A-6.3 Incineration and thermal decomposition methods

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Abstract The CFCs destruction technology has been developed by using the incineration as well as the thermal decomposition technique. For the premixed incineration method, CFCs are perfectly destroyed if CFC/fuel feed ratio is kept within a certain value. This value can be extended by improving the design of he burner. For the thermal decomposition method, CFC-113 has completely been destroyed without producing any harmful by-products if temperature and residence time are appropriately controlled.

Key Words Chlorofluorocarbons, Incineration, Thermal decomposition

1. Introduction

In order to prevent the depletion of stratospheric ozone layer, the establishment of destruction technologies for legislated CFCs is indispensable. Among the several candidates, the incineration and thermal decomposition methods are considered to be closest to practical utilization.

The objective of the present research project is to establish a safe and efficient destruction technology of CFCs. In this report, the experimental results for the destruction of legislated CFCs by incineration and thermal decomposition methods are presented.

2. Experimental Results

(1) Incineration method

In this study, incineration technologies for CFCs by using both premixed and diffusion flames have been developed. In both cases, a cylindrical type burner with inner diameter of 9.6mm was used, which was set in a combustion chamber made of stainless steel. The flow rates of each gas were individually controlled and measured by calibrated mass flow controllers. After cooling of the burned gas, acids were removed with water traps. The burned gas sampled after these treatments was analyzed by gas-chromatography.

In the case of CFC-12/methane/air premixed flames, the amount of unreacted CFC-12 in the burned gas is lower than the detection limit of the gas-chromatograph for molar ratio of CFC-12/methane smaller than around 0.2, although burning velocity decreases with increasing CFC-12 concentration. The degree of destruction decreases with increase of CFC-12/methane if the latter becomes higher than 0.2. No detectable amount of soot formation is observed for the premixed flame experiments. From the observed changes of the flame shape, the cause of the reduction of CFC-12 destruction for higher value of CFC-12/methane may be attributed to the escape of a part of unburnt gas from beneath the edge of the flame.

The premixed combustion method was also applied to destruct CFC-11, -113, 114 and CFC-115. The experiments for CFC-114 and CFC-115 were carried out similarly to that of CFC-12. Since the samples of CFC-11 and -113 are less volatile than the other samples, these CFCs were supplied by carrying with the air to the burner. The burner used was of cylindrical type with inner diameter of 9.6mm. In all cases, the burning velocities decrease with addition of CFC, and stabilization of flames becomes difficult with increase of CFC concentration. The concentration of unreacted CFC in the burned gas is less than the detection limit of gas-chromatograph for molar ratio of CFC/methane smaller than around 0.2. The degrees of destruction decrease with increase of CFC content if the molar ratio of CFC/methane becomes higher than 0.2 (Fig. 1). The cause of the observed reduction of destruction efficiencies for higher values of CFC/methane ratio is mainly attributed to the escape of a part of unburnt gas from underneath the flame.

From these results, it is concluded that complete destruction of legislated CFCs is possible by the premixed combustion method.

For comparison purpose, CFC-12 was also treated with a diffusion flame method. In this case, although CFC-12 is almost completely destroyed for the CFC-12/methane ratio less than 0.6, a great amount of soot formation was observed, which is not desirable because it is possible that harmful by-products are produced in such a condition.

Finally, in order to increase the destruction efficiency of the premixed method, improvement of the burner design was made. The CFC destruction efficiency at higher CFC concentrations has been much increased by improving the design of the burner. Most effective results were obtained by using a doubly coaxial cylindrical burner, in which CFC-12/methane/air premixed gas was supplied to the inner tube and methane/air premixed gas to the outer tube of the burner. In this way, CFC-12 was completely distracted for molar ratio of CFC-12/methane smaller than around 0.8 (Fig. 2).

(2) Thermal decomposition studies of CFC113

In order to know the decomposition characteristics of CFC-113 (1,1,2-trichloro-1,2,2-trifluoroethane) and Halon-1301 (Bromo-trifluoromethane) including the effects of coexistent material and generating hazardous compounds, thermal decomposition studies of CFC-113 and Halon-1301 in the presence of hydrocarbons or water were conducted at the conditions in which oxygen was in excess.

The examination of thermal decomposition products of CFC-113 revealed that the major halogenated compound in emission gas was CFC-12 (Dichloro-difluoromethane) and there were no generation of hazardous compounds. Fig. 3 shows the 99% destruction temperature of CFC-113 itself is 1033K at AR=2.07 (the atomic number ratio of H to Halogen) with hexane, and the higher temperature, however, 1093K was required for the destruction of produced CFC-12. The 99% destruction temperature of CFC-113 with methane was almost same as the case of CFC-113 and hexane mixture. This result indicates that the inhibitory interaction between species cannot found in the oxidative destruction of CFC-113 in the presence of methane.

