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Investigation of Selective Catalytic Reduction Impact on Mercury Speciation under Simulated NO_x Emission Control Conditions

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ABSTRACT

Selective catalytic reduction (SCR) technology increasingly is being applied for controlling emissions of nitrogen oxides (NO_x) from coal-fired boilers. Some recent field and pilot studies suggest that the operation of SCR could affect the chemical form of mercury (Hg) in coal combustion flue gases. The speciation of Hg is an important factor influencing the control and environmental fate of Hg emissions from coal combustion. The vanadium and titanium oxides, used commonly in the vanadia-titania SCR catalyst for catalytic NO_x reduction, promote the formation of oxidized mercury (Hg^{2+}).

The work reported in this paper focuses on the impact of SCR on elemental mercury (Hg^0) oxidation. Bench-scale experiments were conducted to investigate Hg^0 oxidation in the presence of simulated coal combustion flue gases and under SCR reaction conditions. Flue gas mixtures with different concentrations of hydrogen chloride (HCl) and sulfur dioxide (SO_2) for simulating the combustion of bituminous coals and subbituminous coals were tested in these experiments. The effects of HCl and SO_2 in the flue gases on Hg^0 oxidation under SCR reaction conditions were studied. It was observed that HCl is the most critical flue gas component that causes conversion of Hg^0 to Hg^{2+} under SCR reaction conditions. The importance of HCl for Hg^0 oxidation found in the present study provides the scientific basis for the apparent coal-type dependence observed for Hg^0 oxidation occurring across the SCR reactors in the field.

IMPLICATIONS

Boilers burning bituminous coals have shown significantly higher Hg^{2+} species across SCR reactors, while those firing subbituminous coals showed little change in Hg speciation. The water-soluble Hg^{2+} compounds may be removed in a downstream wet scrubber cost effectively. Understanding the science behind Hg oxidation via SCR catalysts will broaden the applicability of SCR systems in Hg removal strategies. Results suggest that a source of chlorine such as HCl is needed for Hg oxidation under SCR conditions. This finding provides a scientific basis for the apparent coal-type dependence on Hg oxidation across SCR reactors observed in field studies.

INTRODUCTION

Coal combustion is a major source of mercury (Hg) emissions that have caused environmental health concern.[1] Speciation (the split among chemical forms of Hg) is an important factor that influences the control and environmental fate of Hg emissions from coal combustion.[2] It is known that controlling the emissions of oxidized mercury (Hg^{2+}), the water-soluble mercuric chloride in particular, is much easier than controlling the insoluble elemental mercury, Hg^0.[3] Emissions of nitrogen oxides (NO_x) are another major environmental concern from coal combustion; the emissions are associated with ground-level ozone, acid rain formation, forest damage, degradation of visibility, and formation of fine particles in the atmosphere.[4] Several regulatory programs, such as the Acid Rain NO_x regulations, the Ozone Transport Commission's NO_x Budget Program, and Ozone and Particulate Matter Transport rulemakings require significant reductions in NO_x emissions from coal combustion sources. As a result of these more stringent NO_x emission control requirements, selective catalytic reduction (SCR) technology increasingly is being applied for controlling NO_x

emissions from coal-fired boilers because of its high NO_x emission control efficiency (>80%). The operation of SCR could affect the speciation of Hg in the coal combustion flue gases. Early field measurements conducted in Europe indicated that SCR reactors installed for NO_x emission control promote the formation of oxidized Hg species.[5] A recent field study conducted in the United States also found increases in Hg^{2+} species across the SCR reactors.[6]

The effect of SCR operation on Hg speciation appears to be dependent on coal type. Boilers burning bituminous coals, which typically have high chlorine (Cl) and sulfur (S) content, have been observed to have significant increases in Hg^{2+} species across their SCR reactors.[6] However, a subbituminous coal from the Powder River Basin (PRB), which contains significantly lower Cl and S content and higher calcium (Ca) content compared with those of the bituminous coals, showed very little change in Hg speciation across an SCR reactor.[6]

