УНИВЕРСИТЕТ ИТМО

Research of the features of measuring ozone depleting substances

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Ozone depleting substances

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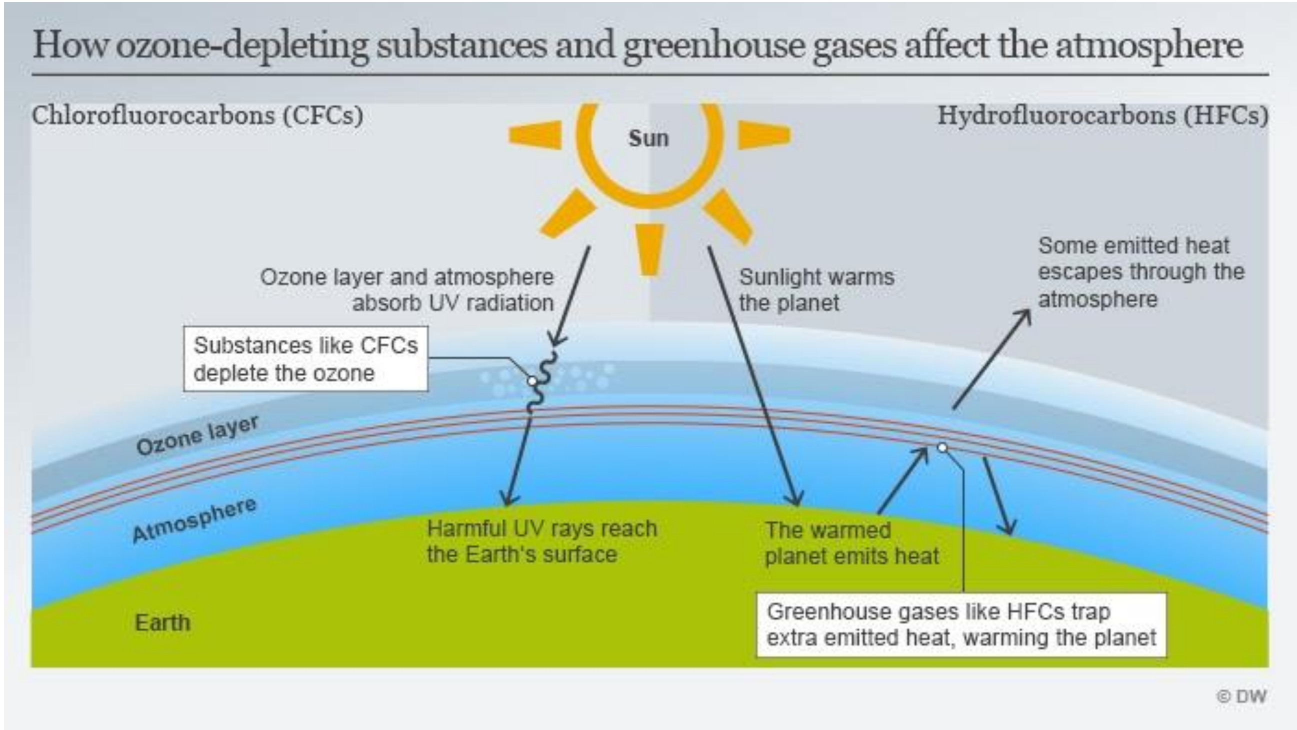
Ozone depletion is caused by an increased abundance of stratospheric chlorine and bromine, derived from long-lived anthropogenically produced ozone-depleting substances (ODSs) that destroy ozone molecules by converting them to oxygen (O2).



