



Full length article

Absorption coefficients, frequency shifts and absorption cross sections measurement versus pressure at room temperature, for hydrofluorocarbon HFC-134a, using a tunable CW CO₂ laser

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ABSTRACT

Infrared absorption in the spectral ranges of 934.92–952.89 cm⁻¹, 969.15–982.13 cm⁻¹, 1037.43–1055.62 cm⁻¹ and 1071.88–1084.62 cm⁻¹ versus pressure of hydro fluorocarbon CH₂FCF₃ was studied using a tunable CW CO₂ laser emission on lines from 10P, 10R, 9P and 9R branches with a maximum output power of 3.44 W (at 10P (24)). The laser was provided with an absorber cell which is located outside the laser cavity.

The absorption coefficients of HFC-134a molecule were determined versus the gas pressure between (0.2–800 mbar), (0.2–45 mbar), (0.2–450 mbar) and (0.2–80 mbar) for lines from 10P, 10R, 9P and 9R branches respectively. The frequency shifts of the absorption lines of HFC-134a in relative to the central frequencies of laser lines were calculated vs. the pressure on the basis of these absorption coefficients. The chosen lines were taken according to IR spectrum of the investigated gas given by HITRAN cross section database. So the absorption was achieved for HFC-134a at the spectral lines of 10P-9R branches situated from 10P (10) to 9R (30) emitted by a tunable CW CO₂ laser.

The absorption cross sections of HFC-134a determined in this work were compared with the relevant data given by HITRAN cross section database and a good agreement was observed almost for all lines.

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1. Introduction

As known, the chlorofluorocarbons (CFCs) are used as refrigerants in refrigerating and air-conditioning systems; cleaning agents for metal and electronic components; and in many other applications. However, the stability of these gases, in addition to their chlorine content makes them a good contributor in the depletion of the ozone layer of the earth. This was the reason to stop using CFCs and to introduce environmentally acceptable alternative, such as the hydro fluorocarbons like HFC-134a (CH₂FCF₃). Because of its physical properties and zero-ozone depleting potential, HFC-134a is regarded as the most suitable replacement for CFCs in refrigeration and air conditioning applications. Also it can be used in many applications; which include polymer foam blowing, and aerosol products. It has a negligible photochemical reactivity, and a low vapor thermal conductivity. HFC-134a is also being developed for use in pharmaceutical inhalers because of its low toxicity and no flammability [1].

The photo oxidations of HFC-134a with O₂-N₂ and Cl₂ were carried out to determine the products of chemical reactions between these constituents at the Earth's surface and at the troposphere [2].

More details about IR spectrum in the range of mid-IR region of HFC-134a were obtained, carrying out a comprehensive spectroscopic study of HFC-134a molecule as given in [3].

A far IR spectrum of HFC-134a molecule with high resolution at low temperature located at 665.52 cm⁻¹ was obtained using a collisional cooling cell adapted to a synchrotron source [4].

The HFC-134a is the most rapidly growing hydro fluorocarbon in terms of atmospheric abundance. It is currently used in a large number of household refrigerators and air-conditioning systems and its concentration in the atmosphere is forecast to increase substantially over the next decades of years [5].

The rate coefficients vs. the temperature are reported for the gas-phase reaction of OH radicals with 2,3,3,3-tetrafluoropropene (CF₃CFCH₂), and 1,2,3,3,3-pentafluoropropene ((Z)-CF₃CFCHF), which are major components in proposed substitutes for HFC-134a in mobile air-conditioning units. The global warming potentials for CF₃CFCH₂ and (Z)-CF₃CFCHF were calculated using infrared absorption cross sections which were measured in [6].

