Advanced Gas Cleaning Technology

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CONCLUSION

The fundamental study on sorption of HCl in flue gas by hydrated lime synthesized from various methods (including samples with high specific surface area) was conducted by a lab-scale setup with the STDR. The influence of specific surface area of hydrated lime, inlet HCl concentration, reaction temperature and humidity on the $Ca(OH)_2$ conversion was elucidated. As a result, it was found that there exists a minimum in the final conversion with respect to the reaction temperature in humidified gas and that HCl concentration affects only the reaction rate without changing the final conversion. Furthermore, XRD analyses of reacted sorbent revealed that calcium chloride hydroxide is the only reaction product formed during dechlorination process instead of calcium chloride. This explains that 1 mol of hydrated lime reacts with 1 mol of HCl under the operation condition of incineration plants.

ACKNOWLEDGEMENT

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RETENTION OF ALKALI AND HEAVY METAL ELEMENTS WITH MULTIPLE SORBENTS

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ABSTRACT

Removal of Hg^0 vapor from the simulated coal combustion flue gas with two kinds of sorbents; one is activated carbon and another is inorganic composites based on Silica and partly Kaoline, Fe_2O_3 and $ZnFe_2O_4$ was investigated. Inorganic composite sorbents were reported that they have removal capacity with heavy metals and sodium compounds, in addition sulfur. On the hand, activated carbon has been studied with Hg removal all over the world and reported to have effective Hg removal capacity.[1] We compared the efficiency of Hg removal between them. The Hg^0 removal experiments were carried out in a conventional flow type packed bed reactor in the temperature range of 25-200 ℃ using simulated flue gases containing Hg vapor. It is found that activated carbon was far superior in Hg removal capacity to inorganic composites at any conditions. However, inorganic composites had Hg removal efficiency about 15-30%. And Hg removal activity was temperature dependent for all sorbent samples.

INTRODUCTION

Hg emission to the environment is one of the major environmental issues, because Hg emitted to the environment can be converted through biogeocoenosis to an organic form, methyl-mercury is a neurotoxin in fish, animals, mammals and we human being.[2,3] The major man made sources of mercury emission in to the atmosphere are the flue gases from coal combustors. And mainly they presents as elemental Hg^0 and oxidized $Hg^{2+}(HgCl_2)$. $HgCl_2$ can be removed efficiency with wet scrubber, because that is soluble in water. But elemental Hg^0 is insoluble in water, so it should be removed by solid adsorbents.

EXPERIMENTAL

Materials

Activated carbon (coconut shell derived) used in this study was obtained from DAINEN CO.LTD .BET surface area was ca. 881.75 m^2/g, total pore volume was 0.5402 mL/g and Loss of ignition was 86.2 wt%. Inorganic composites was contributed by BASE, Tokyo University of Agriculture and Technology. The inorganic composites was consisted of SiO_2 (80-90 wt%), Kaoline (0-10 wt%), Fe_2O_3 (0-10 wt%) and $ZnFe_2O_4$ (0-10 wt%). They were put into elliptic rotator and mixed with two different rotation speeds.

Apparatus and procedure

Elemental mercury vapor removal experiment was carried out in a fixed-bed flow type reactor. Fig.1 shows the experimental apparatus. As shown in Fig.1, the continuous mercury analyzer (MS-1, DM-5: Nippon Instrument) was established to measure the amount of

percolated Hg at the reactor exit. To confect Hg^0 reference gas, Hg^0 was injected into vacuum-bag contained known amount of Air by using syringe pump till adequate concentration. DM-5 always drafts 0.5 L/min by pump, so mercury concentration can be varied by varying N_2 and SO_2 flow rate. In this test, Hg concentration was kept ca.1000 μ g/(Nm^3 · min). Prior to the Hg^0 removal test run, 0.5 g of sorbent sample was packed in the quartz tube reactor. Experiment performed at atmospheric pressure in the temperature range of 25-200 ℃. Hg removal experiment was commenced for 120 seconds after flow gas contained Hg vapor was fed into reactor. The mercury adsorption efficiency was quantified by comparison between the Hg^0 concentration in the gas before and after adsorption.

