Non-invasive high-speed isotopic Raman spectroscopy for biomedical applications

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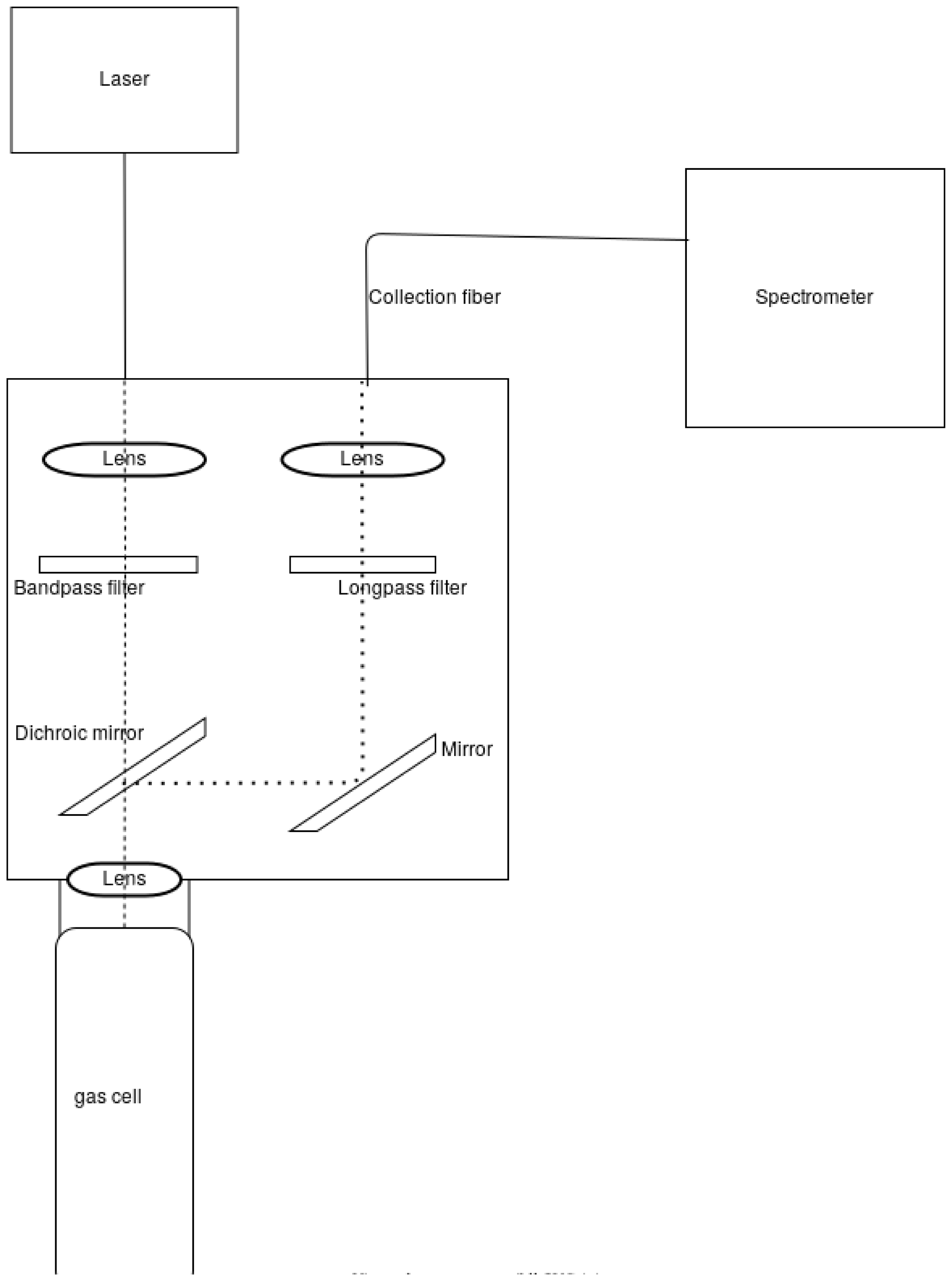
INTRODUCTION

Recently, preference in medical diagnostics has been given to non-invasive methods. One of the most promising is the analysis of air exhaled by a person. For such a task, it is proposed to use ultraspectral resolution Raman spectroscopy. A spectrometer has been developed for high-speed non-invasive diagnostics of diseases of the digestive system using drugs low-enriched in carbon-13 at concentrations of 20%. High-resolution isotope spectrometry system for measuring the concentration of C12 / C13 in non-invasive patient exhalation in real time, which improves the speed and accuracy of measurements. The principle of high-resolution Raman spectroscopy at a wavelength of 532 nm with an integration time of 10 ms is used. Demonstrated analysis of CO2 13C and CO2 12C isotopes with a selectivity of at least 0.1δ ‰ 13C during a test of 10 ms without thermal stabilization systems. The spectrometer is equipped with a software solution for medical decisions.

