Using of Absorption Method in the Spectral Range 4860-4880 cm\(^{-1}\) for Noninvasive Online Diagnostics of Oncological Diseases

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Early diagnostics of cancer has great importance nowadays that is especially true for oncology of gastrointestinal tract \([1,2]\) having grave clinical course. For prevention and early diagnostics of diseases in order to provide timely treatment new simple and noninvasive methods are required, for instance, breath tests based on measuring in the air expired by the patient \(^{12}\)C and \(^{13}\)C isotopes contained in \(^{12}\)CO\(_2\) and \(^{13}\)CO\(_2\), which are released after splitting labeled urea by H. pylori urease.

Among the methods of measuring carbon isotopes concentrations in the expired air those based on the method of absorption spectroscopy are promising, combining high sensitivity and accuracy with obtaining on-line results. In these papers frequency tunable diode lasers (TDL) operating in the infrared spectral range near wavelengths of 4.3, 2.0 and 1.6 \(\mu\)m were used as radiation sources.

This paper informs on theoretical and experimental investigation for developing optical measuring system performing selective analysis of gaseous mixtures containing \(^{12}\)CO\(_2\) and \(^{13}\)CO\(_2\). The research was conducted using TDL operating in the range 4860-4880 cm\(^{-1}\).

In the experiments InGaAlAs/InP single-mode TDL made by Vertilas VCSEL Diodes (Germany) was used as an radiation source. Tuning in the range of 4860-4880 cm\(^{-1}\) was performed due to pump current modulation in the range of 4.0-9.5 mA and diode temperature variation in the range of 20-35\(\degree\)C. In all the TDL frequency tuning range the power of laser generation was \(\sim\)1 mW.

In the laser tuning range there are more than 10 rotational absorption lines of each isotopologue of \(^{12}\)C\(^{16}\)O\(_2\) and \(^{13}\)C\(^{16}\)O\(_2\) of the 20013-00001 vibrational band, one set of lines partially overlapping with another. Using the HITRAN database for calculation of absorption spectra shows that spectral range of 4876.5-4878.5 cm\(^{-1}\) is the most suitable for measuring since it has absorption lines of \(^{12}\)C\(^{16}\)O\(_2\) and \(^{13}\)C\(^{16}\)O\(_2\) insignificantly overlapping with each other.

In the course of experiments TDL radiation modulated by a generator built in a control unit passed through a multipass gas cell, its optical length being changed in the range 0.8 to 4.8 m. Optical cell was filled with gaseous mixture containing isotopologues of \(^{12}\)C\(^{16}\)O\(_2\) and \(^{13}\)C\(^{16}\)O\(_2\) at the temperature 296K and total pressure 1 atm, value of \(^{13}\)CO\(_2\) isotopologue concentration to the total CO\(_2\) concentration being approximately 0.7\%. Laser radiation passed through the gas cell was registered with the help of two photodetectors (PD), for this purpose the radiation was spacially divided by beam splitter. Signals received by PD were processed with the help of analog-to-digital converter. In order to identify experimentally obtained spectral absorption lines we calibrated laser frequency. For this purpose we measured absorption spectra of isotopically pure \(^{12}\)C\(^{16}\)O\(_2\) (pressure being 996 millibar) at modulation of TDL pump current at operating temperature of 20.2\(\degree\)C.

The conducted research shows opportunity of using laser diode spectroscopy for high-precision analysis of \(^{13}\)C isotope content in the expired air that can provide on-line diagnostics of oncological disease in the early stage. The described method could become a base of new effective methods of non-invasive medical diagnostics.

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References