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Documents and standards

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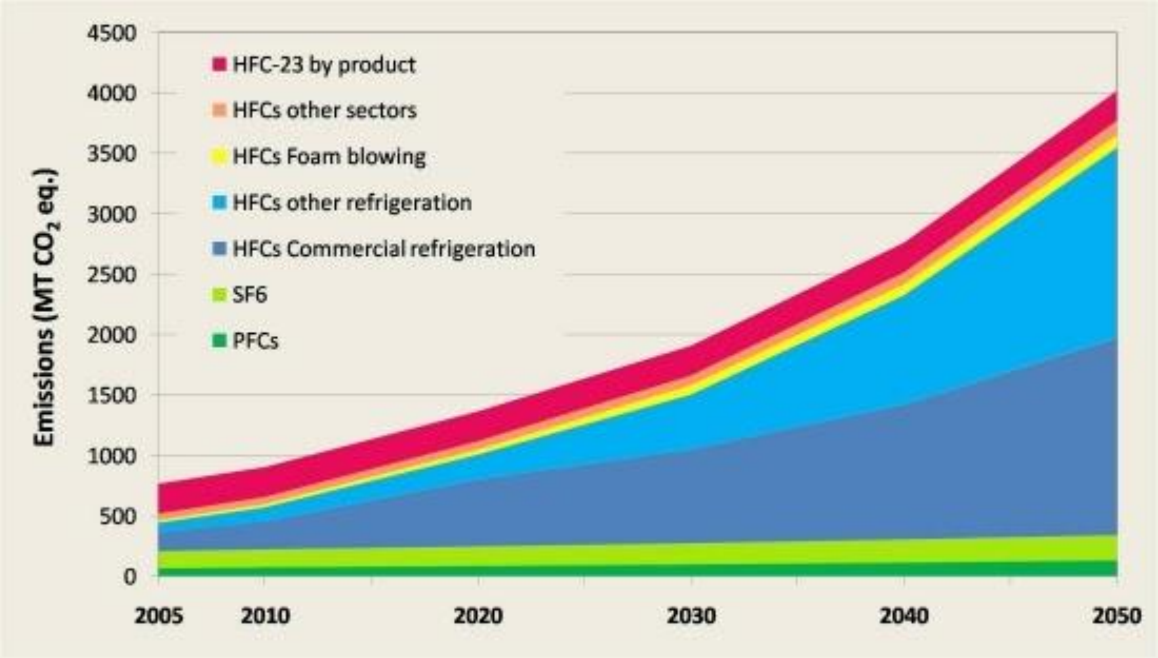
From 2021, a 20-year plan to reduce the amount of greenhouse gases used and a transition plan to eliminate hydrofluorocarbons (HFCs) begins to operate in the Russian Federation.



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Aim of the work

The work purpose is research of the features of measuring ozone depleting substances at ecological monitoring. There are several tasks which helps to achieve the goal:

1. To describe refrigerants which are effect on ozone layout;
2. To analyze interaction of refrigerants for better understanding the nature;
3. To choose the method of freon measuring for controlling the leaks into the atmosphere.

Refrigerants

Freons are highly volatile, chemically inert substances near the earth's surface, widely used in everyday life and in production as refrigerants (in refrigerators, air conditioners, refrigerators), sprayers in aerosol packages.

Group	Chemical compounds	Freons	Impact on the ozone layer
A	Chlorofluorocarbons (ClFC)	R-11, R-12, R-13, R-111, R-112, R-113, R-113a, R-114, R-115	Effect on ozone depletion
	Bromofluorocarbons (BrFC)	R-12B1, R-12B2, R-113B2, R-13B2, R-13B1, R-21B1, R-22B1, R-114B2	
B	Chlorofluorohydrocarbons (HClFC)	R-21, R-22, R-31, R-121, R-122, R-123, R-124, R-131, R-132, R-133, R-141, R-142в, R-151, R-221, R-222, R-223, R-224, R-225, R-231, R-232, R-233	Effect on mild ozone depletion
C	Hydrofluorocarbons (HFC)	R-23, R-32, R-41, R-125, R-134, R-143, R-152, R-161,R-227, R-236, R-245, R-254	Ozone-safe freons

Analyzing methods

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Method	Minimum detectable concentrations, %	Advantages	Disadvantages
Chromatography - mass spectrometry	0,00001-0,01	It is an arbitration method for the analysis of freons. Determination of complex mixtures, mass concentrations is possible	Sample is destroyed, spectral overlap, frequent recalibration, analysis time, high cost
Absorption spectroscopy	0,00001-0,1	Simplicity of design, long calibration interval	Source dependence, spectral overlap of complex mixtures, cross-sensitivity
Рамановская спектрометрия	0,000001-0,001	The unique characteristic of each substance, high speed of action	Weak signal that needs to be amplified, need to exclude fluorescence

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Chromatography - mass spectrometry

