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Letter to the Editor

Refractive index of octofluoropropane (C_3F_8) in the 300–150 nm wavelength range

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Abstract

The refractive index of octofluoropropane (C_3F_8) has been measured by Fabry–Perot interferometry down to 152.4 nm.

1. Introduction

Nowadays fluorocarbons are good candidates as Cherenkov radiators. As the spectrum of Cherenkov light varies as λ^{-2} and mostly lays in the VUV, the ideal radiator medium must be transparent in the VUV. It must also have a chromatic dispersion low enough to prevent chromatic correction and, if possible, a fairly high index value at atmospheric pressure. Experimentalists working at the development of ring imaging Cherenkov counters (RICH counters) in the WA89 experiment at CERN, point out the interest of precise measurement of refractive indices of fluorocarbon gases in the VUV.

First we measured refractive indices of carbon tetrafluoride (CF_4) and hexafluoroethane (C_2F_6) in the 300–140 nm wavelength range [1,2]. The chromatic dispersion obtained let us to conclude that in Cherenkov detectors using CF_4 or C_2F_6, achromatisation devices cannot be avoided. In the present paper, we give results for octofluoropropane (C_3F_8). Literature gives only the measurements of Gault and Shepherd [3] in the visible wavelength range.

2. Experimental setup

The measurements have been performed with a Fabry–Perot interferometer (FP), according to an experimental technique previously described [4,5]. The performances of the magnesium fluoride FP have been related in a previous paper [6]. The light sources are a lead and a platinum hollow cathode lamp. The platinum lamp has a magnesium fluoride window.

The errors on pressure, temperature and spacer thickness are weak compared with the errors produced by the measurement of the fractional part of the recorded fringes. The statistical treatment of about twelve measurements for each wavelength allows us to estimate the accuracy on $(n-1)$ to about 0.2%.

3. Results and discussion

The measured refractive indices are given at standard temperature and pressure conditions (0°C and 760 mm Hg) using the virial coefficient deduced from Dymond and Smith [7] and Brown [8]. Our experimental results are given in Table 1. The vacuum wavelengths of measurement points appear in the first column and our measured values of $(n-1) \times 10^6$ in the second. In the third column we present the results of the Cauchy formula of the

Table 1
C_3F_8 (octofluoropropane) refractivity expressed as $(n-1) \times 10_6$. Comparison with Gault and Shepherd's results

Wavelength [nm]	Present work	Gault and Shepherd	Sellmeier fitting
152.472	1411.1		1411.9
167.153	1362.5		1362.1
182.203	1326.0		1325.5
205.003	1287.4		1286.9
220.424	1268.05		1268.1
239.452	1251.1		1250.3
261.496	1233.9		1234.7
280.282	1223.7		1224.4
447.27		1157.3	1184.3
587.72		1147.2	1173.8
668.0		1143.7	1170.6
706.71		1142.4	1169.5

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dispersion curve fitted by Gault and Shepherd [3] in the visible range. From their formula, given for 15°C and 760 mm Hg temperature and pressure conditions, we give temperature-corrected values to allow a comparison with our results.

Using our measurements, we fit a one-term Sellmeier formula:

$$n - 1 = \frac{A \times 10^{-6}}{\lambda_0^{-2} - \lambda^{-2}},$$

where $A = 0.279337$ and $\lambda_0^{-2} = 2.408623 \times 10^{-4}$ for wavelengths expressed in nm units. The fitted values are given in the last column.

$\lambda_0 = 64.43$ nm is a single wavelength which represents the whole absorption spectrum in the far UV. It corresponds to an excitation potential $E_0 = 19.12$ eV. Obviously it is not possible to give an effective physical meaning to this value.

In Fig. 1 we have plotted these results; the solid line represents the interpolated values obtained from the Sellmeier formula. The results of Gault and Shepherd [2] are lower than our values, the discrepancy being of about 2.7×10^{-5} (2.3%). The discrepancy may be enhanced by the fact that these last values are not included in the Sellmeier fitting. Besides, Gault and Shepherd [3] used a gas with an impurity which may reach 1.5% while in the present work the gas impurity is given to be about few ppm. The provider guarantees the gas to contain less than 1000 ppm of other halocarbons and less than 5 ppm of water.

It is necessary to notice that the recorded Fabry–Perot fringes at 152.4 and 167.1 nm show a noticeable decreasing amplitude as the pressure grows, and therefore the accuracy is lower for these wavelengths. In this paper we are not able to assign the absorption to the gas itself or to O_2 included as impurity in the supplied gas.

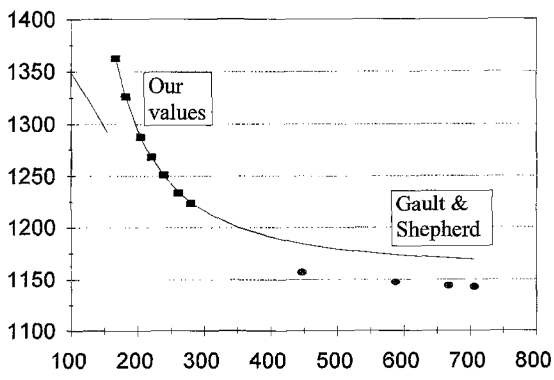

Fig. 1. The refractivity of C_3F_8 (octofluoropropane) expressed as $(n-1) \times 10^6$ is plotted versus the wavelength in nm. The solid line corresponds to the Sellmeier formula fitted with our measurements.

4. Conclusion

To compare the dispersive properties of C_3F_8, C_2F_6 and CF_4, we calculate the Abbe number at 162, 157 and 152 nm. For CF_4 and C_2F_6 gases we obtain identical values: 43 and only 39 for C_3F_8. These values are to be compared to that of helium which is the least dispersive gas known, for the same wavelength triplet: 78.

These results point out the fact that from a chromatical point of view, helium is still the most suitable gas. However in RICH counters, radiator gases need to have not only low chromatic dispersion but also high refractive index. So gas mixing of helium and fluorocabons seems to be a convenient compromise.

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