CHAPTER IV

EXPERIMENTAL

4.1 Test materials and chemicals

Table 4.1 The specifications of test materials and chemicals

Type	Use	Company	Purity / Grade
Acetaldehyde(g)	Sample gas	TIG*	Acetaldehyde 2000 ppm balanced with N_2
Ammonia(g)	Sample gas	TIG	Ammonia 2000 ppm balanced with N_2
Trimethyl amine(g)	Sample gas	TIG	Trimethyl amine 2000 ppm balanced with N_2
Distilled Water	For preparing water vapor	-	-
Oxygen	Coexisting gas	TIG	Industrial grade
Carbon dioxide	Coexisting gas	TIG	HP, 99.99
Nitrogen (g)	Carrier and diluents gas to reactor	TIG	UHP 99.999 % min
Nitrogen (g)	Carrier gas for GC (FID detector)	TIG	UHP 99.999 % min
Hydrogen	For flame ignition	TIG	HP, 99.99%
Air Zero	For flame ignition	TIG	N / A
Helium	Carrier gas for GC (TCD detector)	TIG	UHP, 99.999%

* Thai Industrial Gases Co., Ltd.

4.2 Experimental setup

Figure 4.1 shows the actual arrangement of the experimental apparatus of the gaseous pollutant remover used in the present work. **Figure 4.2** presents its schematic diagram.