NO_x in coal combustion flue gas are reduced to nitrogen (N_2) and water (H_2O) in an SCR reactor consisting of metal oxide catalysts such as titanium oxide (TiO_2)-supported vanadium oxide (V_2O_5). A reducing agent such as ammonia (NH_3) or urea (NH_2CONH_2) is injected into the SCR reactor operating at temperatures of ~350 °C. The NO_x reductions proceed according to the following reactions:

$$2NO + 2NH_3 + 1/2\ O_2 = 2N_2 + 3H_2O \qquad (1)$$

$$2NO_2 + 4NH_3 + O_2 = 3N_2 + 6H_2O \qquad (2)$$

Laboratory-scale experiments have indicated that metal oxides, including V_2O_5 and TiO_2, could promote the transformation of Hg^0 to Hg^{2+} in combustion flue gases.[7] Recent pilot-scale tests also suggested that SCR has the potential to impact Hg speciation, and the effects appear to be dependent upon coal type.[8] However, the reactions that are important to transform Hg^0 into Hg^{2+} in the SCR reactor are not well understood.

The work reported here is bench-scale research that focuses on studying Hg^0 oxidation in the presence of simulated coal combustion flue gases and under SCR NO_x emission control conditions. The effects of HCl and SO_2 in the flue gases on Hg^0 oxidation were studied. A previous bench-scale study found that NO_x and HCl promote Hg^0 oxidation, while SO_2 and H_2O reduce Hg^0 oxidation in the presence of coal combustion fly ash.[9] It was hypothesized that transition metal oxides, such as iron oxide (Fe_2O_3), present in coal fly ash may be instrumental in catalytic oxidation of Hg^0. In the present study, the effects on Hg^0 oxidation of the acidic flue gas components and the basic NH_3 gas added for NO_x reduction reactions were evaluated in the presence of an SCR catalyst. The emissions of acidic flue gases generated by the combustion of different types of coals depend upon the coal type and its composition. Emissions of acidic flue gases may be reduced significantly in the presence of NH_3, and they also may be catalytically converted into other, more reactive, species for Hg^0 oxidation under the SCR emission control conditions. The objective of the study is to gain a better understanding of the complex, confounding interactions of flue gas components occurring under SCR emission control conditions and resulting in changes in Hg speciation in coal combustion flue gases.

EXPERIMENTAL PROCEDURES

SCR Reactor System

A bench-scale reactor system was designed and constructed to simulate the SCR reaction conditions for studying Hg^0 oxidation. The reactor system is shown in Figure 1. The system consists of the preheating and premixing sections, the Hg generation unit, the SCR reactor, and the online reactor effluent measurement unit. Flue gas components, including carbon dioxide (CO_2), SO_2, air, and N_2, were mixed and preheated to 350 °C and then mixed with another preheated stream of nitrogen oxide (NO) and HCl at the main heating section. Water also was pumped into the hot section at a calibrated rate to simulate the moisture content in flue gas and was mixed with the other flue gas components. NH_3 was preheated and flowed into the static mixing section to achieve better mixing with the other flue gas components. The gas mixture then flowed into the Pyrex reactor. The alkaline NH_3 reacts with the acid gas components in the gas mixture to form ammonium (NH_4^+) salts at temperatures lower than the SCR reaction temperatures. Therefore, the simulated flue gas mixture was preheated by the electrical furnaces and maintained at 350 °C by temperature-controlled electrical heating tape to prevent such reactions taking place and to reduce the amount of NH_3 available for reducing NO_x. The fine-particle NH_4^+ salts formed from the neutralization of NH_3 are sticky and otherwise would tend to deposit on the reactor walls and potentially adsorb Hg species in the flue gas mixture. If not avoided through the use of such precautions, the deposition of NH_4^+ salt particles on the reactor walls would make the measurement of trace Hg species in the reactor very difficult. Proper preheating and mixing of the gas mixture are very important for simulating the SCR reaction conditions and for measuring Hg speciation. All the heating and mixing sections upstream of the Pyrex reactor are made of stainless steel to minimize the corrosive effect of the acidic gases. Gas cylinders of N_2-diluted gaseous species were used instead of pure gases for some components (i.e., SO_2/N_2, NO/N_2, O_2/N_2, and NH_3/N_2).