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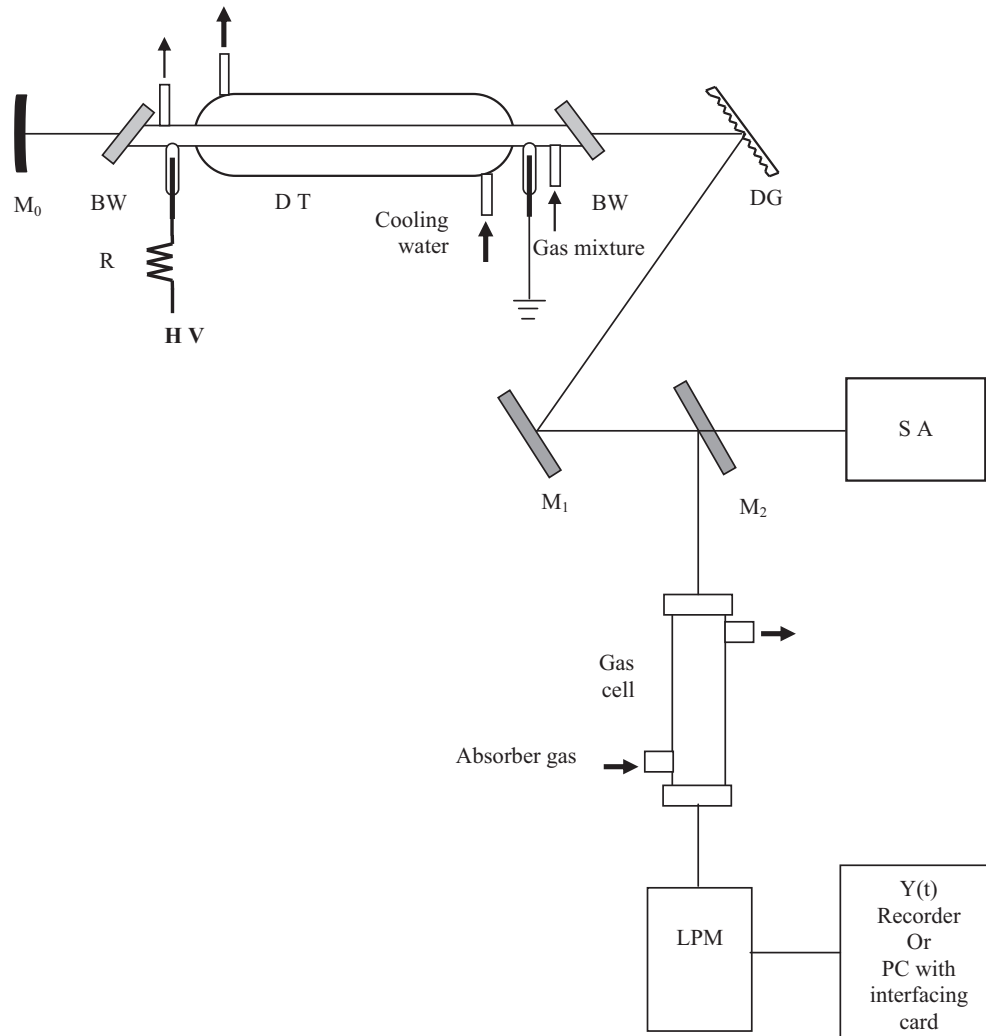


Fig. 1. The experimental set-up consists of: a tunable CW CO₂ laser with M₀ - high reflective mirror; DT-discharge tube with two Brewster windows (BW); R- ballast resistor; H.V. - high voltage; DG- diffraction grating with a rotating stage (Standa Co.); Gas cell for absorber gas with KBr windows located outside the cavity, M₁ - plane mirror, M₂ removable plane mirror; SA - CO₂ spectrum analyzer; LPM - laser power meter; Y (t) recorder.

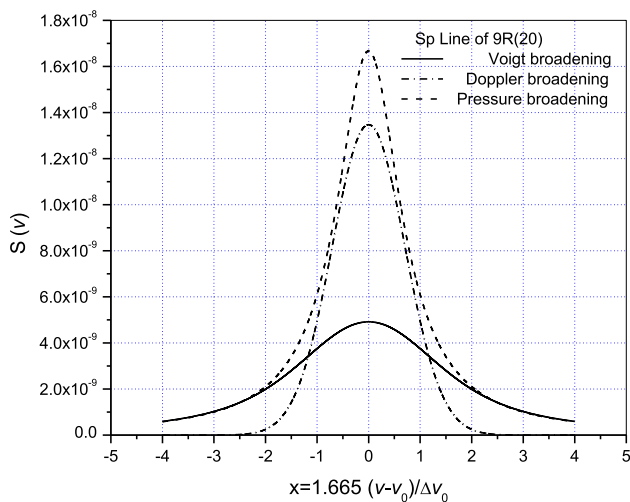


Fig. 2. Shape functions of spectral line 9R (20) with Doppler, pressure and Voigt broadenings.

In Ref. [7] a comprehensive and self-consistent set of new calculations of radiative efficiencies (REs) and global warming potentials (GWPs) for hydro fluorocarbons (HFCs) and hydro chlorofluorocarbons (HCFCs) and others as alternative compounds of CFCs were given.

The molecules of CFCs, HCFCs and HFCs slowly degrade in the atmosphere, leading to the formation of HF, COF₂ and COClF, where the second and the third compounds further degrade to form HF, which forms a permanent reservoir of stratospheric fluorine due to its extreme stability [8].

The work [9] reports new laboratory measurements of the infrared absorption cross sections of the compounds CFC-113a, CFC-112 and HCFC-133a and presents the calculations of radiative efficiencies and global warming potentials using cross-sections together with atmospheric lifetimes. Also, high-resolution infrared absorption cross sections for HFC-134a have been obtained over the spectral range 750–1600 cm⁻¹ using a high resolution FTIR spectrometer with a resolution of 0.015 cm⁻¹ and a 26 cm path length cell at different values of pressure and temperature appropriate for atmospheric conditions [10]. This approach could be used similarly to HFC-134a in the atmosphere.

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