SPECTROSCOPIC DETECTION OF BIOLOGICAL NO WITH A QUANTUM CASCADE LASER

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Introduction

In this work we compare two Quantum Cascade Laser based spectroscopic methods for sensitive detection of Nitric Oxide. A setup with a 100m Multipass absorption cell and a Cavity Enhanced Spectroscopy (CES) setup are described. The characteristic properties such as detection limit, dynamic range, and simplicity in handling are reported and the advantages and disadvantages of each method are discussed. Both experimental techniques detected biological NO, which is produced in the human respiratory tract and released in exhaled breath.

Setup with a 100m Multipass Cell

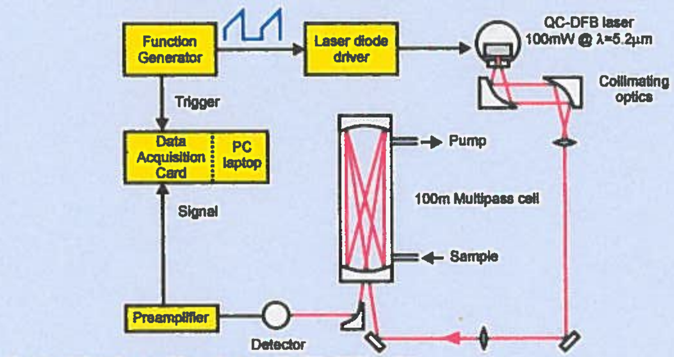

Figure 1. Schematic setup of the spectrometer with a 100m-Multipass Cell

Nitric Oxide in exhaled breath

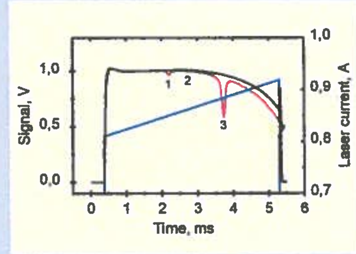

Figure 2

Transmitted intensity of pure Nitrogen (black) and a breath sample (red) at 50Torr and laser current (blue).
(1) H_2O @ 1918.860 cm^{-1}, (2) CO_2 @ 1918.76 cm^{-1}, (3) CO_2 @ 1918.585 cm^{-1}

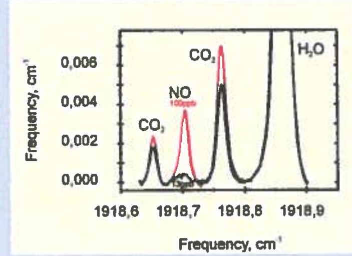

Figure 3

Absorption of a breath sample from nose (red) and mouth (black) at 50Torr.

Cavity-Enhanced-Spectroscopy

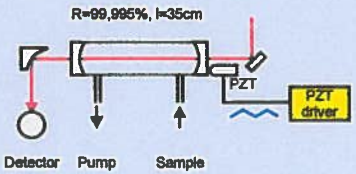

Figure 4. High finesse Cavity with piezo modulation of one mirror

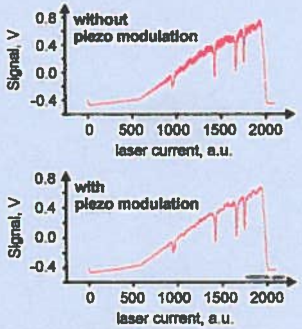

Figure 5. Reduction of base line noise by modulation of one of the the high Q cavity mirrors

Data-acquisition and analysis

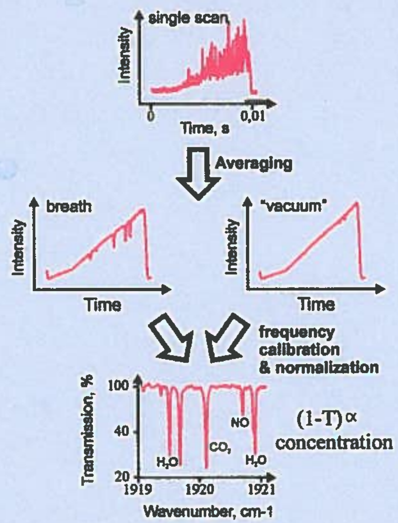

Figure 6. Data acquisition and analysis

Gas spectra measured with CES

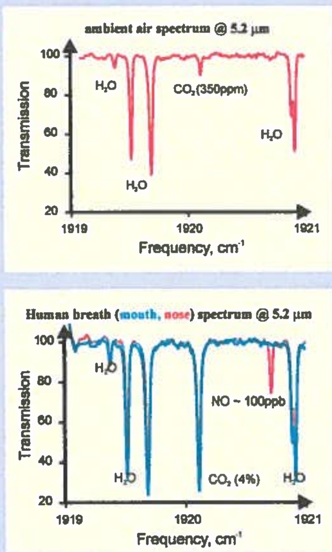

Figure 7a,b. Transmission spectra of ambient air and breath measured by CES

CO_2 calibration

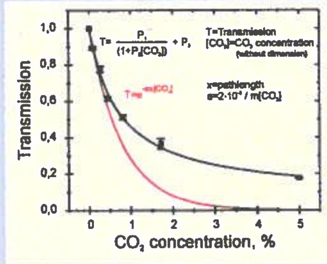

Figure 8. Transmission of CES-cavity @ 1920.111 cm^{-1} for different CO_2 concentrations from 0% to 5% and hyperbolic curve fit (solid line). The dotted line shows the calculated transmission for a multipass cell with the same pathlength as the CES-cell for low CO_2 concentrations.

Conclusions

Multipass cell

- Minimal detectable absorption = 10^{-4}
- Simultaneous detection of NO, CO_2, H_2O
- Measured detection limit for NO is 2ppb

Cavity Enhanced Spectroscopy

- Minimal detectable absorption = 10^{-2}
- Simultaneous detection of NO, CO_2, H_2O
- Detection limit for NO 15ppb
- Effective pathlength 670m (smaller for higher absorption in the cell)
- Broad dynamic range (T~1/conc.)