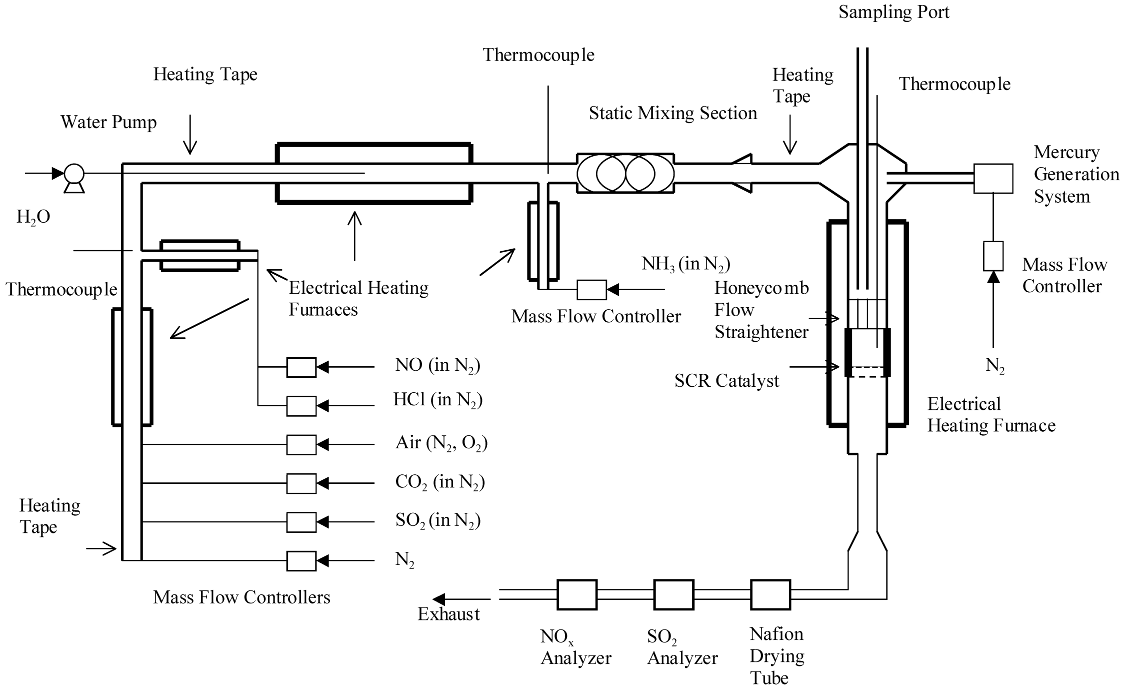

Figure 1. SCR reactor system.

An Hg generation unit consisting of an Hg permeation tube surrounded by a temperature-controlled water bath was used to generate Hg^0 vapor for the oxidation experiments. Details of the generation system are described elsewhere.[3] The Hg^0 vapor was carried by an N_2 stream into the top of the SCR reactor (4 cm in inner diameter and 35 cm in length). The simulated flue gas stream was introduced at the top of the SCR reactor in the opposite flow direction relative to the mixed Hg^0/N_2 vapor stream to create a mixing zone where mixing of Hg^0 with the flue gas is expected to occur. The flue gas mixture containing Hg^0 and NH_3 passed through a honeycomb flow straightener to obtain a good velocity distribution before passing through the honeycomb SCR catalyst. Mixing of Hg was promoted by the N_2 carrier velocity, residence time, and static mixing effect of the flow straightener. A thermocouple was positioned near the inlet of the catalyst for controlling and monitoring the SCR catalyst temperature. A sampling tube also was positioned near the inlet of the flow straightener for taking gas samples close to the inlet of the SCR catalyst. The gaseous effluent stream exiting the SCR reactor passed through a drying tube to remove moisture in the flue gas. The dried gas then passed to an online ultraviolet (UV) dry SO_2 analyzer (Bovar Engineering, Inc., model 721AT2; accuracy of approximately ±5%) for measuring SO_2. An online chemiluminescent NO_x analyzer (Advanced Pollution Instrumentation, Inc., model 200AH; accuracy of approximately ±5%) downstream of the SO_2 analyzer was used for measuring NO_x.