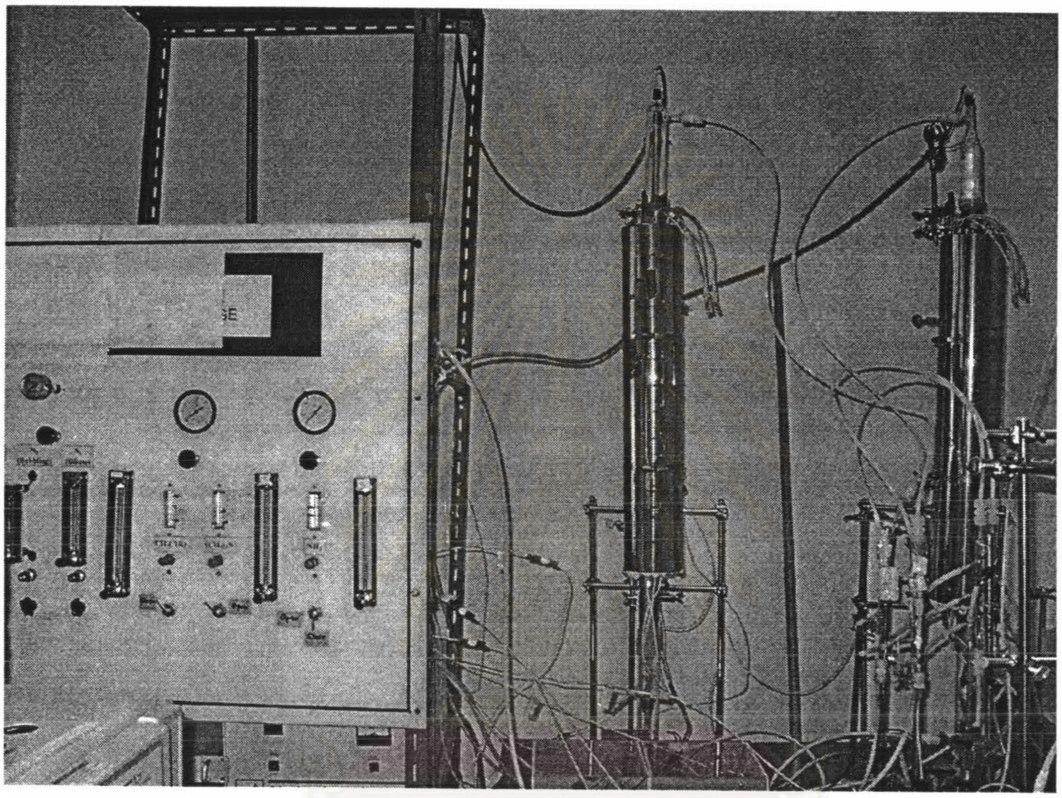

Figure 4.1 Arrangement of present experimental apparatus

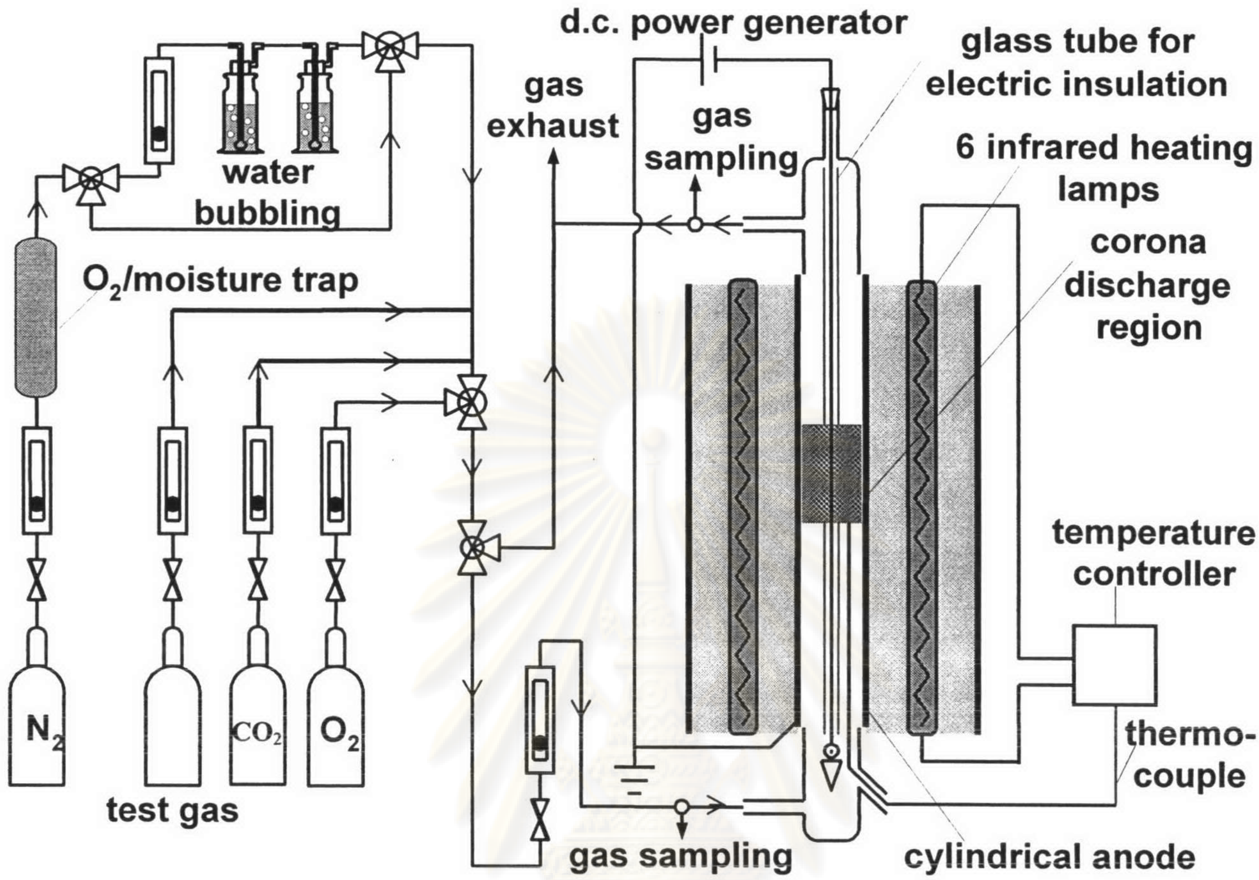

Figure 4.2 Schematic diagrams of experimental apparatus

4.2.1 Details of the experimental apparatus

Figure 4.1 and **Figure 4.2** show the photograph and the schematic diagram of the experimental setup, which consists of a deposition-type corona discharge reactor, a high voltage DC generator, a temperature controller and a test gas mixing system.

