CHAPTER IV

DEVELOPMENT OF EXPERIMENTAL APPARATUS

4.1 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.

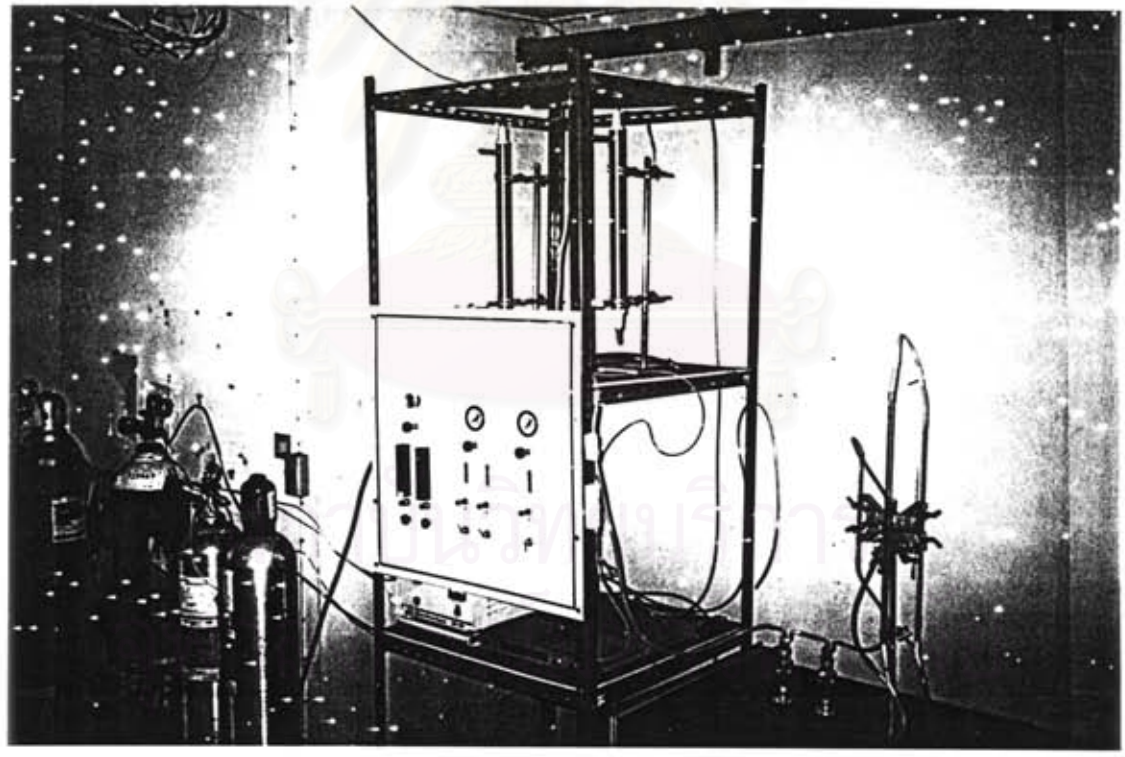

Figure 4.1 Arrangement of present experimental apparatus

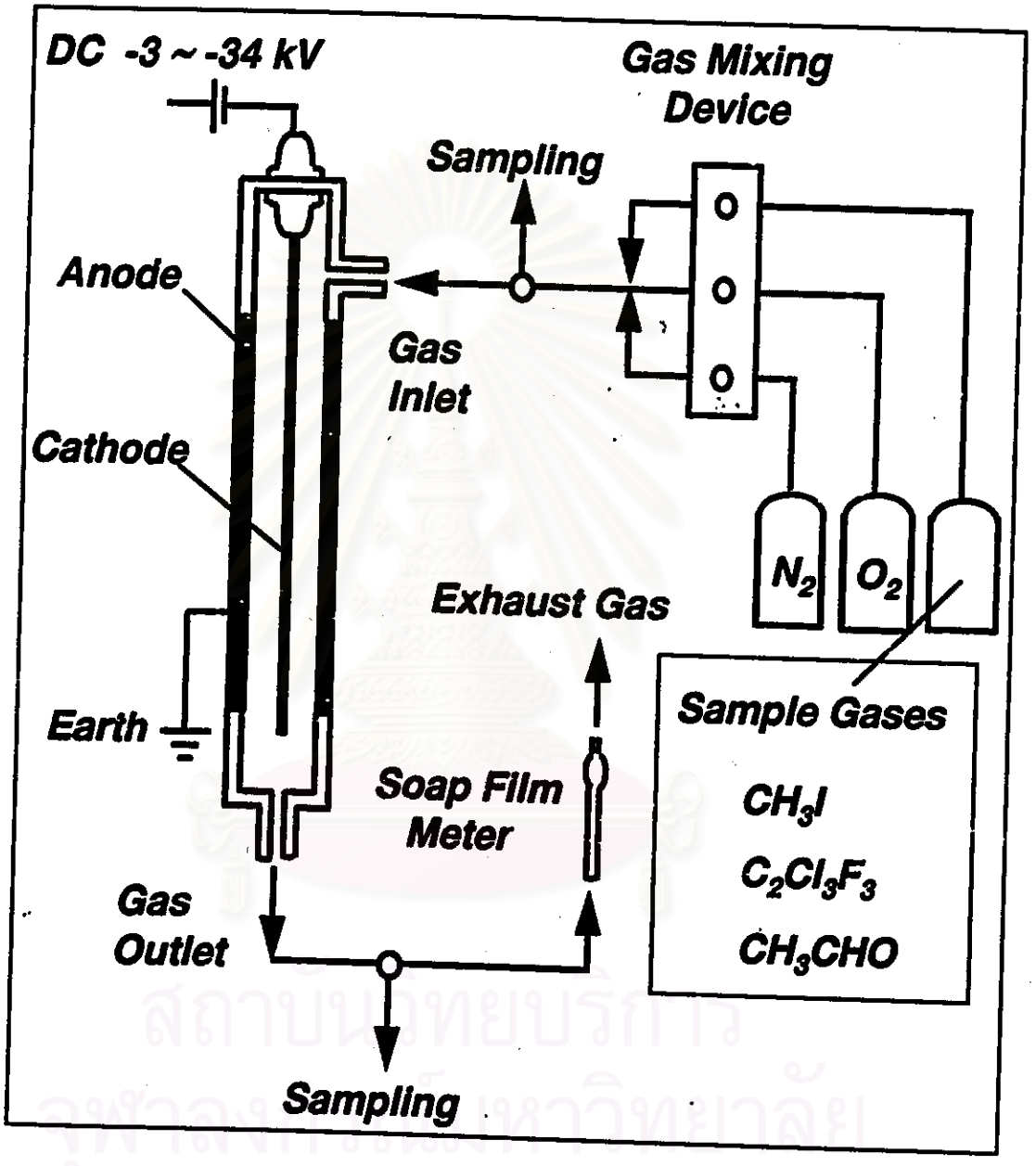

Figure 4.2 Schematic diagram of experimental apparatus

4.2 Details of device

As shown in **Figures 4.1** and **4.2**, the gaseous pollutant remover consists of a deposition-type corona-discharge reactor, a gas mixing device, a high-voltage DC generator and a set of soap film flow meter.

The constructed deposition-type corona-discharge reactor is shown in **Figure 4.3**. It consists of two electrodes, a stainless-wire cathode and a stainless-tube anode (reactor). The inner diameter and effective length of the anode are 40 mm and 370 mm, respectively. The cathode whose diameter is 0.5 mm is sustained at the center of the reactor vessel by ceramic insulators at the top and bottom of the reactor. However, when the effects of reactor structure on gaseous removal efficiency are to be investigated, the dimensions of the anode and the cathode are changed. Details of those electrode dimensions are indicated in **Chapter 5**.

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 number of energetic electrons to the corona-discharge reactor. **Figure 4.4** shows the high-voltage DC generator adopted in this work. A voltage of -3 kV ~ -34 kV is required to generate discharge current of 0.05 mA ~ 2 mA.

