Thermal Decomposition of Lower-GWP Refrigerants

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The use of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) has been widely restricted. They have been replaced with hydrofluorocarbons (HFCs) in order to protect the ozone layer. However, the leakage of refrigerant into air from active or end-of-life air conditioners has been a serious environmental issue owing to the high global warming potential (GWP) of HFCs. It has therefore been widely recognized that the replacement of HFCs with lower-GWP refrigerants is a reasonable solution of the problem. In Japan, the lower-GWP refrigerants such as R1234yf and R32 are considered as candidate alternatives for conventional HFC refrigerants. However, these lower-GWP refrigerants are often chemically unstable. To assess the risks when lower-GWP refrigerants are exposed to high-temperature solid surface, it is necessary to clarify their decomposabilities and products. However, the high reactivities of products like hydrogen fluoride (HF) make this quantification difficult. Moreover, in case of combustion, some researchers proposed that the reactivity of a molecule with more fluorine atoms than hydrogen atoms, like R1234yf, is affected by humidity. Thus, its flammability limits and product composition are influenced by temperature and humidity. In this study, to discuss on the effects of temperature and humidity in thermal decomposition, mixtures of refrigerants and air were decomposed in heated tube and the products were analyzed with FT-IR to quantify decomposed refrigerants and hydrogen fluoride which was the main toxic product. The tested refrigerants were R1234yf, R32, R134a and R22. The temperature of the heated tube and humidity in the mixture were systematically changed. Because the concentration of hydrogen fluoride was influenced by the tube material due to the chemical reaction between hydrogen fluoride and the tube material, several kinds of heated tubes, made with stainless steels and Inconel alloy, were used. The thermal decomposition characteristics of lower-GWP refrigerants were compared with those of conventional non-flammable refrigerants.