DESTRUCTION OF PCDD/FS FORMED BY PENTACHLOROPHENOL VIA GLIDING ARC DISCHARGES

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Introduction

Dioxins are known to be recalcitrant contaminants, as environmental hormones that disturb ecosystems and induce cancers and behavior disorders in living organisms. Since the first report on "Dioxin" formation and emission from waste incineration, numerous studies on reduction of dioxin emission have been devoted to this unwanted phenomenon. In terms of technological processes, the methods for PCDD/Fs control can be roughly divided into two groups: good combustion practice and pipe-end emission control[1]. The former methods include intervention in the technological process and providing good combustion conditions that amount to generated dioxins to be as small as possible. Among the methods for pipe-end emission control, there are mainly physical adsorption and physio-chemical decomposition. Although activated carbon(AC) adsorption has been broadly applied to achieve reliable removal efficiency for PCDD/Fs control, a large quantity of absorbed AC needs to be further treated prior to final disposal. Catalytic degradation is another important method for the reduction of PCDD/Fs emissions from incineration processes, which simultaneously eliminates NO_x and PCDD/Fs with satisfied efficiency. In catalytic degradation[2], flue gas is necessary to heat up to proper temperature for treatment, and the catalyst is normally sensitive to poisoning by sulfur or halogen containing compounds.

The number of industrial applications of plasma technologies is extensive and involves many industries. Generally, two very different kinds of plasma are used for PCDD/Fs disposal, i.e. thermal and non-thermal plasma[3]. Thermal plasma was mainly adopted to melt fly ash into slag, which can be utilized as recycled construction material. The main drawbacks of thermal plasma are high energy consumption and complicated electrode structure. An alternative for plasma processing is the non-thermal one. Silent, glow, corona, short pulse, electrical discharges are directly produced in the processed gas, mostly under low pressure. Gliding arc is a new technology of non-thermal plasma. In recent years, researchers are paying increasing attention on this new technology for environmental protection. It was demonstrated that gliding arc plasma efficiently destructed volatile organic compounds (VOCs)[4](higher than 90%), NO_x[5],SO_x[6].

In this paper, a trial test on destruction of PCDD/Fs in flue gas via gliding arc discharge is preliminarily performed, whereas PCDD/Fs is synthesized from pentachlorophenol(PCP) with $CuCl_2$.

Materials and Methods

The schematic diagram of experimental setup is shown in Fig.1 70 mg PCP powder mixed with 1.0 g $CuCl_2$ is placed in a ceramic boat and covered with some quartz sand which has been baked for two hours at 800℃, Then, the ceramic boat is pushed into the mid-place of the quartz tubular furnace, 50 cm in length and 2 cm in diameter. The N_2 set at 300 ml/min induces into quartz tubular furnace. The reaction time for each run is 30 minutes. In order to obtain maximal production of PCDD/Fs, temperature is set 550 ℃ for reference to our previous study[7].

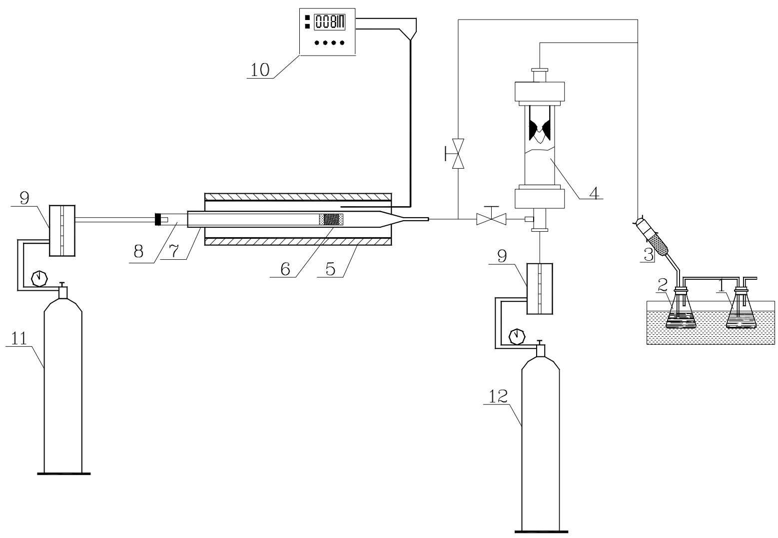

Fig. 1. Experimental setup of discharge on PCDD/Fs by gliding arc plasma
1,2 toluene, 3.XAD-2 resin, 4. Gliding Arc Reactor , 5. tubular furnace, 6. ceramic-boat, 7. quartz tube 8. handspike, 9. flow meter, 10. control panel, 11.N_2, 12 dry air

The gliding arc reactor was made from a ceramic tube of inner diameter 100 mm and total volume 2.35 L. The upper and bottom part of the reactor supplied with a Teflon seal comprising two electrodes made of stainless steel. The flue gas discharged from tubular furnace joint with carrying gas was injected into the reactor through a capillary of inner diameter 1 mm.