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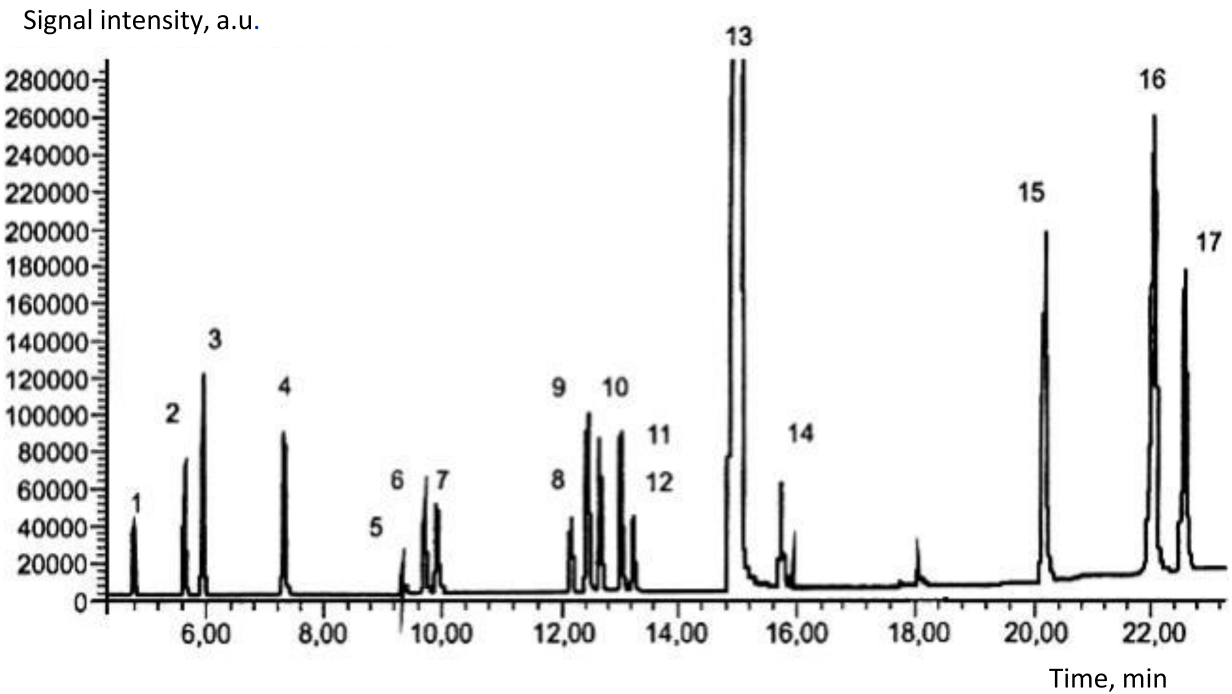

Chromatogram of a mixture of freons and hydrocarbons : 1 – propane (4,77); 2 – R-13B1 (5,64); 3 – R-115 (5,94); 4 – R-12 (7,31); 5 – isobutane (9,35); 6 – R-143a (9,71); 7 – butane (9,90); 8 – R-125 (12,19); 9 – R-22 (12,45); 10 – R-12B1 (12,68); 11 – R-114 (13,02); 12 – R-114a (13,26); 13 – mixture of freons R-11 (14,87) and R-134a (14,88); 14 – pentane (15,76); 15 – R-113 (20,18); 16 - carbon tetrachloride (22,00); 17 – R-114B2 (22,56)