The deposition-type corona-discharge reactor is shown in **Figure 4.3**. It consists of a SUS tube, 3.7 cm. inner diameters and 80 cm. length, as the anode. The cathode is a 0.5 mm stainless steel wire suspended from a silicone plug at the top of the reactor and straightened along the axis of the vertical anode by a small weight. The reactor cathode is connected to a high voltage DC generator (Matsusada, HAR-30N5). The high voltage DC generator whose maximum allowable voltage is 50 kV is utilized to supply a steady stream of low energy electrons to the corona-discharge reactor. **Figure 4.4** shows the high voltage DC generator adopted in this work. A slim Pyrex glass tube is used to sheath either end of the cathode in order to limit the corona discharge zone to an effective length of 10 cm in the middle section of the reactor. In this way the discharge zone is restricted to the region from 10 - 20 cm above the mid length of the reactor to utilize a more nearly uniform axial temperature distribution within the discharge zone. A type - K thermocouple is inserted into the reactor to measure the gas temperature in the discharge zone. To control the reactor temperature, 6 infrared heating lamps (200V, 700W each) are installed lengthwise around the outside perimeter of the reactor. The temperature control unit consists of a temperature controller (FENWAL, AR - 24L) and a thruster's power regulator (Shimaden, PAC15C003081 - NO).

The desired concentrations of acetaldehyde, ammonia, trimethyl amine and / or coexisting CO_2, and O_2 are adjusted by diluting standard gases with pure N_2 carrier gas. To studied the influence of CO_2 on the removal efficiency, the desired percentage of CO_2. An additional O_2 / moisture trap is installed on the N_2 gas line to ensure the removal of trace O_2 and moisture in the carrier and diluents gas. To study the influence of water vapor on the removal efficiency, the desired concentration of water vapor is achieved by bubbling nitrogen gas through distilled water in the bottle placed in temperature - controlled bath.