Test Procedures

A commercial SCR catalyst with a vanadia/titania formulation and a honeycomb configuration, designated as Catalyst A, was used in the study. A small piece (2.2 cm for both sides and 1.9 cm in length) of the catalyst sample was placed into the catalyst compartment of the SCR reactor. The reactor system was heated overnight at 425 °C under an N_2 atmosphere. This cleanup procedure was employed before each test for removing any adsorbed species in the catalyst to minimize the residue effect caused by the previous test. The temperature of the reactor was then lowered to below 350 °C, and SO_2 and HCl gases were added to precondition the catalyst at the same levels as the next day's experiment. The temperature of the reactor was raised to 350 °C and maintained overnight. This catalyst preconditioning procedure was applied before each test. The next morning, the remaining components of the simulated flue gas mixture, CO_2, NO, H_2O, and NH_3, plus Hg^0 were added into the reactor. The flows of the flue gas components were maintained at the levels designed for the test by using the mass flow controllers. The variability of the gas concentrations is approximately ±2.5%. A constant total flow rate of 400 cm^3/min [at a standard temperature of 25 °C and pressure of 101.4 kPa (STP)] was used for all tests. The concentrations of SO_2 and NO_x at the outlet of the reactor were monitored continuously for 4 hr by using the SO_2 and NO_x analyzers, respectively, to ensure that the NO_x reduction reached a steady state. Then, the two gas analyzers were disconnected from the outlet of the reactor, and the reactor outlet was connected to a sampling train. Sampling for Hg (under positive pressure) then was started with a sampling time for each test of 2 hr. The outlet flow rate was measured by using a Gilibrator electronic flow meter (model 2) every 10 min during the sampling period.

Hg Sampling Method

The Hg speciation method[10] developed by Ontario Hydro (OH) was used for measuring Hg^0 and Hg^{2+} in this study. The method was modified slightly for the bench-scale experiments with small volumetric gas flow, and the simulated flue gases sampled in the present study were free of particulates. No particulate filter was used, and smaller impingers (25 cm^3) were installed instead of the 100-cm^3 impingers specified by the OH method. These smaller impingers were used for the much smaller gas volume (0.05 m^3) sampled in this study than those (1–2.5 m^3) targeted by the OH method. The smaller impingers also were equipped with screw caps designed for positive pressure sampling. In summary, the sampling train consists of a series of eight impingers immersed in an ice-water bath. The first three impingers contain a 1-N potassium chloride (KCl) aqueous solution for capturing Hg^{2+}. Hg^0 is insoluble in the KCl solution and passed through the first three impingers. The next impinger contains a solution of 5% nitric acid and 10% hydrogen peroxide followed by three impingers containing a solution of 10% sulfuric acid and 4% potassium permanganate, for capturing Hg^0. The last impinger was empty to condense and remove any moisture remaining in the flue gas. The sample fractions captured by the different impingers were prepared and analyzed as specified in the OH method.[10] Each prepared fraction was analyzed for total Hg by cold vapor atomic absorption. Sampling by the modified OH method was done at the SCR outlet by removing the drying tube and the two gas analyzers shown in Figure 1 and connecting to the OH sampling train. The concentrations of Hg in the impingers after a sampling period of 2 hr reached 3–7 μg/L, which are well within the range (1–10 μg/L) of the instrument (FIMS100) calibrated according to the OH method. The low gas sampling volume (0.05 m^3) employed in this study was still able to collect enough Hg required by the OH method for analysis.