Table 1. Experimental Conditions of Gliding Arc Reactor

Parameter	Value
Power frequency (Hz)	50
Carrier gas flow rate (L/min)	2.2 (air)
Narrowest electrode gap (mm)	2.0
Length of electrode(mm)	150
Maximum voltage(kV)	10

The sample pretreatment method is described elsewhere according USEPA method 8280B[8]. All analyses are performed on a low resolution Thermo Finngan Voyager mass spectrometer (LRMS) with a trace 2000 high-resolution gas chromatograph (HRGC). Chromatographic separations are carried out on a 60 m DB-5 quartz capillary column. The temperature program for GC oven was: initial temperature 100 ℃, held for 2 minutes;100~200℃ at 25℃/minute; 200~280℃ at 3℃/minute;280℃ held for 20 minutes. Carrier gas: Helium(99.999%), 1 ml/min; splitless sample injection. Mass spectrum condition: electron impact ionization 70 eV; electron multiplier voltage 420V; ion source temperature 220℃; interface temperature 250℃; SIM(selected ion monitoring mode). All the isotope standard samples were purchased from Wellington laboratories, Canada.

Results and Discussion

The content of Dioxin under no discharge and discharged have been analyzed as shown in Table 2. From this experiment, we found that the destruction of dioxin homologues by gliding are discharge ranged from 41.49% to 77.02%.(Fig.2), though homologue of HxCDF is no detected in discharged sample and so does to TCDD in no discharged sample, which is possibly due to the losing in analytical process.

In this process, free electrons are accelerated by gliding arc plasma and obtain enough energy to cause inelastic collision[9], they will transfer all or part of its kinetic energy to PCDD/Fs molecules with which they have collided, resulting in a change to the PCDD/Fs molecules such as ionization, dissociation or excitation. Gliding arc plasma simultaneously discharges UV ray to dissociate the C-Cl bond in PCDD/Fs molecule. Thus, both above electrical destruction and photoelectric effect jointly decompose Dioxin.

This result demonstrates that gliding arc plasma is capable to effectively destruct dioxin in flue gas, which may serve as a potential candidate for the in-site elimination of PCDD/Fs in flue gas as well as fly ash.

Table 2 Destruction of PCDD/Fs by Gliding Arc discharge

Type of dioxin		Dioxin Level(ng)	
		No discharge	After dicharge
PCDFs	TCDF	78.17	40.06
	PeCDF	17.85	7.26
	HxCDF	3.47	0.00
	HpCDF	56.70	24.57
	OCDF	1853.79	426.00
	Total	2009.98	497.90
PCDDs	TCDD	0.00	8.96
	PeCDD	20.91	6.95
	HxCDD	112.69	36.60
	HpCDD	384.79	225.15
	OCDD	27972.31	10245.55
	Total	28490.71	10523.21
total-concentration		30500.68	11021.11
I-TEQ		34.29	13.25

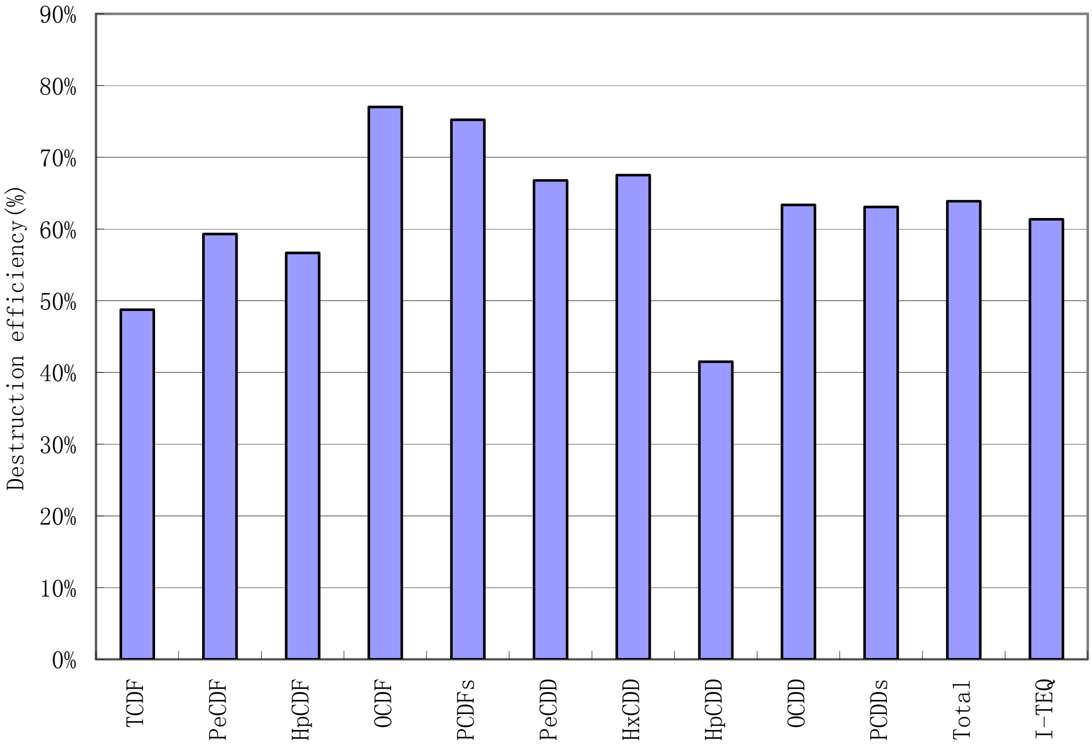

Figure 2. PCDD/Fs destruction efficiency for each homologue

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