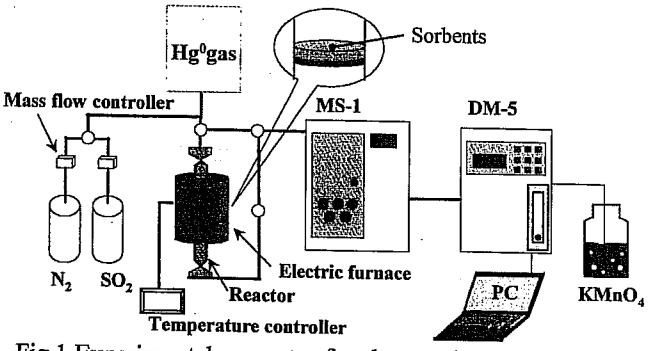

Fig.1 Experimental apparatus for elemental mercury removal

RESULTS AND DISCUSSIONS

Effect of temperature on Hg removal

The effect of temperature on Hg removal activity of used sorbent samples was examined at the temperature 25℃ and 100℃, flow gas was N_2 . We used three samples as shown in table 1 and activated carbon. Fig. 2 shows the amount of percolated Hg with blank test and through the sorbent, in this case sorbent number 1; SiO_2 90%, Kaoline 5% and Fe_2O_3 5% was settled in the reactor. Fig. 3 shows the Hg removal efficiency for these samples. First, it is evident that at the temperature of 100℃, Hg removal efficiency of these samples are higher than that of at 25℃. Secondary, the Hg removal efficiency of activated carbon was far highest of the four sorbent samples. At this time, we have not concluded the reason yet. And we are proceeding another content of sorbent.

Table 1. Inorganic sorbent composition

Unit wt%

Sorbent sample	SiO_2	Allophene	Kaoline	Kaolinite	Fe_2O_3	$ZnFe_2O_4$	Rotational speed,r/min
1	90	0	5	0	5	0	3000
2	80	0	10	0	10	0	3000
5	90	0	5	0	0	5	3000

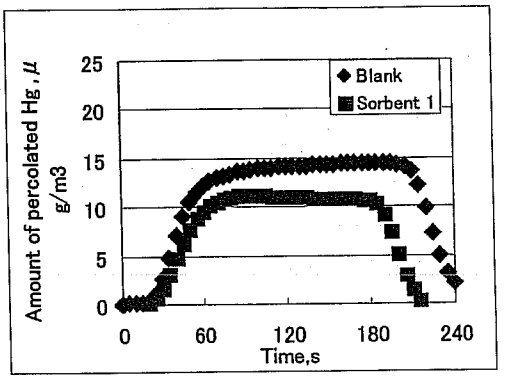

Fig.2 Amount of percolated Hg with blank test and through the sorbent 1

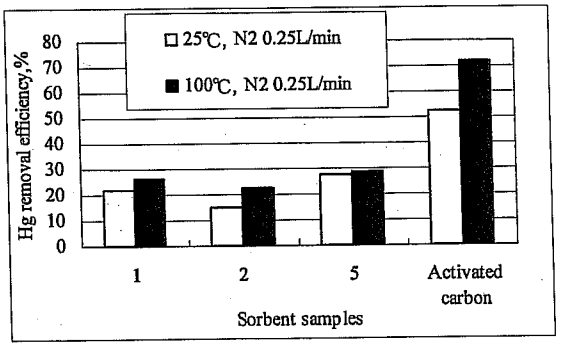

Fig.3 Hg removal efficiency at the temperature of 25℃ and 100℃

Effect of the presence SO_2 (500ppm) on Hg removal activity for selected sorbent samples

The effect of the presence of SO_2 (500ppm) on Hg removal activity of used sorbent samples were examined at the temperature of 100℃. We performed experiment in two kind of inorganic sorbent samples, differ from Kaoline and Fe_2O_3 content. Table 2 shows the composition of the used sorbent samples. Fig.4 shows the Hg removal efficiency under the presence of 500ppm SO_2/N_2.

It is reported that the following reactions occur on the surface of activated carbon under the presence of SO_2.[4]

$$2SO_2+O_2=2SO_3 \quad (1)$$
$$H_2O+SO_3=H_2SO_4 \quad (2)$$
$$Hg+1/2O_2=HgO \quad (3)$$
$$HgO+H_2SO_4=HgSO_4+H_2O \quad (4)$$

If the same reaction occur on the inorganic sorbent samples, Hg removal efficiency is higher when SO_2 presence. Moreover, it is reported that Fe_2O_3 has a sulfur removal capacity, so if Fe_2O_3 combined with SO_2 on the surface of sorbent, FeS generated. We suggest the following reactions to remove Hg^0 for Fe_2O_3 under the presence of SO_2.

$$Hg+2Fe_2O_3+5SO_2=HgS+4FeSO_4 \quad (5)$$

Sorbent sample included 10% Fe_2O_3 was better Hg removal efficiency than that of 5% Fe_2O_3. It might occur the reaction (5), but we have not concluded yet. More samples are needed to determine the reaction (5).