Figure 4.5 shows a gas mixing device used to adjust and control the concentrations of three kinds of dilute sample gases to be removed, methyl iodide (CH_3I), 1,1,2-trichloro-1,2,2-trifluoroethane ($C_2Cl_3F_3$) and acetaldehyde (CH_3CHO). Before feeding a gas mixture to the reactor, the inlet concentrations of individual gases are adjusted by mixing each lab-grade standard gas with N_2 and/or O_2, depending upon the aim of removal study.

Figure 4.3 Deposition-type corona-discharge reactor

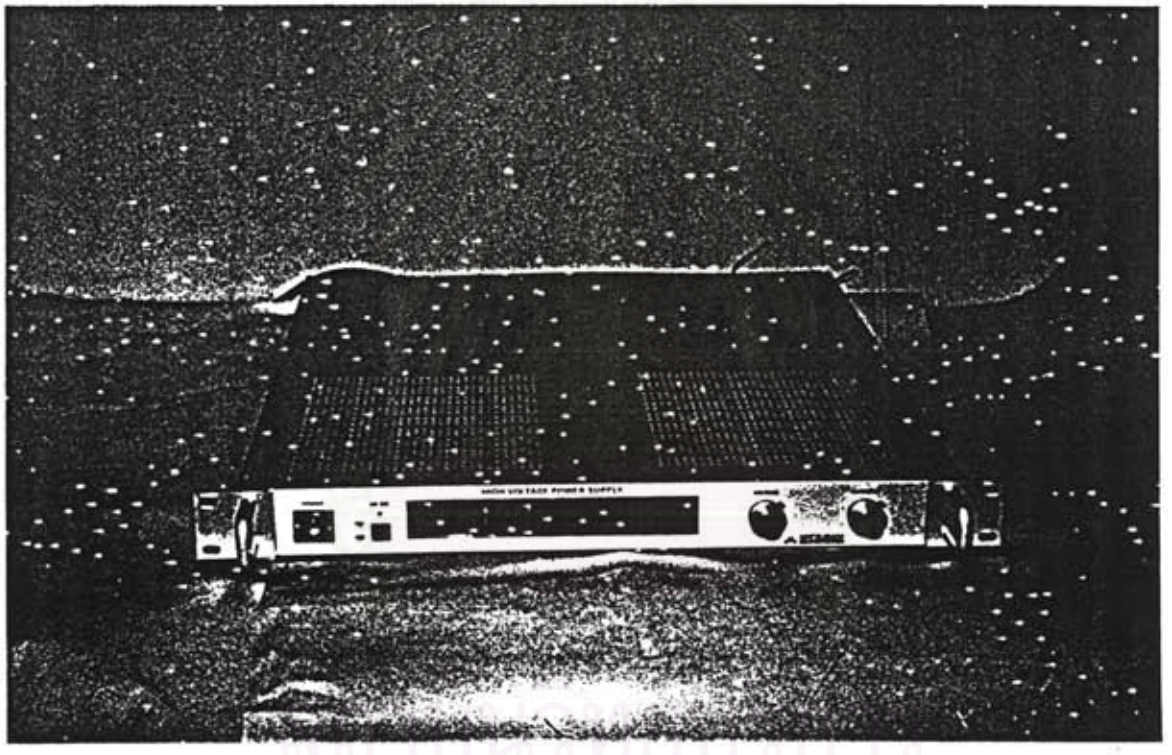

Figure 4.4 High-voltage DC generator

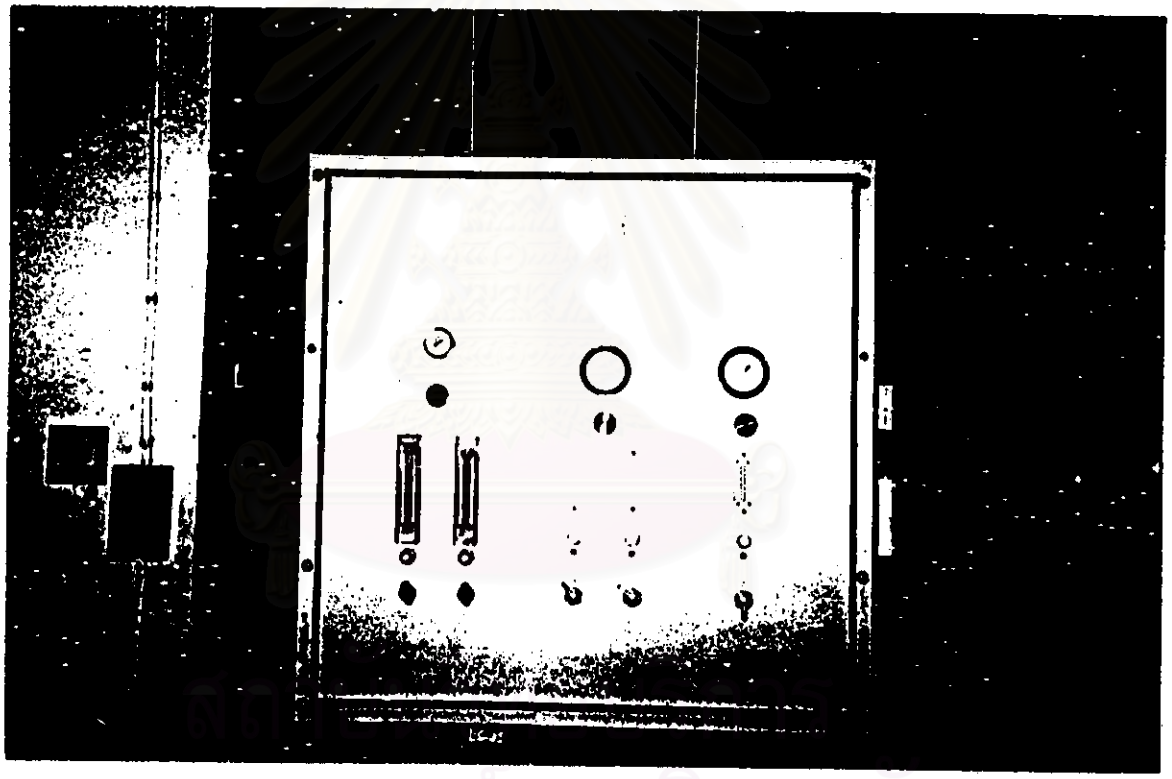

Figure 4.5 Gas mixing device

Figure 4.6 Soap film flow meter

When mixed with N_2, removal from N_2 gas is expected. When mixed with N_2 and O_2, removal of individual gas from air is aimed.

A set of soap film flow meter shown in **Figure 4.6** is used to measure the total flow rate of gas mixture passing through the reactor.

4.3 Analytical instruments

In the present study, the concentrations of individual gases at the inlet and outlet of the reactor are analyzed by using a gas chromatograph (Shimadzu Corp., GC 14A and 14B) with a flame ionization detector (FID).

The packed material in the GC column used for detecting the concentrations of all kinds of gases is polyvinylbenzene (Millopore Corp., Porapak Q) with 80~100 mesh size and usable at maximum temperature of 250 °C.

To conduct the test run of the device (see **Section 4.5**), acetaldehyde (CH_3CHO) was used. The column, injection and detector temperatures of the FID-gas chromatograph in the case of CH_3CHO analysis were set at 150°C, 180 °C and 180°C, respectively.

To investigate the effects of the reactor structure on gaseous removal efficiency (see **Chapter 5**), the analytical conditions of the FID-gas chromatograph adopted for each gas were given in **Table 5.2**.

4.4 Operating procedure

To operate the gaseous pollutant remover, the following implementation must be made carefully because of the great risk of accident due to the high voltage supplied to the reactor.

4.4.1 Ensure that the reactor is grounded and each unit of the apparatus is securely connected.

4.4.2 Adjust the flow rates of individual gases with the gas mixing device and measure their flow rates with the soap film flow meter.

