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Analysis of methane as a biomarker of human breath using gas photoacoustic spectroscopy

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The methane (CH_4) produced in the intestine by methanogenic archeas of the species *Methanobrevibacter smithii*, as well as acetone (CH_3COCH_3) from hepatic ketogenesis can act as human respiration biomarkers for diabetes mellitus. The higher glucose levels and the percentage of glycated hemoglobina in the blood, the higher the concentrations of these gases in the breath. In this sense, biomarkers can be useful for early diagnosis and non-invasive disease monitoring. In the breathing of healthy individuals, CH_3COCH_3 is detectable in the range of 0.39 to 1.09 ppmV. Methane-positive individuals have a detectable CH_4 concentration in the range of 3 to 8 parts per million by volume (ppmV), while methane-negative individuals exhale CH_4 below 3 ppmV. In the case of CH_4, 3 ppmV is usually the limit of detection of gas chromatography used for this type of analysis, which makes it difficult to establish exactly the concentration of CH_4 exhaled by methane-negatives. Therefore, Photoacoustic Gas Spectroscopy (PGS) becomes advantageous because it has a lower detection limit, allowing non-destructive and non-invasive measures. This technique is based on the generation of acoustic energy by transforming light into thermal energy in a linear manner. The radiation source adopted is the Quantum Cascade LASER emitting at 1360 cm^{-1} (CH_4 absorption). After the electrical characterization of the LASER (T = 0 ºC; R = 12 µV; P = 19.5 mW; i = 700 mA), wave number scans were made and the resonance frequency of the detector was determined (3.851 kHz). Then, several calibrations of the system were obtained with synthetic air, in which it was possible to investigate an unexpected phenomenon, a non-linear behavior of the photoacoustic signal as a function of the concentration due to processes of resonant energy transfer between the energy levels of the CH_4 and the O_2. Therefore, the calibration must be done with pure nitrogen gas. The system was calibrated and the efficiency of the KOH and liquid N_2 filters used to remove CO_2 and H_2O from the gas sample was tested, as well as the CH_4 adsorption in the Tedlar bag was evaluated. Due to the pandemic for the new Coronavirus, the tests were interrupted in March 2020. So far, the breathing of 10 volunteers under endocrinological supervision has been analyzed. As perspectives, we intend to resume the CH_4 influence tests, perform simulated breathing measurements and quantify the CH_3COCH_3.The detection limit found for CH_4 was 0.42 ppmV. It is concluded that PGS was sensitive to analyze the CH_4 of human breath.

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