Experimental Approach and Test Conditions

The approach employed in this study was to pass a simulated coal combustion flue gas mixture containing NH_3 and trace Hg^0 through a bench-scale SCR reactor under NO_x reduction conditions and measure Hg speciation at the outlet of the reactor. The HCl and SO_2 levels in the simulated flue gases were varied for simulating the combustion of PRB coals and bituminous coals with different S and Cl contents. Hg speciation samplings near the inlet of the SCR reactor with the catalyst removed were conducted at the beginning and in the middle of the test program. It was found that the inlet concentration obtained from the two samplings was 19.3 ppb (±1 ppb) with very little Hg^{2+} (~2%). The small volumetric flow of the bench-scale reactor makes the simultaneous samplings of inlet and outlet of the SCR reactor impractical. The simulated flue gas mixtures preheated to 350 °C to avoid the formation of NH_4^+ salts also makes the construction of a bypass of the SCR reactor for sampling reactor inlet Hg speciation impractical. Inert Teflon valves are not available for allowing bypass operations at these temperatures.

It has been suggested in the previous field[5,6] and pilot[8] studies that coal type seems to be the major factor in determining the impact of SCR on Hg speciation. A series of four bench-scale tests was conducted in the present study to simulate the combustion of PRB and bituminous coals with different Cl and S contents. The compositions of the simulated flue gas mixtures used for these tests are shown in Table 1. A base flue gas mixture consisting of 350 ppm NO_x, 315 ppm of NH_3, 15% CO_2, 3.5% O_2, 5.3% H_2O, 19 ppb Hg^0, and balance in N_2 was used for all the tests. A sub-stoichiometric NH_3/NO_x ratio was used in all tests to simulate the low NH_3 slip commonly practiced in the field. The concentrations of HCl and SO_2 gases added to the base gas mixture were varied for simulating the combustion of different types of coals. Test P1 simulated the combustion of a PRB coal that has low S and Cl contents such that most of the Cl in the coal would be converted into HCl in the combustion flue gas. Test P2 also simulated combustion of a PRB coal, but no HCl was added to the flue gas mixture to simulate a PRB coal in which a high calcium (Ca) content would result in all Cl released from the combustion of this coal being reacted with Ca such that no HCl would exist in the flue gas. Test B1 simulated the combustion of a low-S and high-Cl bituminous coal, and the combustion of a high-S and low-Cl coal was simulated by the B2 test. All the tests

Table 1. Summary of simulated flue gas composition.

Flue Gas Component	Unit	Test P1	P2	B1	B2
HCl	ppm	8	0	204	134
SO_2	ppm	280	280	934	2891
NO_X	ppm	350	350	350	350
NH_3	ppm	315	315	315	315
CO_2	%	15	15	15	15
O_2	%	3.5	3.5	3.5	3.5
H_2O	%	5.3	5.3	5.3	5.3
Hg^0	ppb	19	19	19	19

were conducted at 350 °C and at a constant total flue gas flow rate of 400 cm^3/min (at STP). The calculated space velocity for the tests was 2609 hr^{-1}, similar to those used in the field. Sampling for Hg speciation using the OH method was started after the simulated flue gas mixture passed through the SCR reactor for 4 hr, and the NO_x concentration measured at the outlet of the reactor showed that the concentration reached a steady-state value.

RESULTS AND DISCUSSION

NO_x Reduction Results

Results of the NO_x reduction for the tests are summarized in Table 2. NO_x reductions of 85–88% were observed for the tests. Figure 2 shows the NO_x concentration profile at the outlet of the SCR reactor for Test B1. Similar NO_x concentration profiles were observed for the other three tests. During the first few minutes after the remaining components of the simulated flue gas mixture (CO_2, NO, H_2O, and NH_3, plus Hg^0) were added into the reactor, the NO_x concentration remained near 0. The pre-conditioning of the SCR catalyst by SO_2 overnight before the NO_x reduction experiment started may make the catalyst very reactive for the initial period of reduction of NO_x. Then, the outlet NO_x concentration increased quickly to ~120 ppm and reduced slowly to reach a steady-state concentration of less than 50 ppm in ~3 hr.

The fresh SCR catalyst used in the tests exhibited strong NO_x reduction catalytic activity under the widely different SO_2 concentrations (280–2891 ppm) employed in the tests. The levels of NO_x reduction (85–87%) obtained from the bench-scale SCR reactor are similar to those observed in the field, suggesting that the reactor system used in the present study simulates closely the SCR NO_x emission control conditions in the field.