Experimental setup



METHODS

Raman spectroscopy, being a non-invasive method of analysis and allowing the simultaneous determination of the isotopic composition of several substances in a gas sample under study, can be used to analyze the air exhaled by a person and diagnose diseases. Carbon isotopes in exhaled CO_2 may be a valuable biomarker of cachexia (wasting of the body) associated with the acute phase of the reaction caused by endotoxemia (accumulation of toxic substances in the body). Tonsillopharyngitis in the throat of a person is another type of disease that can be detected when analyzing a human expiratory sample .
The determination of the $^{13}CO_2$ isotopologue in the air exhaled by a person can be carried out using an IC . This method has high accuracy, sensitivity and stability of the analysis of $^{13}CO_2$ exhaled by a person, but it is complex and can be applied only in high-budget laboratories. There is a less expensive method for detecting $^{13}CO_2$ isotopologues using IIRS. However, this method is only suitable for simple breath tests in which a small number of human expiratory samples are examined, for example, to detect diseases of the gastrointestinal tract and to detect the bacteria Helicobacter pylori.
Raman spectroscopy has advantages over IMS and IIKS methods, the most important of which are lower cost, ease of sample preparation, and the ability to simultaneously detect all molecular components in a human expiratory sample, including N_2 and O_2.

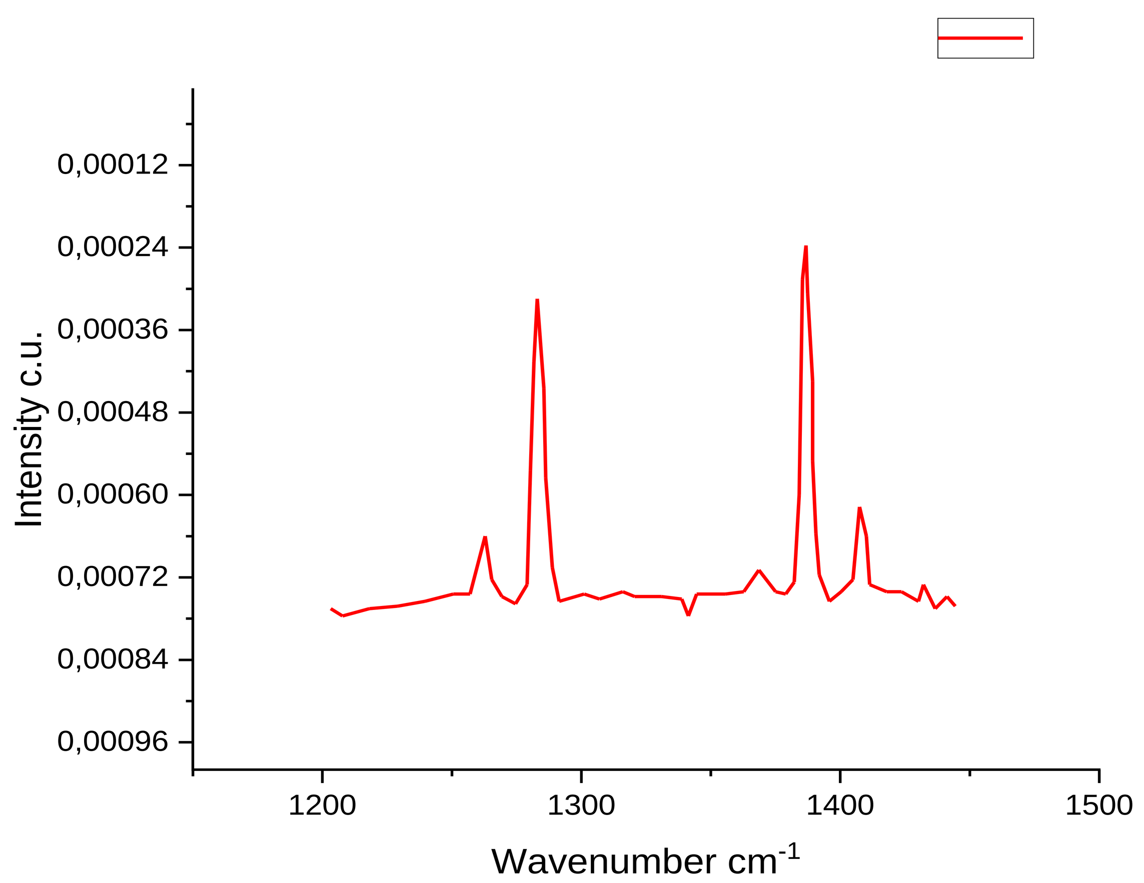


Fig. 1 . Raman spectra of air exhaled by a person, obtained at a pressure in a gas cell of 1 atm and an exposure time of a CCD camera of 1800 s in the range of 1225-1450 cm-1