4.4.3 Feed the gas mixture to the inlet of the reactor and wait till its concentration becomes stable.

4.4.4 Turn on the high-voltage DC generator and adjust the discharge current as desired, and then keep it stable.

4.4.5 Take samples at the inlet and outlet of the reactor to be analyzed with the gas chromatograph.

4.4.6 Stop feeding the gas mixture and turn off the DC generator after the completion of the experiment. Be careful that high voltage still remains in the reactor cathode.

4.5 Test run

As described previously, design and construction of a gaseous pollutant remover is one objective of this work. After the completion of constructing the device, testing its performance is necessitated. In this case, removal of dilute acetaldehyde (CH_3CHO) from N_2 was conducted experimentally. The reactor diameter and length were 40 mm and 370 mm, respectively. A cathode wire of 0.5 mm diameter was used. The total gas flow rate and space velocity of the gas mixture were 100 cc/min and 12.9 h^{-1}, respectively. High voltage of -8 kV

~ -12.7 kV was applied to the reactor to induce corona discharge of 0.05 mA ~ 1.0 mA.

The definition of removal efficiency, ψ, used in this work is as follows.

$$\psi = (C_{in} - C_{out}) / C_{in} \qquad (4.1)$$

where C_{in} and C_{out} are the inlet and outlet concentrations of the pollutant in the gas sample. The removal efficiency of CH_3CHO from N_2 was experimentally determined at three inlet concentrations of 50, 200 and 500 ppm.

4.6 Experimental results

Figure 4.7 shows the removal efficiency, ψ, of CH_3CHO from N_2 as a function of the discharge current, I, corresponding to different inlet concentrations to the reactor. It is found that ψ increases as I increases. This is because the probability of electron attachment increases with the number of electrons available for colliding with CH_3CHO.

Furthermore, it can be seen that ψ increases as C_{in} of CH_3CHO decreases. For example, at 0.05 mA, when C_{in} are 50 ppm and 500 ppm, about 98% and 38% of CH_3CHO, respectively, are removed. Consequently, if sufficient number of electrons compared to the number of electronegative gas molecules are supplied to the reactor, the removal efficiency improves.

The above experimental results is similar to the results obtained by Tamon et al., 1995. This proves that the present gaseous pollutant remover has shown a great potential for ultrahigh gas purification.

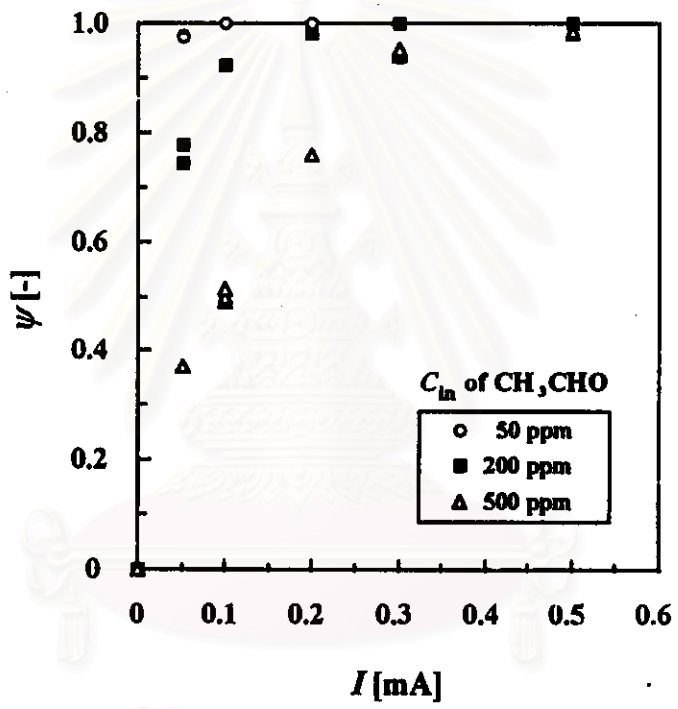

Figure 4.7 Removal efficiency of CH_3CHO from N_2 as a function of discharge current, corresponding to different inlet concentrations; (cathode diameter = 0.5 mm, anode diameter x length = 40 mm x 370 mm, SV = 12.9 h)