Effect of Flue Gas Species on Hg^0 Oxidation

The Hg speciation results measured in the present study are summarized in Table 3. Two Hg speciation samples were taken at the inlet of the SCR catalyst by using the OH method after Tests P1 and B1. Two OH samples also were taken at the outlet of the Hg generation unit at the beginning of the test program. The total Hg concentrations (19.3 ppb) with very little Hg^{2+} (0.5 ppb) measured near the inlet of the catalyst are the same as those (19.2 ppb total Hg with 0.5 ppb Hg^{2+}) measured at the outlet of the Hg generation unit. The two inlet OH speciation results obtained in the presence of two different simulated flue gas mixtures (Test P1 and Test B1) showed Hg^0 as the only Hg species. The consistent inlet results suggest that the presence of HCl and SO_2 at different concentrations in the simulated flue gas mixture have very little effect on changing the speciation of Hg in the mixture before passing through the SCR catalyst. The results also suggest no gas-phase, homogeneous oxidation of Hg^0 at the inlet.

The speciation results shown in Table 3 suggest that HCl has a significant effect on the conversion of Hg^0 into Hg^{2+} under SCR NO_x emission control conditions. All tests except P2 showed most of the Hg sampled at the outlet of the SCR catalyst was in the Hg^{2+} form. As shown in Table 1, the gas mixtures used for Test P1 and P2 were identical except that 8 ppm of HCl was added to the simulated flue gas mixture for the P1 Test, and no HCl was added in the P2 Test. Almost all the Hg measured in the P1 Test was Hg^{2+}, but very little Hg^{2+} was measured in the P2 Test. The total Hg concentration (13.1 ppb) at the outlet of the SCR catalyst measured for the P2 Test is ~60% of that (19.3 ppb) measured at the inlet. The results of the two outlet replicate tests are similar to each other, indicating good precision of the tests. One possible explanation for lower Hg being measured at the outlet for the P2 Test is that the adsorption of Hg^0 by the SCR catalyst may take place in the absence of HCl in the flue gas mixture. Evidence of Hg^0 adsorption was observed during the initial scoping tests of the SCR reactor system. When a gas mixture with 3% O_2, 10% CO_2, 240 ppm NO, and 30 ppb Hg^0 (balance N_2) was passed through the SCR catalyst at 350 °C, very little Hg^0 was measured at the outlet of catalyst by using an online UV Hg analyzer. Hg^0 was measured at detectable levels (>2 ppb) at the outlet immediately after NH_3 was added to this gas mixture. The effect of flue gas species on the adsorption of Hg^0 by the SCR catalyst requires further investigation.

Two tests were conducted for simulating the combustion of bituminous coals that have S and Cl contents much different from those of the PRB coals. The B1 test simulated the combustion of a low-S and high-Cl bituminous coal, and the combustion of a high-S and low-Cl coal was simulated by the B2 test. Results presented in Table 3 show Hg^{2+} was the predominant Hg species measured at the outlet of the catalyst for both tests. It appears that the relatively high HCl concentrations present in the simulated flue gases used for these two tests provide adequate Cl for converting Hg^0 to Hg^{2+}. The total Hg concentration (16.9 ppb) measured at the outlet of the catalyst for Test B1 is comparable to that (19.3 ppb) measured at the inlet. However, much higher outlet total Hg

Table 2. Summary of NO_x reduction results.

