

DECOMPOSITION OF HYDROFLUOROCARBONS IN A DIELECTRIC-PACKED PLASMA REACTOR¹

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Abstract. This study investigated the decomposition of hydrofluorocarbons (HFCs) by using a dielectric-packed nonthermal plasma reactor with barium titanate beads as the packing material. The target HFCs were 1,1,1,2-tetrafluoroethane (HFC-134a) and 1,1-difluoroethene (HFC-132a). The effect of several parameters such as reaction temperature, oxygen content and initial concentration on the HFC decomposition efficiency was evaluated. The decomposition products were analyzed, and some decomposition pathways were elucidated. The energy requirements for the decomposition of HFC-134a and HFC-132a were found to be 0.038 and 0.062 mol MJ⁻¹, based on the initial concentrations of 200 and 120 ppm (parts per million, volumetric), respectively.

1. INTRODUCTION

Hydrofluorocarbons (HFCs) being used as replacements for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) have high global warming potentials (GWP). Among several technologies available for the treatment of the HFCs, nonthermal plasma process can be an effective method when the HFCs exist as impurity, i.e., low concentration. In this study, the decomposition of HFCs using the nonthermal plasma was investigated. The HFCs used are HFC-134a (1,1,1,2-tetrafluoroethane) and HFC-132a (1,1-difluoroethene). The nonthermal plasma reactor of this study was cylindrical dielectric-packed bed reactor. The effect of oxygen content, reaction temperature, initial HFC concentration, energy density (discharge power divided by gas flow rate) on the decomposition were examined, and the results were discussed. Decomposition products from the plasma reactor were identified and quantified by Fourier Transform Infrared (FTIR) spectroscopy, from which some of the reaction pathways for the decomposition were elucidated.

2. EXPERIMENTAL

The experimental apparatus is basically the same as used in the previous study [1]. The dielectric-packed bed plasma reactor consisted of a quartz tube of 24 mm inner diameter with two porous electrodes 25 mm apart through which the gas mixture passed. The space between the electrodes was filled with 12 cm³ barium titanate (BaTiO₃) dielectric beads (3.5 mm diameter). The plasma reactor was covered with a heating mantle to control the reaction temperature to a desired value. The reaction temperature was varied from 150 to 250°C. An AC voltage in the range of 16.5-20.5 kV_{pk-pk} at a frequency between 10.25-13.25 kHz was applied to the electrodes. The electrical discharge occurred in the barium titanate bed between the two electrodes.

The feed gas was composed of pure nitrogen and pure oxygen and a small amount of hydrofluorocarbon (HFC). All the gases used were controlled by mass flow controllers (MKS Mass Flo). The hydrofluorocarbons used as the pollutant were HFC-134a (C₂H₂F₄) and HFC-132a (C₂H₂F₂). The flow rate of the feed gas was typically 1.0 L min⁻¹. The content of oxygen in the feed gas was changed from 0 to 100% by volume. The initial concentration of HFC-134a was changed in the range

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