RESULTS

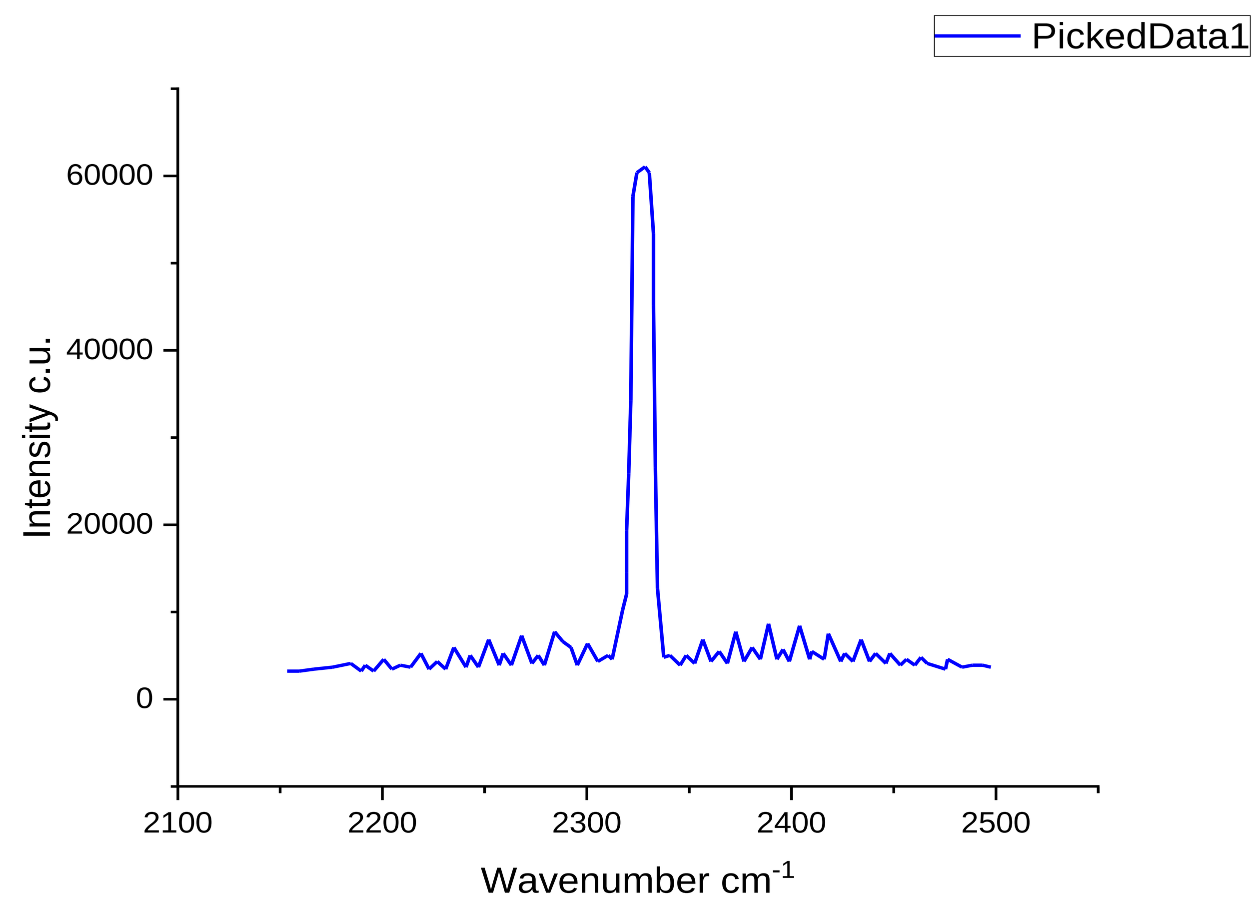


Fig.2Raman spectra of air exhaled by a person, obtained at a pressure in a gas cell of 1 atm and an exposure time of a CCD camera of 600 s in the range of 2150-2500 cm-1