		Test			
NO_x	**Unit**	**P1**	**P2**	**B1**	**B2**
Outlet NO_x concentration	ppm	44	52	44	43
NO_x reduction	%	87	85	87	88

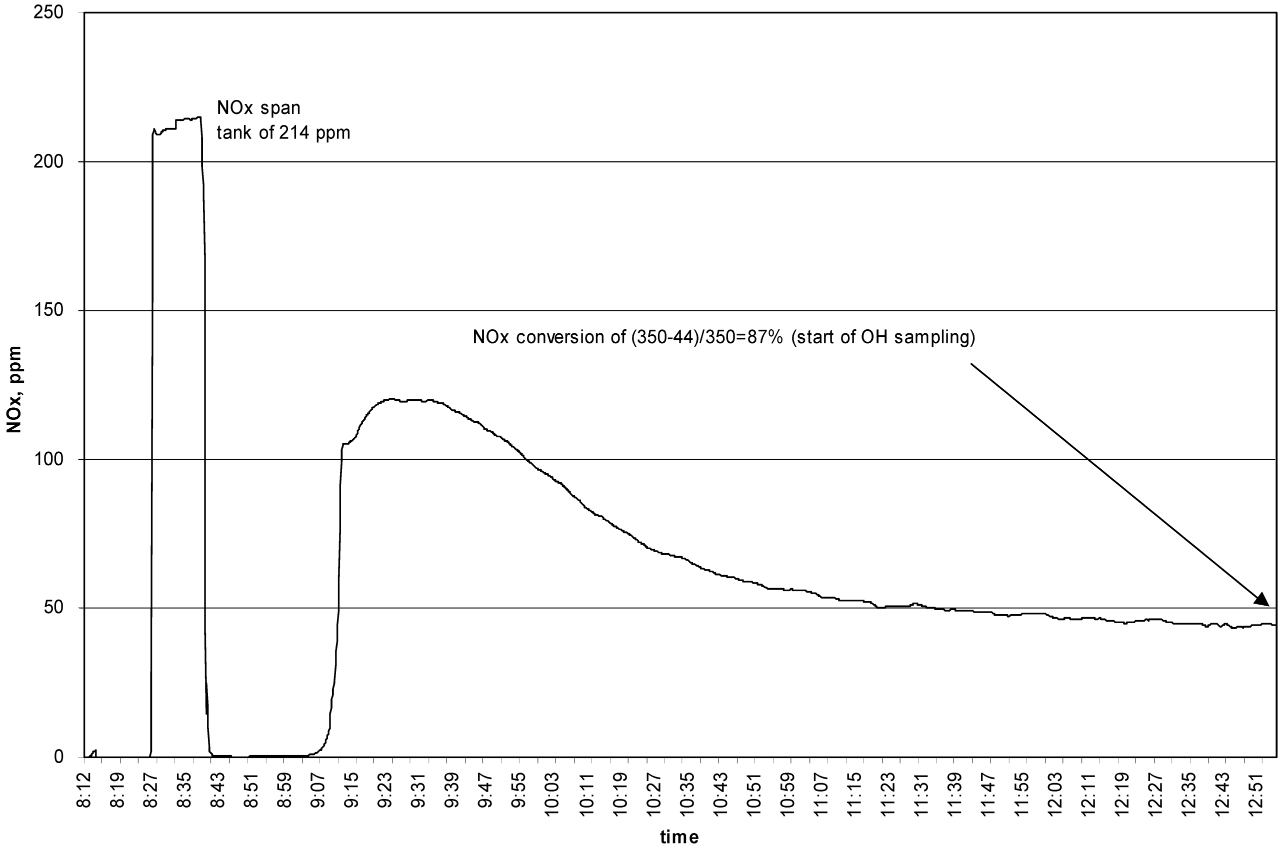

Figure 2. NO_x concentration vs. time (hours:minutes) measured at SCR reactor outlet for Test B1.

concentration (32.7 ppb) was measured for Test B2. The reason for such high total outlet Hg concentration is not known at the present time. A sudden rapid increase in Hg^0 (spike) produced by the Hg^0 generation unit may be the underlying reason. The Hg^0 spike had been observed by using the online Hg analyzer during the initial scoping tests. The high Hg concentration measured in Test B2 was unlikely because of the adsorption of Hg by the catalyst during the previous test. As discussed in the experimental section, the catalyst sample was heated overnight at 425 °C in an N_2 atmosphere before each test for removing any adsorbed species including Hg for minimizing any residual effect caused by the previous test. The high Hg concentration measured in Test B2 also may represent analytical error but was not studied further.

