reaction mechanism and transport data helps establish expected timescales for conversion.