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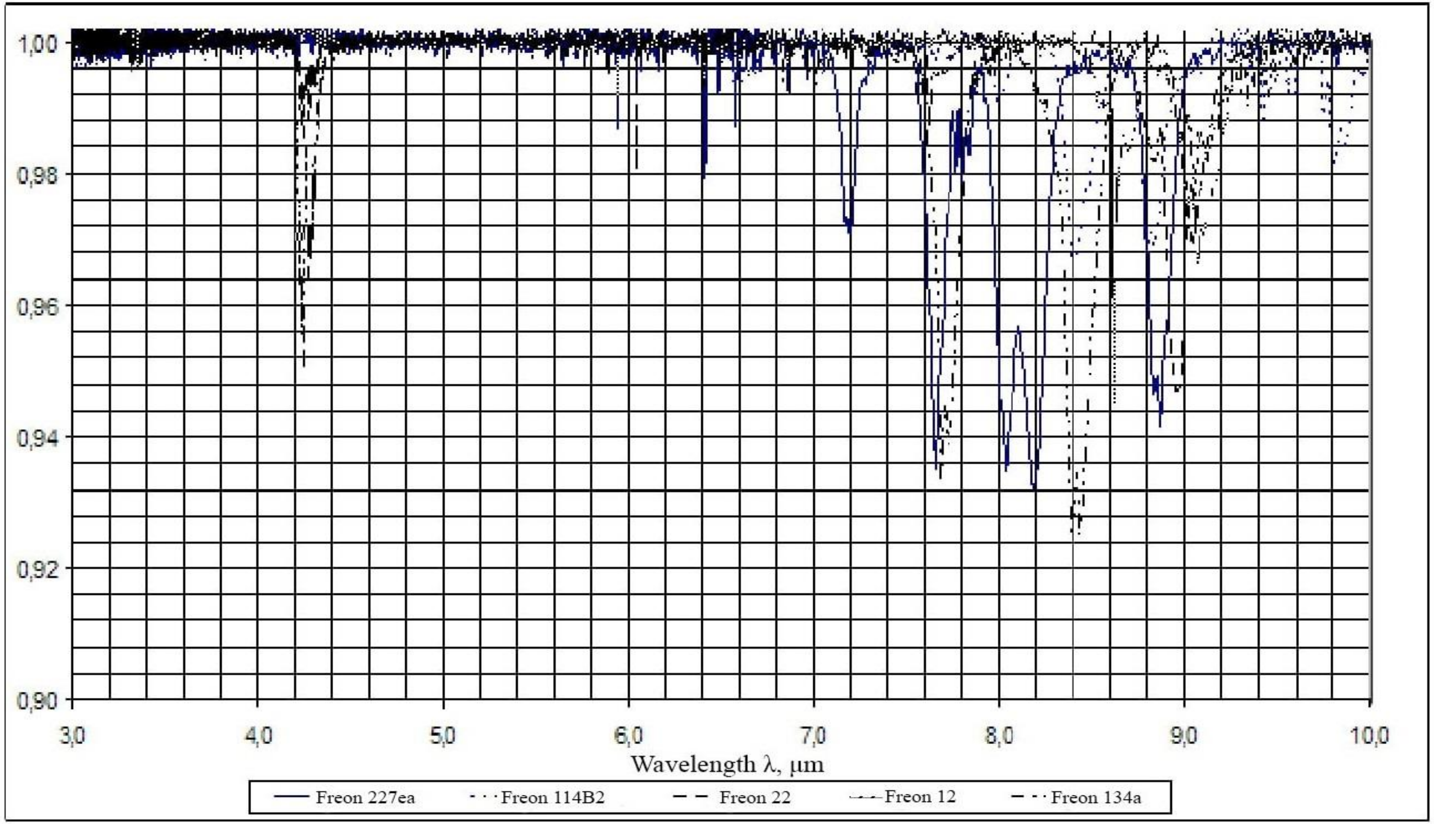
Absorption spectroscopy



Raman Spectroscopy

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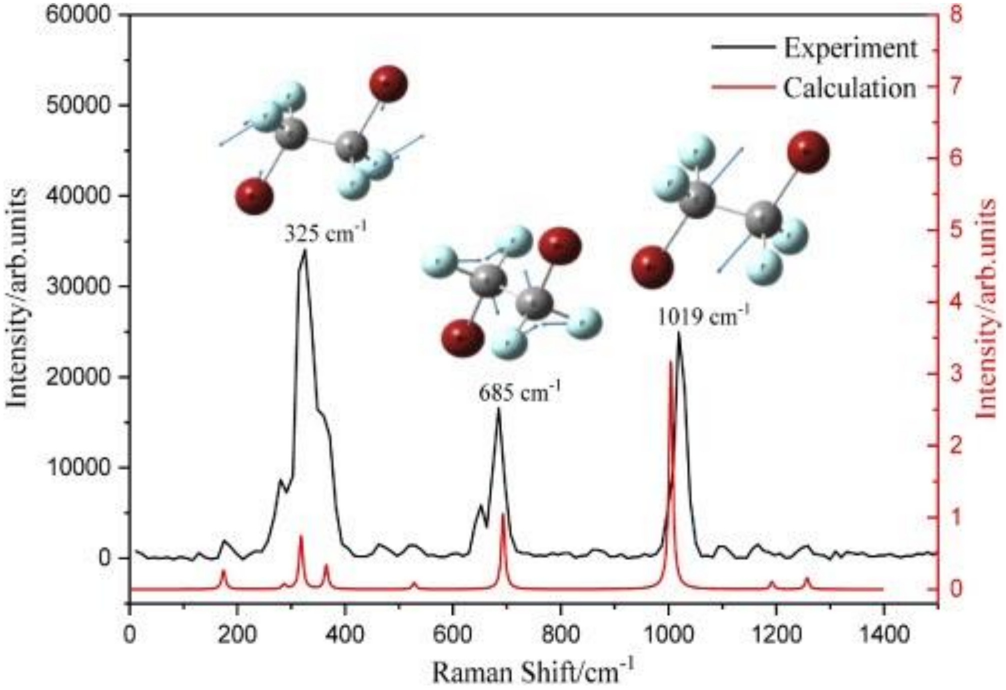
The Raman spectrum of the Freon 114B2 sample. It is observed from the figure that there are three strong characteristic peaks of the Freon 114B2 molecule in the Raman spectrum.