Table 3. Summary of mercury speciation results.

		Test				
Mercury Speciation	**Unit**	**Inlet**	**P1**	**P2**	**B1**	**B2**
Hg^0 concentration	ppb	18.8	0.7	12.6	0.7	3.3
Hg^{2+} concentration	ppb	0.5	17.8	0.5	16.2	29.4
Total mercury concentration	ppb	19.3	18.4	13.1	16.9	32.7
Hg^{2+}	%	2.6	96.7	3.5	95.9	89.9

Importance of Cl Source on Hg^0 Oxidation

It appears that HCl is the most critical flue gas component for converting Hg^0 to Hg^{2+} under SCR emission control conditions. Hg^{2+} was measured as the predominant species at the outlet of the SCR catalyst for the three tests (P1, B1, and B2) that had widely different HCl and SO_2 concentrations. The HCl concentration (8 ppm) used for test P1 was much lower than those used for the other two simulated bituminous coal combustion tests. However, it is still much higher than that (19 ppb) of the Hg^0 in the flue gas and appears to be adequate for converting most of the Hg^0 to Hg^{2+}. Hg^0 was found to be the predominant species for the only test (P2) that had no HCl present in the flue gas. The observation of no Hg^0 oxidation for this test may be because of the lack of a Cl source in this test. The importance of HCl in the flue gas for oxidation of Hg^0 under SCR emission control conditions observed in the present study seems to be consistent with a recent field study. Significant increases in Hg^{2+} across the SCR reactor were observed for boilers burning bituminous coals with total Cl concentration measured in the flue gases ranging from 108 to 19 ppm.[6] However, a boiler burning a PRB coal with 1.5 ppm total Cl measured in the flue gas showed very little change in Hg speciation across the SCR reactor.[6] The PRB coal tested has a Cl content below the detection limit (<60 μg/g), and high Ca content (25%) was found in the fly ash. The lack of HCl available for Hg^0 oxidation for this coal with low Cl content and high Ca content may be the main reason for very little Hg^0 oxidation observed across the SCR reactor.

The importance of a Cl source in low-temperature, heterogeneous oxidation of Hg^0 catalyzed by metal oxides present in fly ash has been suggested in a recent modeling study.[11] The study suggested that Hg^0 oxidation may be promoted by a Deacon-type process for producing Cl_2 from HCl, which further reacts with Hg^0, leading to Hg^0 oxidation. The SCR catalyst used in the present study contains V_2O_5 and TiO_2, which may be reactive for promoting the Deacon-type process. Such oxides have been shown to promote the transformation of Hg^0 to Hg^{2+} in combustion flue gas.[7] Another recent modeling study suggested that low-temperature oxidation of Hg^0 by a reactive source of Cl is significant for coals with appreciable Cl content.[12] The large Cl storage capacity of unburned carbon in coal fly ash is believed to provide a source of reactive Cl for Hg^0 oxidation over a broad temperature range below that for the homogeneous reaction.[12] The SCR catalysts also have significant surface areas as well as active sites, which could retain the reactive Cl generated at the catalyst surfaces and serve as a reactive Cl source for reactions with Hg^0 to oxidize the Hg^0.

CONCLUSIONS

A bench-scale reactor system has been constructed in the present study for closely simulating the SCR emission control conditions in the field. The system was tested using different gas mixtures simulating the combustion of bituminous and subbituminous coals with different Cl and S contents. NO_x reduction levels (~85%) similar to those observed in field units were achieved by the system under the different simulated coal combustion conditions tested in this study. Almost complete oxidation of Hg^0 to Hg^{2+} was observed in all but one of the four simulated coal combustion tests. In the fourth test, no Hg oxidation was observed when HCl was absent from the simulated flue gas. This result strongly suggests that HCl is important for providing the source of Cl for Hg^0 oxidation under SCR emission control conditions. The importance of HCl for Hg^0 oxidation found in the present study provides a scientific basis for the apparent coal-type dependence observed for Hg^0 oxidation reported across SCR reactors in prior field studies.

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