In-Situ Real-Time Methane Detection in Breath Using Tunable Diode Laser-Based Spectroscopy

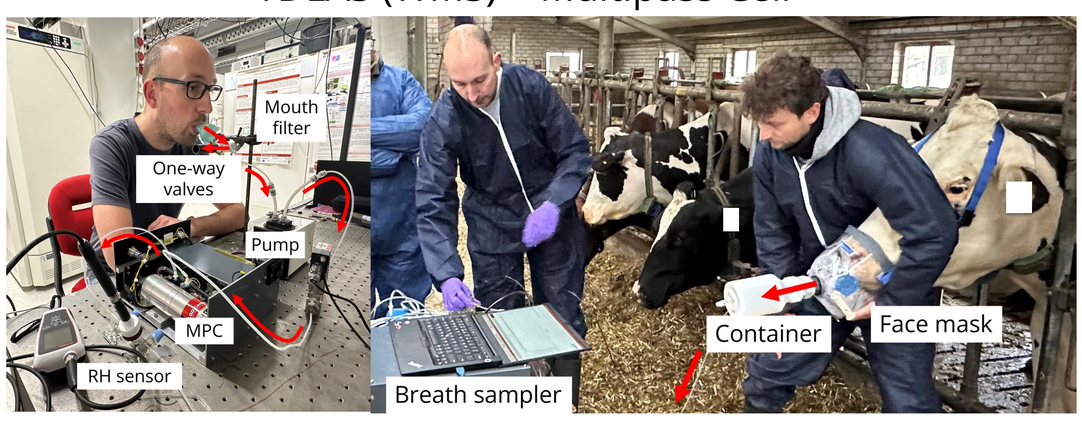
Yueyu Lin*[1], István Fodor[2], Joris Meurs[1], Amir Khodabakhsh[1], and Simona M. Cristescu[1]
[1]*Life Science Trace Detection Laboratory, IMM, Radboud University, 6525 AJ Nijmegen, The Netherlands*
[2]*Animal Breeding and Genomics, Wageningen University & Research, 6708 PB Wageningen, The Netherlands*
**Yueyu.lin@science.ru.nl*

Abstract
Methane (CH_4) emerges as an end-product of microbial fermentation catalyzed by the gut microbiota upon the incomplete digestion of polysaccharides from dietary carbohydrates. Currently, H_2 and CH_4 breath tests are employed to evaluate carbohydrate malabsorption conditions, such as lactose or fructose intolerance, as well as small bowel bacterial overgrowth. Here we report on the development of a custom-built breath analyzer based on a commercial OEM (original equipment manufacturer) module using tunable diode laser absorption spectroscopy (TDLAS) for real-time measurements of CH_4 concentrations in exhaled breath. Since the module exhibited interferences with water and CO_2, correction functions were experimentally identified, validated, and applied. Real-time CH_4/CO_2 profiles from human breath, as well as CH_4 profile from dairy cattle breath were obtained using this system.

Method

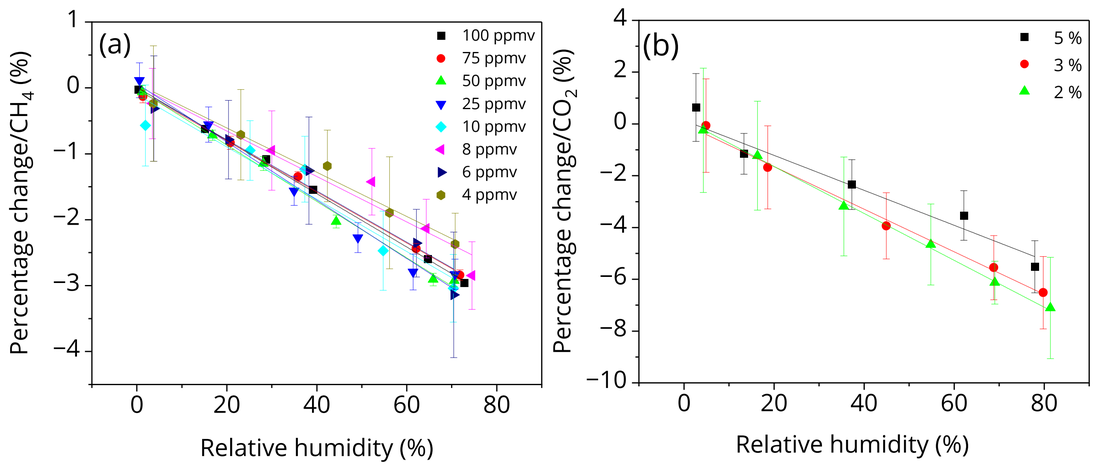


TDLAS (WMS) + Multipass Cell



Real-time CH_4/CO_2 sampling of breath from humans and diary cattle.

