

Investigations on trace elements distribution in PM from a pulverized coal combustion process

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ABSTRACT

Mercury distribution in fly ash from a pulverized coal fired plant was investigated for three coals to elucidate the partitioning mechanisms in combustion processes. The fly ashes were classified by an acoustic sieve. Obtained seven classes of particle diameter was measured its Hg content. It is found that mercury concentration in the sieved fly ash is increased with increasing the average particle diameter. Since large size particles contain much unburned carbons, mercury seemed to be adsorbed on its surface. Relation between unburned carbon and Hg concentration had good correlation for three coal types, however, other factors such as surface area and carbon structure of the unburned carbons should be investigated to establish the Hg partitioning mechanisms on solid phase.

KEYWORDS: Mercury, Fly ash, Partitioning mechanism, Unburned carbon

1. INTRODUCTION

Trace elements such as Hg, Se, and B are emitted from coal combustion processes with partitioning on gas phase, liquid phase, and solid phase. In spite of much investigation, partitioning mechanisms for those elements were not revealed, and many approaches are demanded for general interpretation.

To reveal partitioning mechanisms on solid phase, this study focuses on particulate matter which contains trace elements from combustion processes. Three coal fly ashes were classified to investigate Hg partitioning by analysis of its particle distribution and Hg concentrations.

2. EXPERIMENTAL CONDITION AND SAMPLES

2.1 Samples

Three coal fly ashes (coal N, B, O) from a pulverized coal fired plant were obtained at its electrostatic precipitator. Table 1 shows key properties of sample coals which indicates its Hg concentrations are 0.029~0.064 mg/kg, and the average value of bituminous coal is approximately equal to coal N.

2.2 Particle Size Distribution and Classification

Fig. 1 shows particle size distribution of coal N which has three peaks or smaller than 1 μ m, approximately 20 μ m, and approximately 80 μ m. For analysis of Hg concentrations at each particle size, fly ashes were classified to seven samples by classification interval showed on Fig. 1. Sample 1~4 were classified by an acoustic sieve and sample 5~7 by usual sieves.

Obtained seven samples were measured its particle size distribution by laser diffraction particle size analyzer. Particle size distributions of classified seven samples (coal N) were

showed on Fig. 2.

In the same way, coal B, coal O were classified and measured its particle size distribution.

Table 1 Characterization of study coals

Coal		N	B	O
Proximate Analysis	Moisture wt%	2.6	4.9	4.3
	Ash wt%	15.0	7.1	10.8
	VM wt%	26.4	41.9	30.4
	FC wt%	56.0	46.1	54.5
Ultimate Analysis	C wt%	84.37	76.50	82.09
	H wt%	5.12	5.87	4.80
	N wt%	1.91	1.90	2.06
	S wt%	0.33	0.76	0.52
	O wt%	8.27	14.97	10.53
Trace Element	B mg/kg	17.8	109	43
	Hg mg/kg	0.044	0.029	0.064
	Se mg/kg	0.40	0.16	0.32

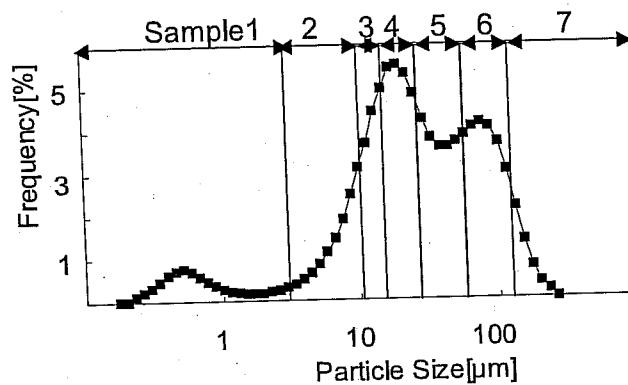


Fig. 1 Particle Size distribution and classification interval for coal N

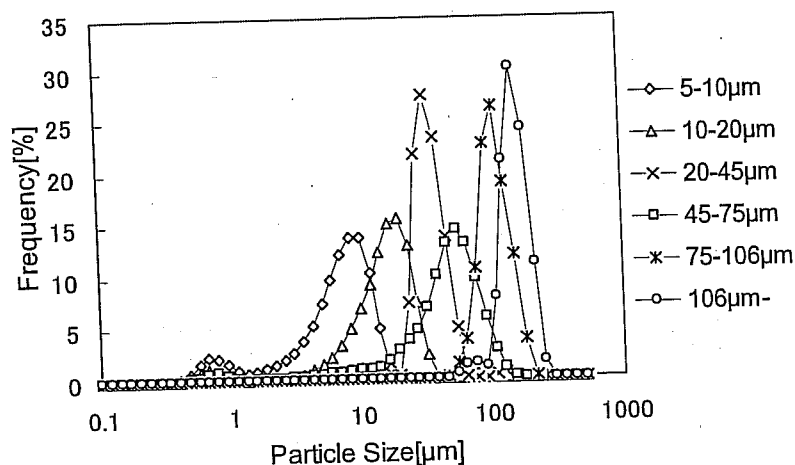


Fig. 2 Classification result (coal N)

2.3 Direct Determination of Hg by GF-AAS

Generally, solid samples are dissolved, and then analyzed trace elements by AAS, ICP-MS. However, dissolution process causes measurement errors from preparation such as sample weighting, acid dissolution, in this study direct determination by GF-AAS were applied for

resolution of those problems.