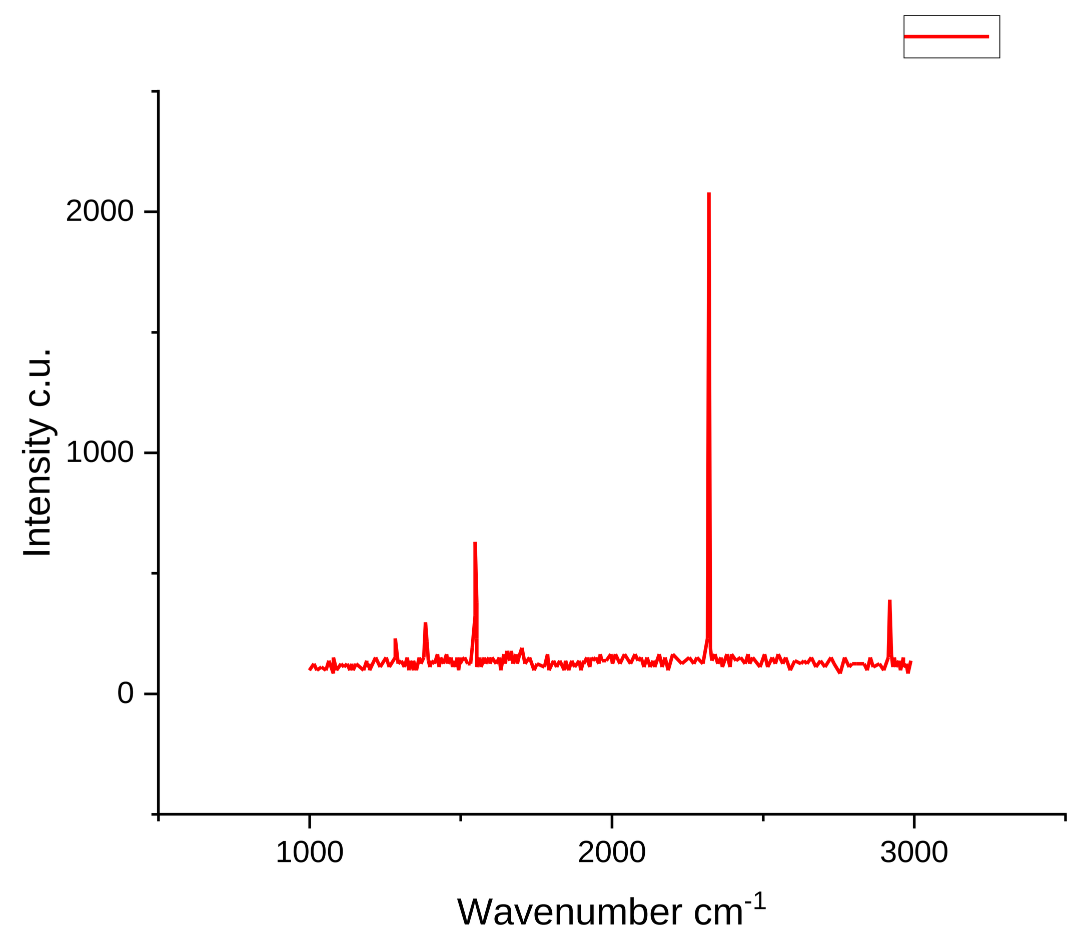


Fig. 3 Raman spectrum of human exhaled air in the range of 1100-3000 cm-1, obtained at a pressure in a gas cell of 1 atm and an exposure time of a CCD camera of 60 s

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