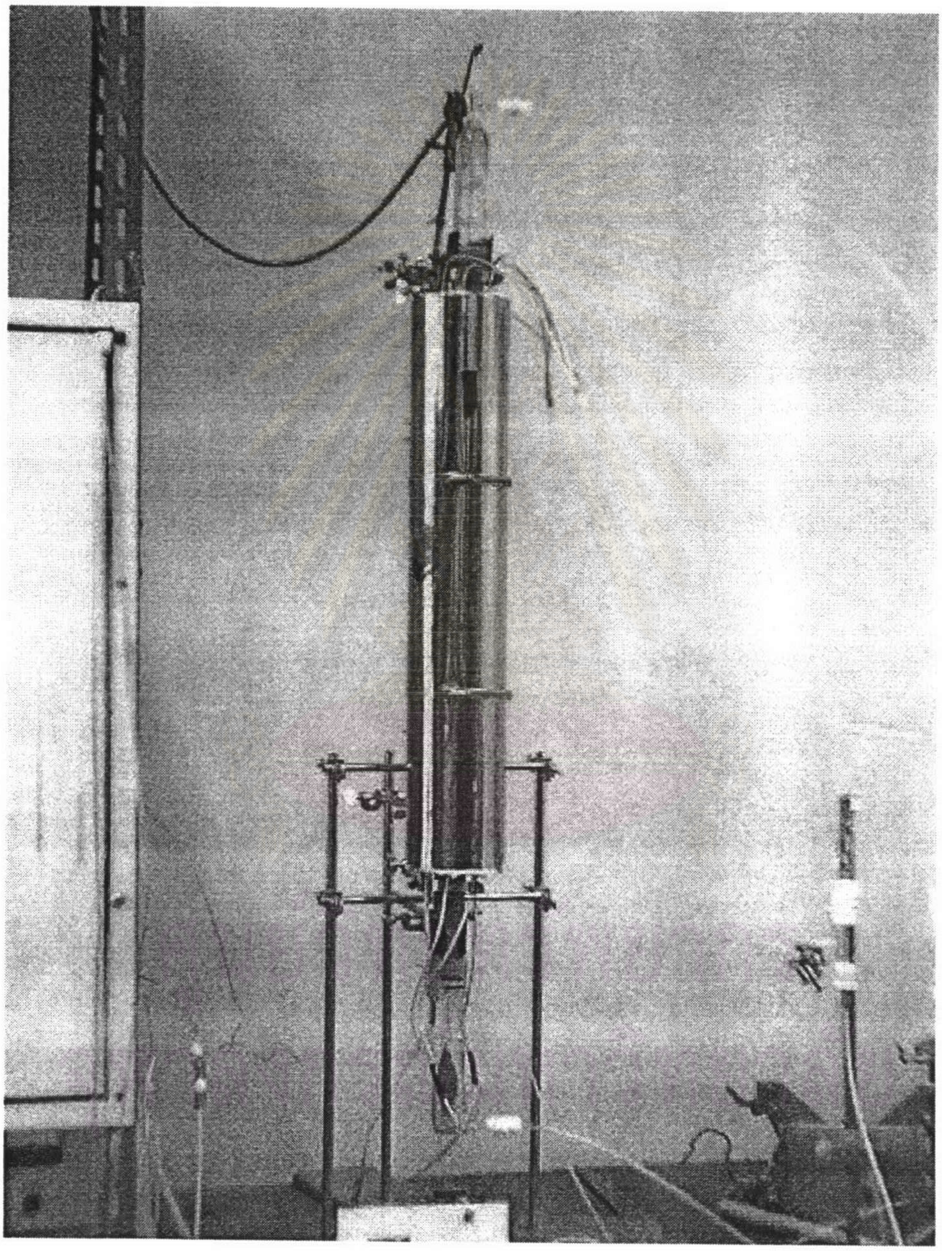

Figure 4.3 Deposition - type corona discharge reactors

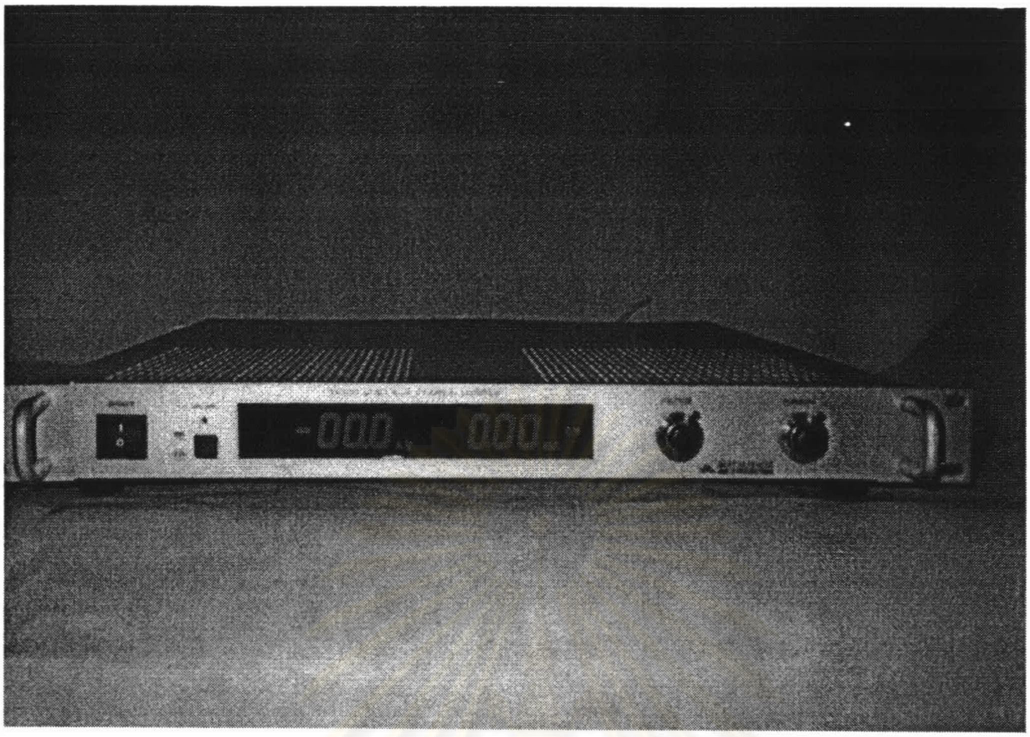

Figure 4.4 High - voltage DC generators

4.2.2 Analytical Instrument

Inlet and outlet concentrations of styrene, acetaldehyde (CH_3CHO) and trimethyl amine $(CH_3)_3N$ in gas mixture are analyzed using a gas chromatograph (Shimadzu Corp., GC 9A) equipped with a flame ionization detector (FID). The packed material in the GC column used for separating the peak of acetaldehyde and trimethyl amine is Polydivinylbenzene (Millopor Corp., Porapak Q) with 60 / 80 mesh size and usable at maximum temperature of 250°C. A calibration curve between the FID peak area of the GC and the concentration of acetaldehyde (CH_3CHO) and trimethyl amine $(CH_3)_3N$ is obtained as shown in the Appendix A.