2.4 Optimization of Analysis Parameters

Because direct determination by GF-AAS is relatively new field of analysis, that parameters should be optimized. Atomizing temperature was the most important parameter, and the best condition for Hg was explored.

Relation between Hg amount and absorbance are showed on Fig. 3-1, Fig. 3-2 with atomizing temperature 1350°C, 1750°C. Depending on the atomizing temperatures, slopes of calibration curves do not change, but dispersion of data plots vary. Shifting atomizing temperature from 1000°C to 1750°C by 100~200°C, the best condition was determined as Fig. 3-1. Precision turns down as Fig. 3-2 if atomizing temperature varying from that condition.

Ashing temperature is another important analysis parameter. Generally Hg is analyzed with matrix modifier at 200~300°C ashing temperature due to its high volatility. In this study to keep Hg in solid samples, ashing temperature set very low 65°C. Because solid samples contain little moisture, that ashing step is possible differently from liquid samples.

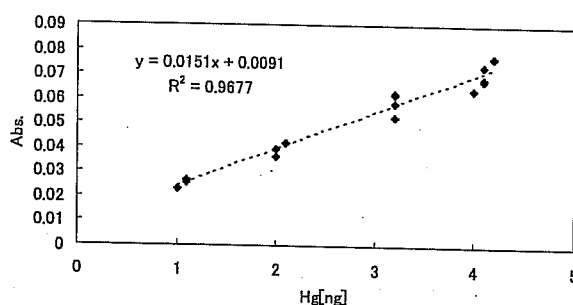


Fig. 3-1 Calibration curve with the atomization 1350 °C

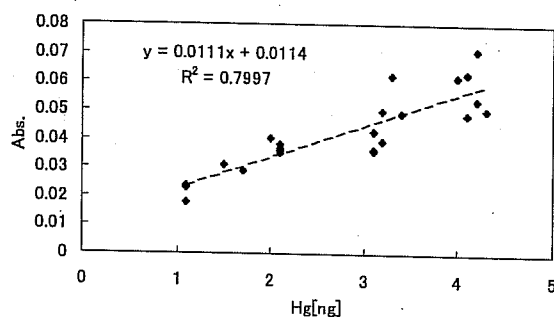


Fig. 3-2 Calibration curve with the atomization 1750 °C

3. RESULT

3.1 Hg Content in Classified Samples

Seven classified samples were analyzed for three coal fly ashes, Hg concentration was plotted against average particle diameter on Fig. 4. Concentrations in the classified fly ash are increased with increasing the average particle diameter for three coals. Because large size particles larger than sample 5 contain unburned portions, Hg resides in unburned particles not in fine particles whose constituents are mainly ash. Fig. 5 and Fig. 6 are small particle and large particle SEM photograms that show unburned particles reside mostly in large size samples. In addition, Hg was not detected from small particle of coal B and coal C.

3.2 Control Factor of Hg Partitioning on Solid Phase

Results of Fig. 4~Fig. 6 show that most of Hg partitioned on solid phase was probably adsorbed on unburned particle surface. Therefore, unburned carbon content was determined to explore the relation between unburned portion and Hg concentration by thermo gravimetric analysis; results were showed on Fig. 7. Because Hg concentration increases with increasing the unburned carbon content for three coals, the carbon rate in fly ash is the main partitioning factor. However, plot data for three coals are not correspond greatly, that is to say other factors such as surface area and carbon structures are seemed to contribute partitioning processes to some extent.

