Reduction of PCDD/F Formation Using Alkaline impregnated Powdered Activated Carbon

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Introduction

Powdered activated carbon (PAC) injection is one of the most convenient and cost effective technology for PCDD/F removal in flue gas from municipal solid waste and industrial waste incinerators. As serious retrofitting is expensive, many incinerators in the world applied this technology. The essential characteristics of PAC for gaseous PCDD/F removal are considered to be large pore size, suitable particle size distribution, and safety[1)]. However, it is not well-known that PAC has catalytic activity for PCDD/F formation. Durkee and Eddinger[2)] reported that coal based PAC produced PCDD/F in dust collector and increased PCDD/F conc. in fly ash greatly. Excess formation of PCDD/F like this is undesirable from the viewpoint of total emission control. Therefore, the development of special PAC which has both high absorption ability and very low catalytic activity seems to be necessary.

The authors found that PCDD/F formation activity of PAC was quite different according to its origin and could be suppressed markedly by so called inhibitors[3)] such as alkaline compounds. This paper describes basic characteristics of alkaline

impregnated PAC (AIPAC) and its application results to full scale incinerators.

Materials and Methods

PCDD/F formation activity test. Fig. 1 shows a schematic diagram of the experimental set-up for the evaluation of PCDD/F formation activity . One gram of various kinds of PAC, AIPAC or fly ash was put into the quartz column (20mm x 250mm) and 100μg of trichlorophenol (TCP) attached to 1 g of glass beads was set on the top of evaluated materials. These two layers were separated by Glass wool. This column was heated at given temperature for 20 min. with aeration of 15ml/min. PCDD/F in flue gas was trapped by an ice-cooled toluene impinger. PCDD/F concentration was determined by analyzing both stuffed materials and toluene.

Preparation of AIPAC. For laboratory experiments, 10g of lignite PAC was mixed with NaOH or KOH solution and stirred. Then, water was removed by heating. For full scale incinerator, AIPAC was prepared by spraying NaOH solution on lignite PAC in the mixing chamber.

Field Test The evaluation of AIPAC was done in a full scale municipal solid waste incinerator. This incinerator was a continuous type and its combustion capacity was about 100t/day. PAC or AIPAC was injected into flue gas with the rate of 100mg/Nm^3 before the electrostatic precipitator (ESP). PCDD/F in flue gas before and after ESP and in collected fly ash was measured. Chlorophenols and chlorobenzenes as PCDD/F precursors were also measured.

Results and Discussion

Fig-2 shows the PCDD/F formation activity of various PAC and fly ash. All PAC

tested produced mainly TCDD from TCP. Especially, coal based PAC had stronger activity than fly ash from ESP. As PAC has large surface area and contains much heavy metals, it sometimes can be active catalyst for PCDD/F formation. Fig-3 shows the effect of temperature on PCDD/F formation by coal based PAC. The optimum temperature of this reaction was 300 like in fly ash. But, PCDD/F formation was observed even at 200. This suggests that PCDD/F formation by PAC occurs in flue gas treatment process, especially in dust collector.

Fig-4 shows that PCDD/F formation by lignite based PAC was greatly reduced by alkaline impregnation. According to Naikwadi *et al*[3], and Karasek *et al*[4] alkaline compounds such as NaOH and KOH showed inhibitory activity on PCDD/F formation by fly ash. Therefore, impregnated alkaline may inhibit PAC's catalytic activity by the reaction with heavy metals distributed on the surface of PAC. Whereas, Addink and Altwicker[5] showed that the higher pH in fly ash was, the less PCDD/F was formed. In fact, NaOH and KOH are strong alkalis and pH may be an important factor, but its mechanism still remains to be cleared out.

Table-1 shows evaluation results in a full scale incinerator. Without PAC injection, PCDD/F conc. in ESP outlet gas and in fly ash were 24ng-TEQ/Nm^3 and 4.6ng-TEQ/g, respectively. When PAC was injected before ESP, PCDD/F conc. in ESP outlet gas decreased to 2.9 ng-TEQ/Nm^3 by absorption, but total emission increased by about 1.6 times. As the temperature of ESP inlet gas was nearly 240, it was considered that much PCDD/F formed in the ESP.

On the other hand, AIPAC injection decreased PCDD/F conc. both in flue gas and in fly ash. This means that PCDD/F absorption ability of AIPAC was almost equal to that of PAC and AIPAC showed significantly lower catalytic activity even in full scale incinerator. Alkaline impregnation gave no bad effect on the absorption ability of AIPAC. Moreover, it also found that AIPAC had PCDD/F precursors removal ability. Table-2 shows gas-dust distribution of chlorophenols and chlorobenzenes. The precursors content in fly ash was higher in case of

AIPAC injection. Therefore, less precursor might attach on the surface of fly ash and then less PCDD/F was formed.

As a result, AIPAC could reduce total emission of PCDD/F as well as PCDD/F conc. in flue gas from incinerators.