The analysis of thermal decomposition products of Halon-1301 suggested that the hazardous compounds were not generated in the decomposition process. Fig. 4 indicates that the 99% destruction temperature of Halon-1301 was almost 1100K and was slightly lower than the case of CFC-12 which generated in CFC-113 destruction.

3. Conclusion

It has been concluded that safe and efficient CFC destruction is possible by using the incineration and thermal decomposition techniques.

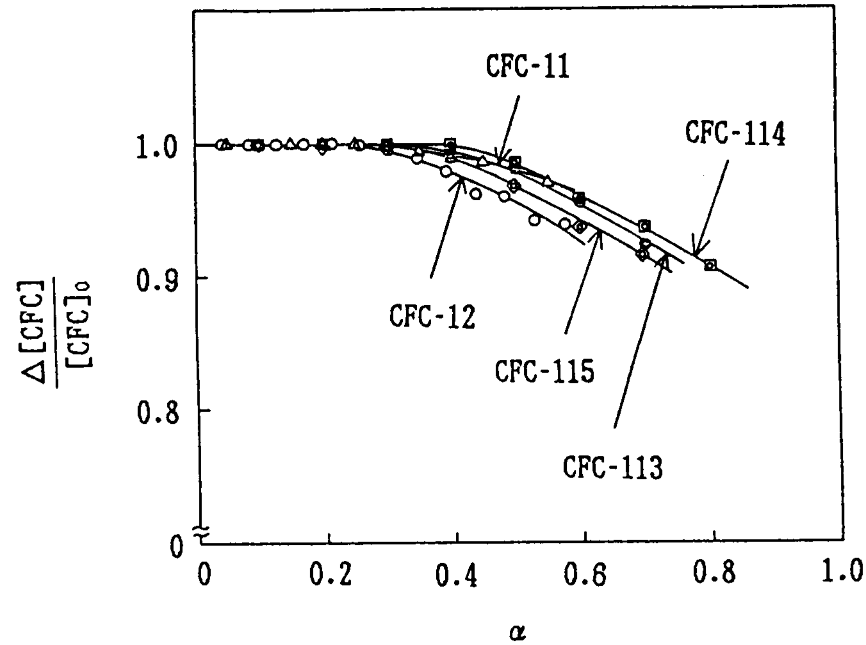

Figure 1. Relation between CFC destruction efficiency and CFC/methane ratio α
△:CFC-11、 ○:CFC-12、 ◎: CFC-113、
⊡:CFC-114、 ◇:CFC-115

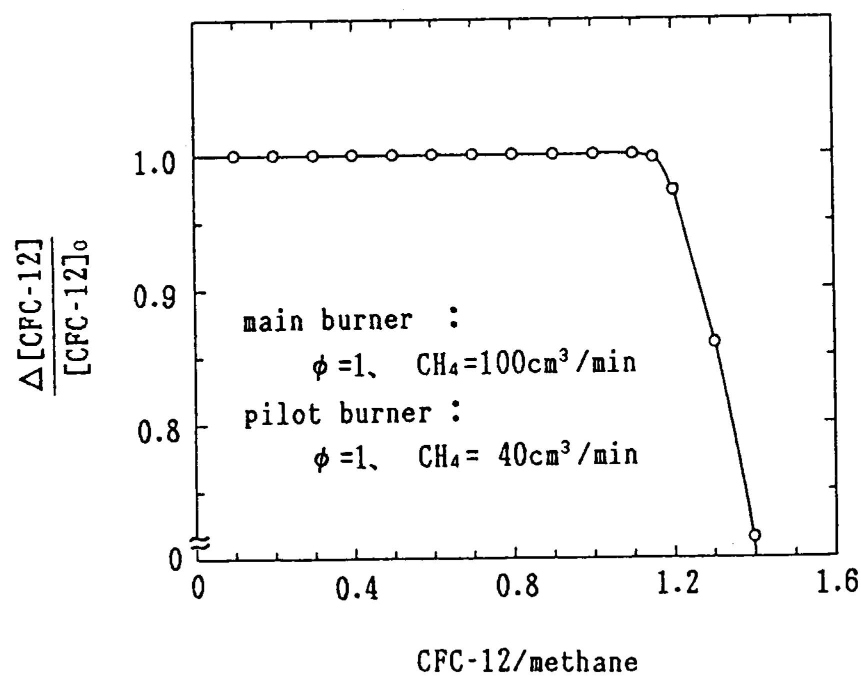

Figure 2. Relation between CFC-12 destruction efficiency and CFC-12/methane ratio α for an improved burner