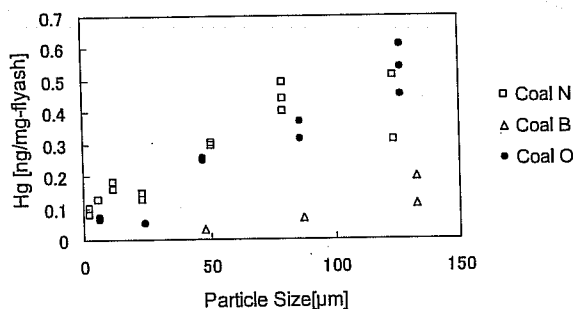


Fig. 4 Hg content at different particle size

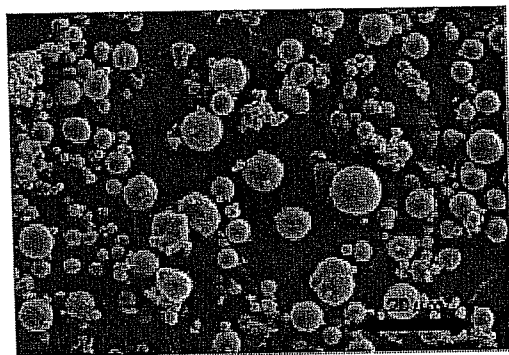


Fig. 5 Small particle

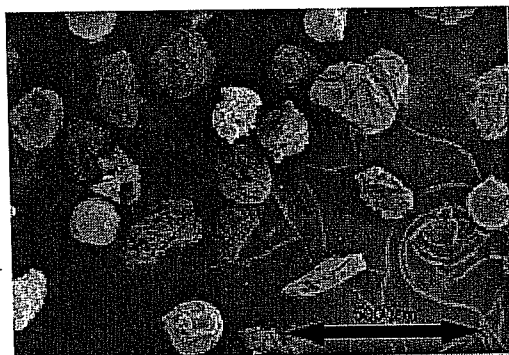


Fig. 6 Large particle

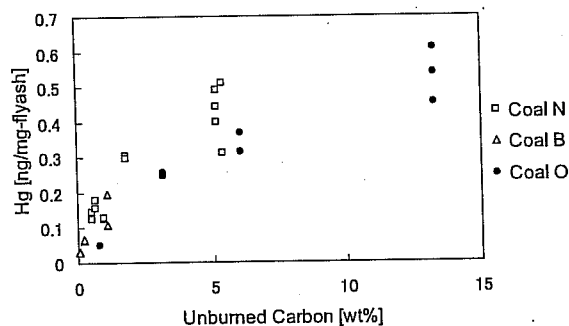


Fig. 7 Relation between unburned carbon and Hg content

3.3 Observation of Unburned Particles by SEM

In addition to carbon content, surface area and structure of the unburned carbon has the possibility to have a role in partitioning mechanisms, and then unburned particles were observed by SEM. Photographs of unburned particles for three coal fly ashes showed on Fig.

8~Fig. 10. Particle morphology has some varieties in three coal fly ashes. Fly ashes for low Hg concentration are coal B, its morphology is non-porous and ashes are adhered on its surface. Fly ashes of coal N and coal O are mainly porous carbon particles, and contain much Hg. Although coal N and coal O are porous particles, there are a few differences between two coals. Those differences in three coals disturb relation on Fig. 7, and indicate that particle morphology affects partitioning mechanisms.

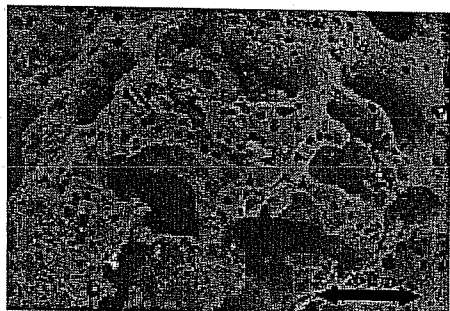


Fig. 8 Unburned particle of coal N

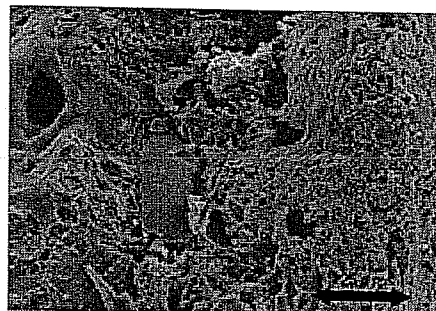


Fig. 9 Unburned particle of coal O

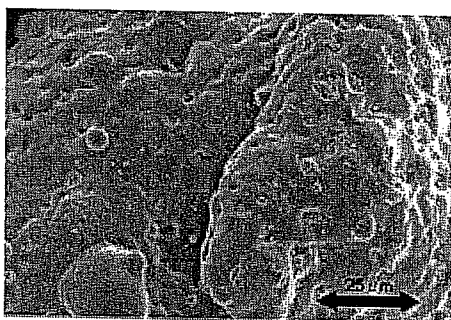


Fig. 10 Unburned particle of coal B

4. CONCLUSION

Mercury distribution in fly ash from a pulverized coal fired plant was investigated for three coals and direct determination by GF-AAS was applied in this study. Concentrations in the classified samples were increased with increasing the average particle diameter. Determination of carbon content in classified samples indicated good correlation between unburned carbon content and Hg concentration. Although unburned carbon content in fly ashes is seemed to be a major factor of partitioning mechanisms, other factors such as surface area and carbon structure should be considered for more applicable mechanisms.