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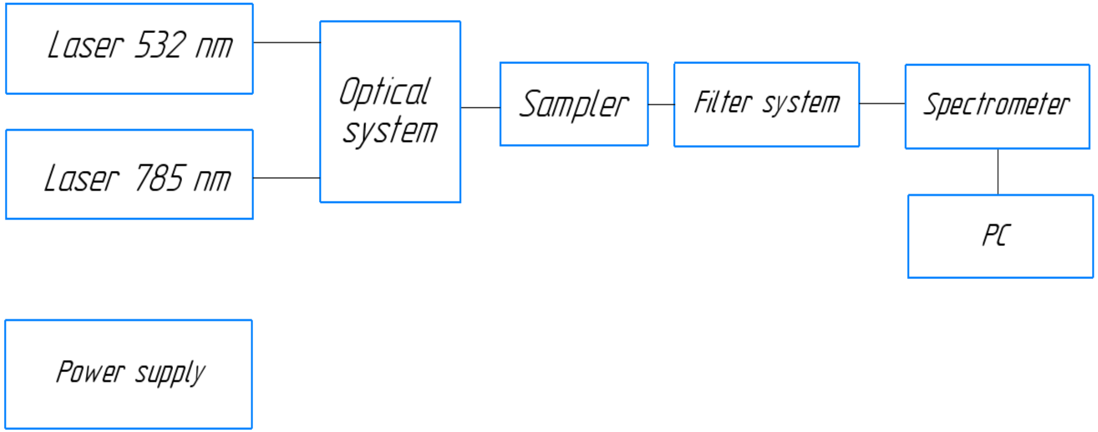
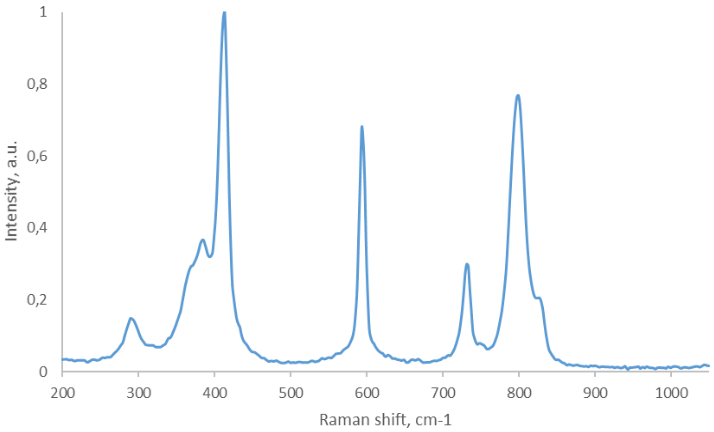
High spectral analyzing system for ozone depleting substances



Block diagram



Raman spectrum of refrigerant R22

Conclusions

1) The description of refrigerants classified as ozone depleting substances has been carried out;
2) The analysis of methods for identification of ozone-depleting substances was carried out.
3) The method of Raman spectroscopy was chosen as the most accurate method for the determination of complex mixtures.
4) Based on the characteristics of the refrigerants, a diagram of an analytical installation was proposed, including 2 radiation sources.

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