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Project Summary

New Chemical Alternative for Ozone-Depleting Substances: HFC-245ca

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Hydrofluorocarbons (HFCs) form a class of chemicals having the potential to replace stratospheric ozone depleting substances such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). This report gives results of a preliminary evaluation of a new HFC (HFC-245ca or 1,1,2,2,3-pentafluoropropane) as a possible alternative for CFC-11 (trichlorofluoromethane) and HCFC-123 (1,1,1-trifluoro-2,2-dichloroethane) refrigerant for low-pressure chillers and as a possible alternative for CFC-11 and HCFC-141b (1-fluoro-1,1-dichloroethane) blowing agents for polyisocyanurate/polyurethane insulation foams. Evaluation tests included an examination of its flammability, stability, thermophysical properties, lubricant miscibility and lubricity, materials compatibility, acute inhalation toxicity, and refrigeration performance. An azeotrope composed of HFC-245ca and HFC-338mccq (1,1,1,2,3,4,4,4-octafluorobutane) was also examined from the standpoint of reducing the flammability of HFC-245ca.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Fully halogenated chlorofluorocarbons (CFCs) and their bromine-containing relatives (halons) are recognized as primary contributors to depletion of Earth's stratospheric ozone layer. As early as 1978, the U.S. Environmental Protection Agency (EPA) promulgated regulations banning the use of CFCs as aerosol propellants in all but a few exempted applications. In the mid-1980's, the EPA began considering additional regulatory restrictions on the use of CFCs and halons. In the course of this consideration, it became apparent that few, if any, alternative chemicals were readily available or had been proven applicable to the numerous CFC and halon uses which had grown dramatically following the 1978 CFC aerosol ban.

Following the advice of an expert panel convened by EPA, the Agency's Office of Research and Development undertook a program to systematically search for additional alternative chemicals to serve as backups in the event the few chemicals proposed by industry fell short of expectations. Over a 3-year period, 37 new compounds were prepared of sufficient stability and in sufficient yield and purity to obtain a limited set of relevant property measurements. All of these compounds were partially fluorinated hydrocarbons or ethers. Based on the thermophysical properties obtained for these compounds, EPA selected 11 chemicals for more extensive evaluation. Hydrofluorocarbon (HFC)-245ca was 1 of the 11 chemicals selected.

Conclusions

HFC-245ca contains no chlorine or bromine and therefore cannot deplete stratospheric ozone. Its measured reaction rate with hydroxyl radical (the primary reaction removing pollutants from the atmosphere) is 9.1 x 10^{-15} cm^3 $molecule^{-1}$ sec^{-1} which translates to an estimated atmospheric lifetime of 5.8 years.

Limited inhalation toxicity testing with the compound was carried out with 2 populations of 10 rats each. The first population was exposed to 1,000 ppm HFC-245ca in air, and the second population was exposed to 50,000 ppm HFC-245ca in air, each exposure lasting 4 hours. All animals survived the tests and exhibited no significant adverse effects during the exposure period or during the subsequent 14-day observation period. Post-mortem examination of the animals indicated no effects. Although these toxicity tests were limited in scope, the results are encouraging and suggest that HFC-245ca may be even less toxic than CFC-11 which has an LC_{50} (rat) of 27,000 ppm.

Sealed tube stability and materials compatibility tests with HFC-245ca, both in the presence and absence of a polyolester lubricant, showed the compound to be thermally and hydrolytically stable and compatible with many common engineering materials.

HFC-245ca was found to be completely miscible with two different polyolester lubricants over the temperature range of -30 to +125°C. Lubricity tests indicated that the chemical is compatible with this type of lubricant and that the presence of the HFC in the oil actually improved the wear performance of the oil.

HFC-245ca has been demonstrated to be slightly flammable, with the extent of flammability dependent not only on its concentration in air and temperature, but also on the moisture content (or relative humidity) of the HFC-245ca/air mixture. At relative humidities below approximately 20% at room temperature, the mixture is nonflammable, while at higher humidities and temperatures the chemical becomes increasingly flammable. A thorough evaluation of the safety risks associated with the compound as a refrigerant or foam blowing agent and ways to mitigate such risks remain to be done. An azeotrope of HFC-245ca and HFC-338mccq (1,1,1,2,2,3,3,4-octafluorobutane) was tested for flammability. The azeotrope (63.8:36.2 volume percent HFC-245ca:HFC-338mccq) was not flammable at room temperature and relative humidities up to 65%. However, the mixture was flammable at 100°C.

The measured vapor thermal conductivity of HFC-245ca is 1.6 times greater than that of CFC-11. Laboratory studies have shown that HFC-245ca should be easy to process using conventional foaming equipment but that changes in foam formulations may be required to approach equivalent insulation and mechanical characteristics of CFC-11 blown foams.

HFC-245ca has been shown to be a potentially viable alternative for CFC-11 and hydrochlorofluorocarbon (HCFC)-123 as a refrigerant in low-pressure chillers. Thermophysical properties of HFC-245ca compare well with those of CFC-11, and modelled performance as a refrigerant in low-pressure chillers indicates a loss of efficiency of 3 to 4% relative to CFC-11 (1 to 2% relative to HCFC-123). Modelled performance was confirmed by laboratory tests in a compressor calorimeter operating under chiller conditions. HFC-245ca has been shown to be compatible and miscible with a polyolester (POE) lubricant over the temperature range of -30 to +125°C.

Five zeotropic mixtures containing HFC-245ca were selected for performance tests in home refrigerators/freezers. Of the five mixtures, a blend of HFC-245ca with cyclopropane performed best with a 19.2% reduction in energy consumption relative to HFC-134a (1,1,1,2-tetrafluoroethane). This blend exhibited a lower volumetric capacity than HFC-134a which suggested that a compressor with larger displacement would be required to deliver the same capacity as HFC-134a.

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***N. Dean Smith** is the EPA Project Officer (see below).*
The complete report, entitled "New Chemical Alternative for Ozone-Depleting Substances: HFC-245ca," (Order No. PB97-125 413; Cost: $25.00, subject to change) will be available only from:
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The EPA Project Officer can be contacted at:
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