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Summary of the doctoral dissertation:

Microprocessor based alveolar fraction sampling system for human exhaled air analyzers

The dissertation is dedicated to the development of a sampling system for human exhaled air, designed to operate with an optoelectronic gas sensor using laser absorption spectroscopy. It is related to research on a non-invasive method of detecting disease markers - gases whose concentration changes are characteristic for a specific disease. In this study, particular attention was paid to nitric oxide (NO), whose increased concentration in the alveolar fraction of exhalation is an indicator of asthma and chronic airway inflammation.

An analysis of the principle of operation and parameters of the sampling systems described in the literature and commercially available ones was carried out, which revealed the lack of human exhalation sampling methodology taking into account the considerations of interoperability with nitric oxide analyzers using laser infrared absorption spectroscopy. The author's system for sampling exhaled air has been developed, which meets the guidelines of the American Thoracic Society (ATS) and the European Respiratory Society (ERS), specifying the recommendations for the operating conditions of medical devices intended for sampling human exhaled air and measuring the fractional exhaled nitric oxide - feNO. The system also allows for automatic and fast determination of the alveolar breath fraction independent of the patient's exhalation parameters such as flow, pressure, humidity, temperature. The influence of temperature and pressure of the air sample was minimized by correction of CO_2 sensor readings leading to the lowest uncertainty of CO_2 concentration measurement. To determine the beginning of the alveolar fraction in exhaled air, an original algorithm was developed to analyze the dynamics of changes CO_2 concentration using Simple Moving Adjacent Average (SMAA) algorithm. It was found that this method accurately detects the beginning of alveolar fraction expiratory phase in both sick and healthy subjects and is highly independent of the patient's respiratory capacity.

Experimental studies of the developed system were carried out using a gas chromatography and a mass spectroscopy. Compared to the air sample without expiratory phase separation, an increase in biomarker amount of over 98% was obtained. Comparative studies with a commercial device were carried out and an increase in the biomarker amount of over 21% was obtained. In addition, it was also found that the developed system allows the efficient collection of other biomarkers such as acetone and acetonitrile.

The developed sampling system was tested in a clinical conditions. The collected alveolar fraction samples were examined using an optoelectronic NO analyzer. The obtained results confirmed the concentration of nitric oxide in the collected samples above the threshold of 50 ppbv, assumed for a healthy adult person. The developed system reached technology readiness level VII.