Table 2. Inorganic sorbent composition

Sorbent sample	SiO_2	Allophene	Kaoline	Kaolinite	Fe_2O_3	$ZnFe_2O_4$	Rotational speed,r/min
1	90	0	5	0	5	0	3000
2	80	0	10	0	10	0	3000

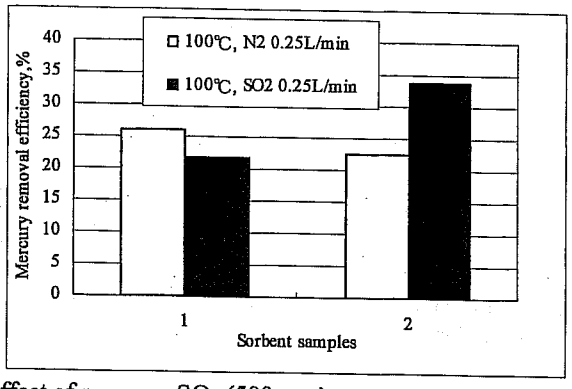

Fig.4 Effect of presence SO_2 (500ppm) on mercury removal efficiency

CONCLUSION

We examined the Hg removal activity for inorganic sorbent samples and activated carbon at the different temperature and in the presence of SO_2. The following results were obtained from in this study. At the temperature of 100℃, Hg removal activities were higher than that of at the temperature of 25℃. And any case, activated carbon was better than the inorganic sorbent samples. In the presence of 500ppm SO_2/N_2 at the temperature of 100℃, it is expected that Fe_2O_3, desulfurization agent, may facilitate to the Hg removal efficiency.

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ENGINEERING TAR-CRACKING CATALYSTS TO OPTIMIZE BIOMASS GASIFICATION

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ABSTRACT

This paper describes a new and more efficient method for engineering and economically producing optimized catalysts, initially for the reduction or elimination of tars in biomass gasification. However, catalytic materials produced by this technology should also be useful for enhancing or modifying the composition of any fuel gas for downstream refining or Fischer-Tropsch synthesis. This technology utilizes new, very high-temperature glassmaking technology to combine catalytically-active materials (e.g. NiO) with refractory glasses (e.g. olivine) to produce, in one step, an attrition-resistant catalyst that through standard glass-processing technology can be made, as a first use, into a tar-cracking bed material for fluidized-bed or circulating fluidized-bed biomass gasifiers. Conventional catalysts for atmospheric or pressurized biomass gasification are manufactured by first fabricating an appropriately sized attrition-resistant substrate (e.g. alpha alumina or olivine) that is then combined with catalyst-containing compounds that are then fused to the substrate to form a catalytically-active material (e.g. NiO) that covers the substrate. This multi-step process is labor and time intensive and the new technology offers a way to significantly reduce the time and cost of producing tar-cracking catalysts, tailoring the composition of fuel gas to simplify downstream cleanup, or to facilitate the use of gas-to-liquids technologies such as Fischer-Tropsch synthesis.

BACKGROUND

Catalysts are recognized as essential for reducing or eliminating the tars that accompany biomass gasification [1]. Two routes are typically followed when using catalysts to reduce or eliminate the tars that are produced when biomass is gasified (tars are typically defined as organic compounds of a molecular weight equal to or greater than 78 – i.e.. Benzene) [2]. The first route is through the use of specially formulated catalysts that have been deposited as a thin layer onto the surface of an otherwise inert ceramic substrate. These substrates are typically formed into shapes designed to maximize contact with passing gases and are typically manufactured as monolithic structures or various sizes of particles or pellets that can be confined in granular beds that are positioned after the gasifier vessel (NiO is frequently used) [3, 4]. Catalysts have also been embedded into ceramic candle filters so that during high-temperature gas-particle separation, intimate gas-catalyst contact is assured [5]. A second route, and the approach which this paper addresses, is the introduction of suitably small fragments, beads, or pellets of catalytic materials into a fluidized bed (FB) gasifier, to comprise all or a portion of the bed.

The use of catalytic materials for tar reduction in the beds of FB biomass gasifiers has been reviewed by Milne, et al. [2] and more recently by Dayton [1] and Devi [4]. These catalysts, examples of which include dolomite [7] olivine [8] and catalytic materials applied to attrition-resistant α-alumina substrates [6], are added to or comprise the bed of a FB gasifier. By being intimately involved in the gasification process, such catalytic materials achieve good contact with pyrolized fuel gases and inhibit tar formation by cracking or reforming tars as they are produced to