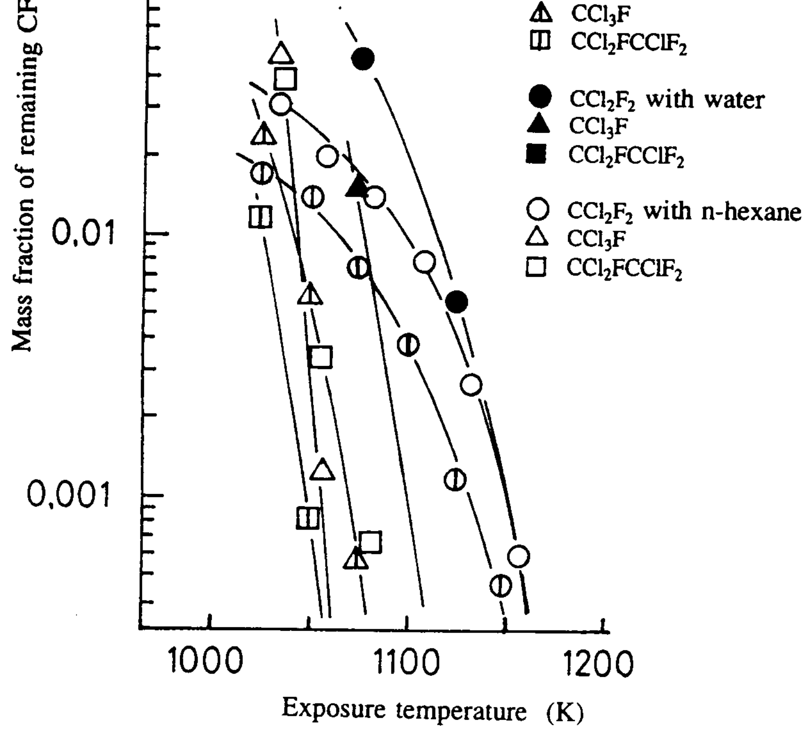

Figure 3. Thermal decomposition characteristics of CFC-113 in the presence of methanol, water and hexane

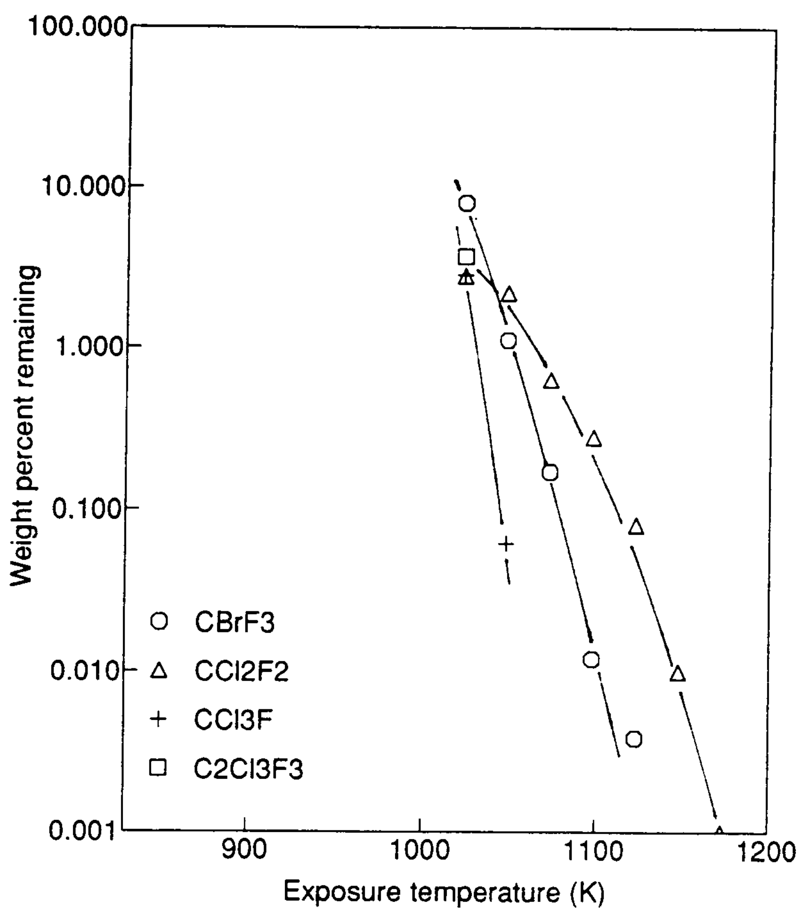

Figure 4. Thermal decomposition characteristics of Halon-1301 in the presence of hexane