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DEVELOPING SCR TECHNOLOGY OPTIONS FOR MERCURY OXIDATION IN WESTERN FUELS

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Project Description

The project will evaluate the ability of selective catalytic reduction (SCR) catalysts, including both currently used SCR catalysts and newly SCR formulated catalysts to enhance mercury oxidation, as well as the use of additives to enhance oxidation. The first catalyst to be tested will be an existing formulation that Haldor Topsoe currently manufactures. A second set of tests will be conducted on several new formulations developed in cooperation with Haldor Topsoe. The catalyst will be tested in flue gas compositions similar to what is found in plants burning Powder River Basin (PRB) and lignite coals and will be varied accordingly. The use of oxidation additives to promote the formation of oxidized mercury (Hg^{2+}) to levels of those seen for eastern coals will also be a primary emphasis.

Goal

The primary goal is to demonstrate that high concentrations of elemental mercury (Hg^0) in certain flue gases can be catalytically oxidized to yield greater than 85% Hg^{2+} . This would allow for removal in existing and future scrubbers and enhance the capture of mercury on low-cost sorbents for unscrubbed systems. Specific objectives include the following:

- Identify the primary component(s) in SCR catalysts that contribute to mercury oxidation
- Quantify the effects of various oxidants on mercury oxidation across SCR catalysts
- Evaluate the effects of temperature (650° and 350°F)
- Evaluate the effects of ammonia (NH_3)

Rationale

There is an increasing recognition of the need for mercury control technologies specifically targeted toward plants burning western U.S. coals which emit predominantly Hg^0 . Laboratory and field tests indicate that western coals pose unique challenges in meeting future mercury control requirements. Recent field data have shown that while significant oxidation of Hg^0 occurs across SCR systems for certain applications, there are also applications where no conversion is measured [1, 2]. In four utility tests (three sites) with eastern

bituminous coals, the Hg^0 levels averaged 63% upstream of the SCR and 26% downstream. For a single utility site burning PRB coal, the Hg^0 went from 92% to 82% across the SCR. These data indicate that the mercury in low-rank western coals may be more difficult to oxidize, and one of the likely causes is low chlorine levels in these coals.

Roughly two-thirds of the Texas and North Dakota lignite-fired generation capacity is currently equipped with either wet or dry scrubbers. In addition, enactment of the Clear Skies Act or other multipollutant bills would increase the likelihood of new SCR and scrubber installations. For these units the best-case scenario is development of a cost-effective mercury oxidation technology to allow removal in the scrubbers. Additionally, for plants burning low-sulfur PRB coals, increasing the level of mercury oxidation will likely enhance the effectiveness of sorbent injection systems.

Approach

The work will be completed in two Tasks. Tasks 1 and 2 will be completed in the Energy & Environmental Research Center's (EERC's) mercury laboratory. A standard concentration of $15 \mu\text{g}/\text{Nm}^3$ of Hg^0 will be used in the flue gas.

Task 1 – Evaluation of Flue Gas Additives and Temperature

Task 1 will quantify the effects of several variables on the performance of a typical, commercially available SCR catalyst in oxidizing Hg^0 . A baseline flue gas composition which simulates that from a low-rank western coal will be used, and the bench-scale system will be modified to enable catalyst testing. The flue gas composition will be fairly typical of that from most western coals in terms of low HCl and SO_2 concentrations. The most critical variables will be the type and quantity of mercury oxidants. Candidate oxidants for addition to the gas stream include HCl, other chlorine species, other halogen species, and acid gases. Another important variable is the flue gas temperature at the catalyst. Tests will be performed at both 350° and 650°F to determine the effectiveness of the catalyst at a lower temperature where the equilibrium further favors the oxidized forms of mercury. Other researchers have performed limited experiments that show improved oxidation at lower temperatures. In addition, the effect of NH_3 will be evaluated at 650°F to determine if there are any effects as reported by others [1–7]. The impact of NH_3 reported by others has been mixed, varying from a negative effect to no effect. Limited testing with NH_3 addition will be performed to identify any effects with the baseline SCR catalyst.

Task 2 – Development of SCR Catalyst for Mercury Oxidation

Task 2 will identify improved catalyst formulations for oxidizing Hg^0 . The focus will be on understanding the fundamentals of the catalyst–mercury interactions and identifying the catalyst components such as Al_2O_3 , TiO_2 , V_2O_5 , and others that are critical to mercury oxidation. Haldor Topsoe will develop and supply different catalyst formulations and provide cofunding for their testing under this task. Up to three new catalyst formulations can be tested. The formulations will be developed based on the interactions observed in Task 1. As the project progresses, results will be discussed with Haldor Topsoe and used as input to its catalyst design effort.

Progress

To date, all efforts have been directed toward securing funding and completing the confidentiality agreement with Haldor Topsoe. These agreements are nearly finished, and firing is expected to begin soon.

Status

As soon as the agreements with Haldor Topsoe are complete, the work will be expedited to ensure the final project deadlines are met.

Quality Assurance/Quality Control

The following procedures will be used to ensure data quality:

- Sampling and analytical analysis protocols will be validated by comparing test data with other data generated using standard protocols in place at the EERC.
- The type and quantity of quality assurance (QA) samples will include calibration of the continuous mercury monitors (CMMs), replicate tests (minimum of three), and a blank at the beginning of each day.
- The QA/quality control data results will then be compared with data quality indicators to qualitatively determine the validity of the data in terms of precision and accuracy. Only when mass balances are $\pm 30\%$ will the data be considered valid.

The data will be collected with a Semtech or Tekran CMM. The commercial Semtech mercury analyzers (Semtech Metallurgy AB, Lund, Sweden) are essentially portable Zeeman-modulated cold-vapor atomic absorption spectrometers that can monitor Hg^0 continuously. The analyzer uses Zeeman effect background correction by applying a modulated magnetic field to a mercury lamp to minimize interferences from the presence of SO_2 , moisture, hydrocarbons, and fine particulate in the flue gas sample. The operating range of the analyzer is $0.3 \mu\text{g}/\text{Nm}^3$ to $160 \text{ mg}/\text{Nm}^3 \text{ Hg}^0$, as specified by Semtech Metallurgy AB.

The system is calibrated using Hg^0 as the primary standard. The Hg^0 is contained in a closed vial which is held in a thermostatic bath. The temperature of the mercury is monitored, and the amount of mercury is measured using vapor pressure calculations. Typically, the calibration of the unit has proven stable over a 24-hr period.

Potential Users/Technology Transfer

Potential users of this technology will be any utility that wishes to use catalyst to enhance mercury oxidation and capture, especially utilities burning western fuels (lignite and PRB) where there is a low concentration of chlorine and, therefore, very little Hg^{2+} . Hg^{2+} can more easily be captured in existing pollution control devices.

References

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