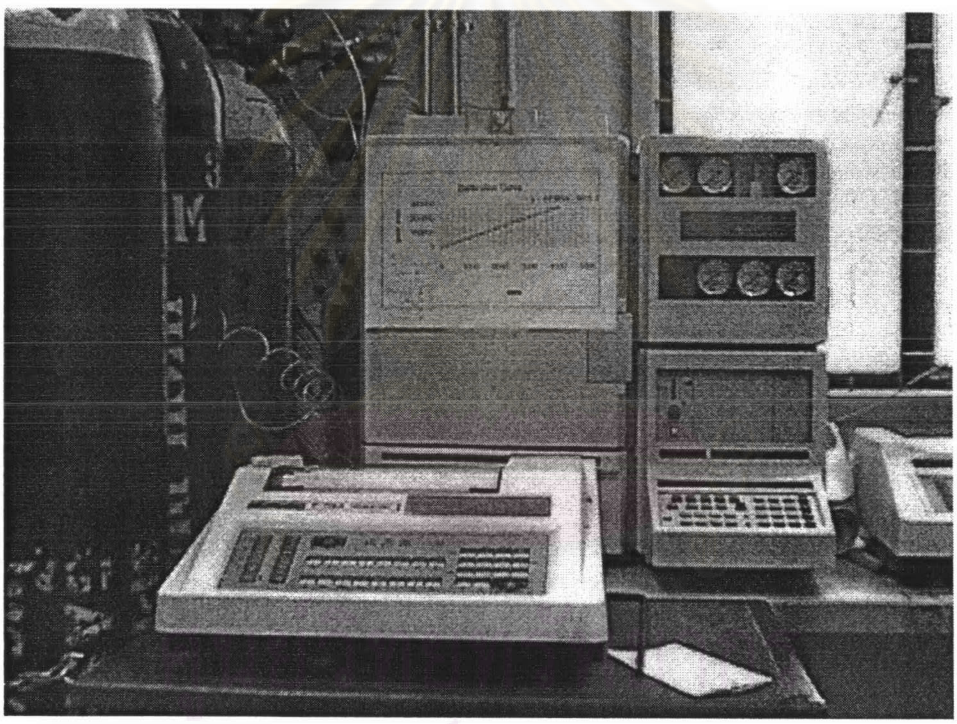

Figure 4.5 FID-Gas chromatograph

Concentrations of NH_3 and CO_2 are analyzed using another gas chromatograph (Shimadzu Corp., GC 14B) equipped with a thermal conductivity detector (TCD). The packed material in the GC column is Chromosorb 103 with 80 / 100 mesh size and usable at maximum temperature of 230°C. A calibration curve between the TCD peak area of the GC and the concentration of ammonia (NH_3) and carbon dioxide (CO_2) is obtained as shown in the Appendix A.