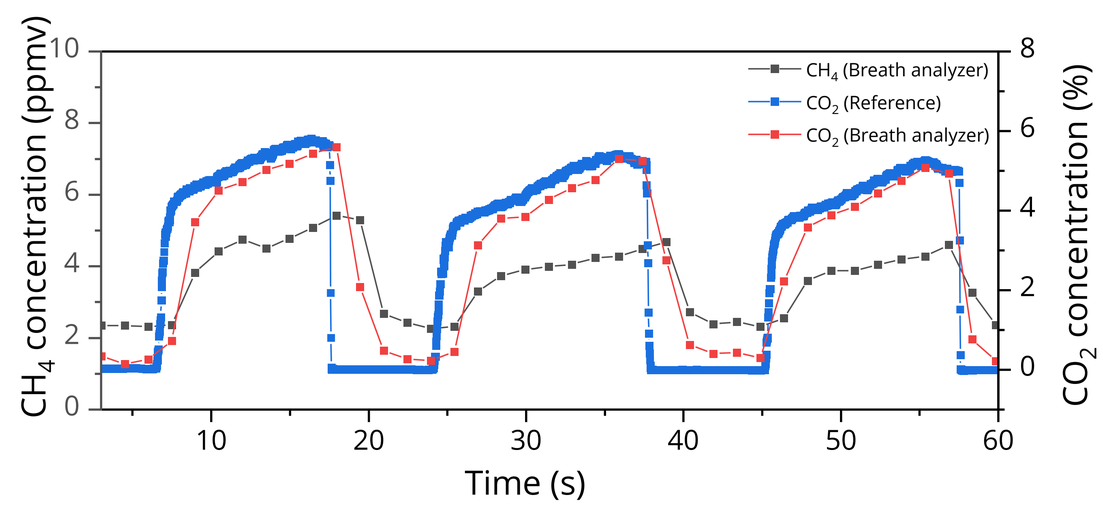
Correction for water spectral interference



- Detection errors after correction functions:
  - CH_4: < 1.5% (>10 ppmv) and < 3% (<10 ppmv)
  - CO_2: < 1.4%
- Detection limitation (1.5 s average):
  - CH_4: ~ 80 ppbv
  - CO_2: ~ 600 ppmv

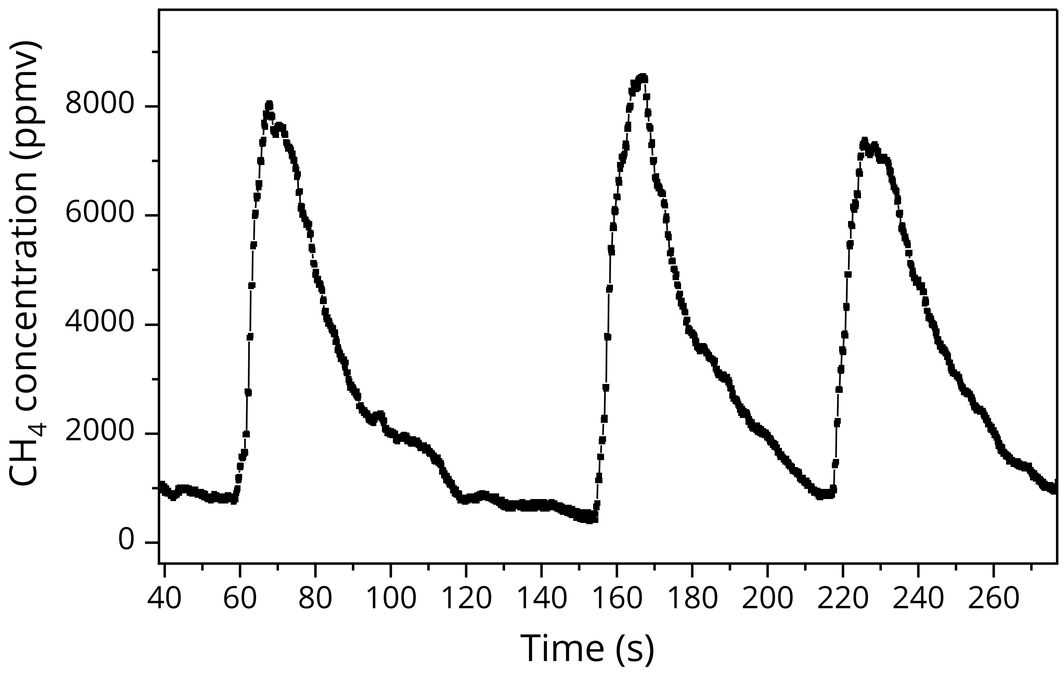
Results

Human breath



- Real-time breath-to-breath profile of CH_4/CO_2
- Good agreement with reference (CAPNOSTAT® 5 CO_2 sensor) for CO_2 at end-tidal phase.

Dairy cattle



- Regular breath concentration : ~ 800 ppmv
- High CH_4 concentration up to 8000 ppmv during eructation

Conclusion
- Our custom-built breath analyzer is suitable for real-time breath profiles from humans and dairy cow.
- Interferences from water vapor for CH_4/CO_2 could be eliminated by using experimentally determined correction functions.

Outlook
- The breath analyzer will be evaluated in clinical practice settings.
- Further research at experimental farms will be planned to investigate the role of CH_4 as an indicator to separate the gas from lung and rumen.