References

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2. Durkee K and Eddinger J; *12th Incineration Conference*, **1993**, 381

3. Naikwadi K, Albrecht I and Karasek F; *Chemosphere*, **1993**, 27, 335.

4. Karasek F, Miyata H and Hayashi S; Japanese Patent No.9-220438, **1997**

5. Addink R and Altwicker E; *Environmental Engineering Science*, **1998**, 15, 19

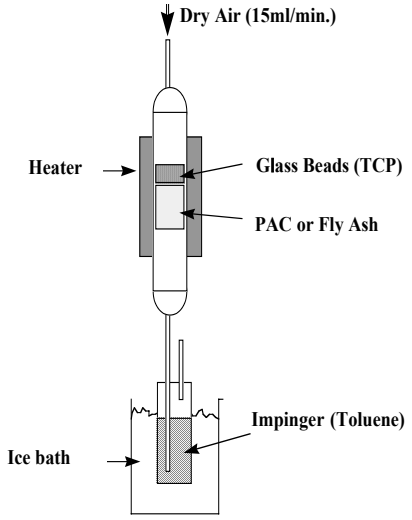

Fig-1. Experimental set-up for PCDD/F formation activity measurement

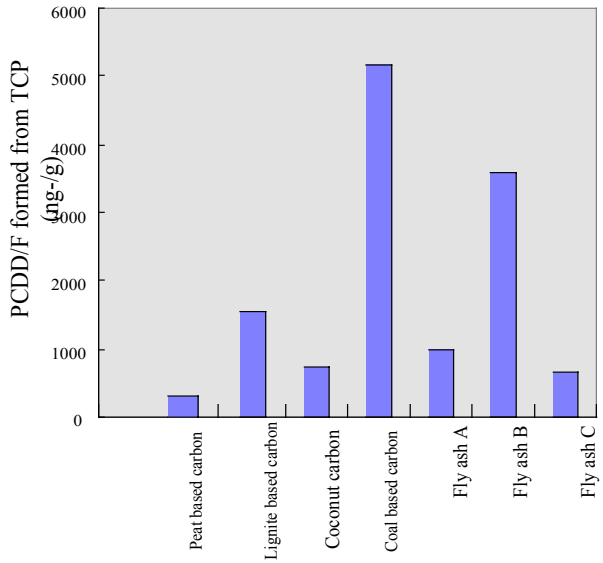

Fig-2. PCDD/F formation catalytic activity of various PAC and fly ash

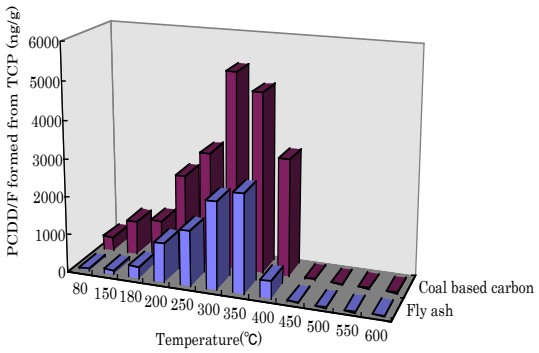

Fig3. Effect of temperature on PCDD/F formation

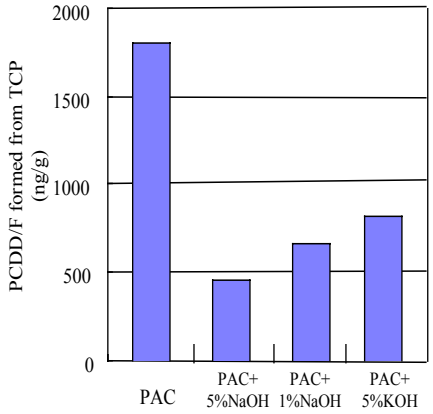

Fig-4. Reduction of PCDD/F formation catalytic activity of activated carbon by alkaline impregnation

Table-1. Evaluation of AIPAC in a full scale incinerator

	ESP outlet gas (ng-TEQ/Nm3)	Fly ash (ng-TEQ/g)	Emission from flue gas (μg-TEQ/h)	Emission from fly ash (μg-TEQ/h)
No Injection	**24**	**4.6**	**576**	**1656**
PAC	**2.9**	**12.7**	**54**	**3524**
AIPAC	**1.2**	**4.1**	**22**	**1150**

Table-2. Chlorophenol (CP) and Chlorobenzene (CB) emission from dust collector

	CP in outlet gas (μg/h)	%	CP in fly ash (μg/h)	%	CB in outlet gas (μg/h)	%	CB in fly ash (μg/h)	%
PAC	**735**	**68.4**	**340**	**31.6**	**387**	**54.3**	**325**	**45.7**
AIPAC	**306**	**23.0**	**1026**	**77.0**	**268**	**25.7**	**776**	**74.3**