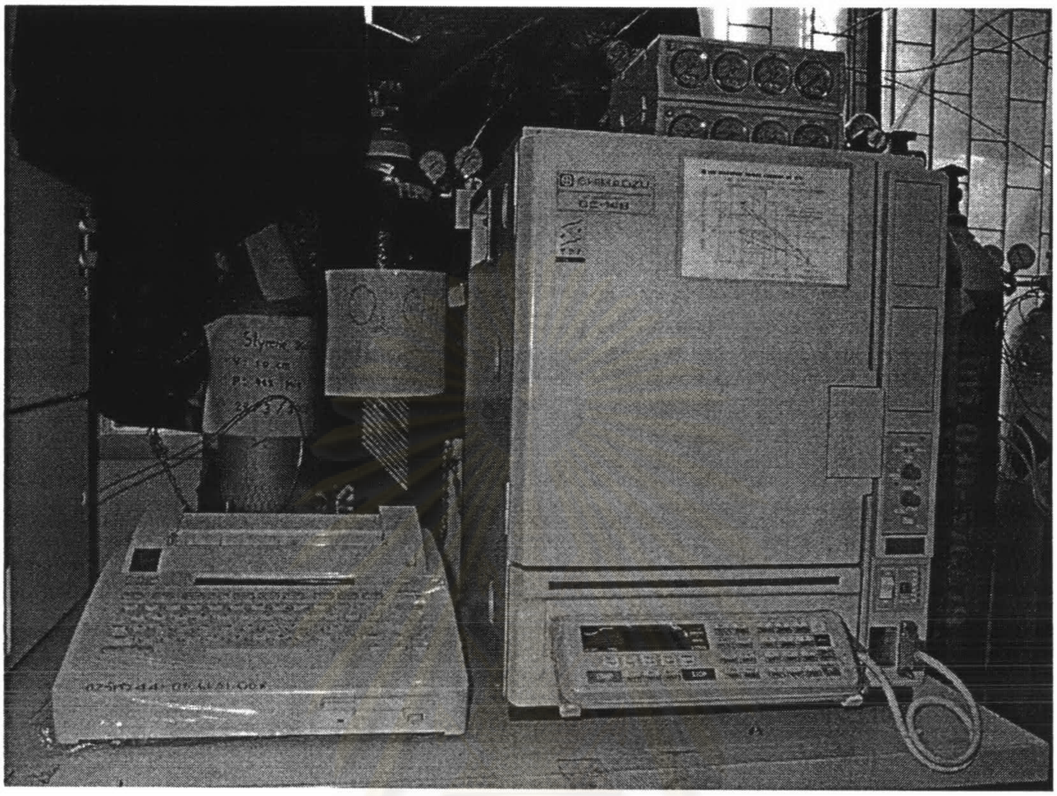

Figure 4.6 TCD-Gas chromatograph

The concentrations of byproduct CO, O_3 and / or NO_x can separately be detected with appropriate gas detector tubes (GASTEC Co., Ltd. and Kitagawa Co., Ltd.).

Table 4.2 Operating conditions of FID gas chromatograph

Sample gas	Column temperature (°C)	Injection temperature (°C)	Detector temperature (°C)	Retention time (min)
CH_3CHO	190	200	200	2.3
$(CH_3)_3N$	190	200	200	5.4

Table 4.3 Operating conditions of TCD gas chromatograph

Sample gas	Column temperature (°C)	Injection temperature (°C)	Detector temperature (°C)	TCD temperature (°C)	Retention time (min)
NH_3	50	100	100	110	2.3
CO_2	50	100	100	110	0.8

4.3 Experimental procedure

To carry out the gaseous pollutant removal experiments, the following implementation steps must be carried out carefully because of the high risk of physical injury caused by the high voltage supplied to the reactor.

a. Ensure that the reactor is securely grounded and each unit of the experimental apparatus is also securely connected.
b. Check the gas line for the experiment (feed gas balance nitrogen, O_2, CO_2 and N_2 for water bubbling)
c. Mix the above streams in the gas mixing device and measure the total flow rate with the soap film flow meter.
d. Feed the gas mixture to the inlet of the reactor and wait until its inlet and outlet concentrations become stable at the reactor temperature of interest.
e. Take gas samples at the reactor inlet and outlet to analyze their concentrations during blank test (zero discharge current).

f. Turn on the high voltage DC generator, adjust the discharge current as desired, and then keep the current stable throughout each experimental run.

g. Take gas samples at the inlet and outlet of the reactor and analyze their concentrations. Shut off the current after the finish of the experimental run.

h. To study the effect of the reactor temperature, reset the temperature as desired and wait until it becomes stable. Return to step (e) until all reactor temperatures have been investigated.

i. Wait for the reactor temperature to cool down sufficiently, stop the flow of the gas mixture and turn off the DC generator after the completion of the experiment. Be careful that high voltage does not remain in the reactor.