Screening diabetes mellitus through monitoring lipid metabolism by measuring and imaging breath acetone using bio-fluorometric gas sensors

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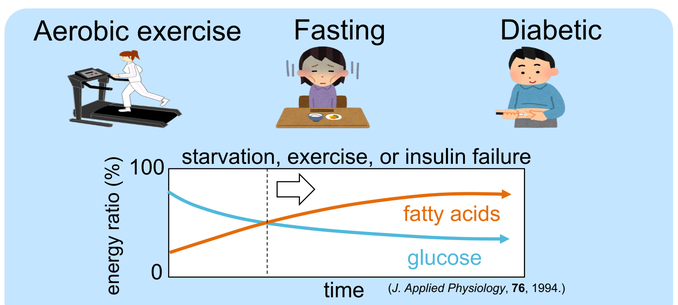
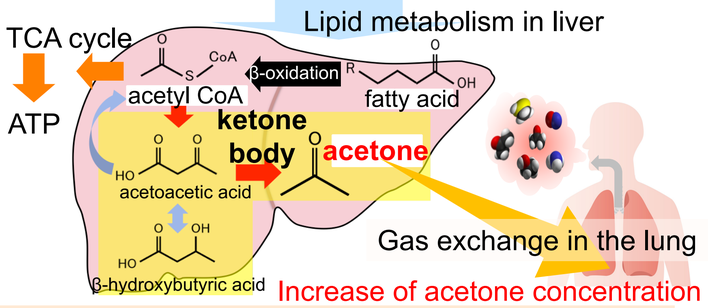
OBJECTIVES

- Developing gas-phase biosensor systems for quantitative monitoring of breath acetone
- Screening diabetes mellitus (DM) patients through assessment of lipid metabolism via breath

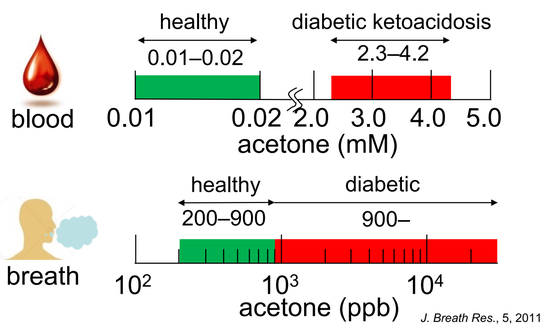
Significance of acetone measurement





Effective indicator for assessment of lipid metabolism

Concentration ranges of acetone

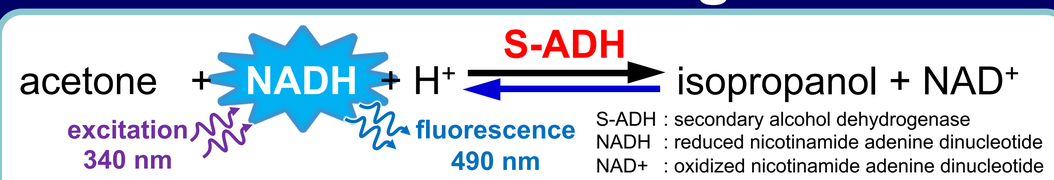


Conventional methods

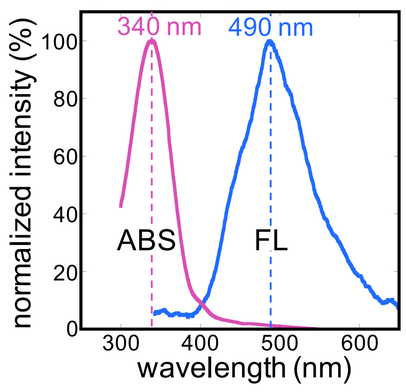
Method	Characteristics
GC-MS	◯ sensitivity, selectivity ✕ continuity
semiconductor	◯ continuity, convenience ✕ selectivity

Require continuous, sensitive & selective sensor

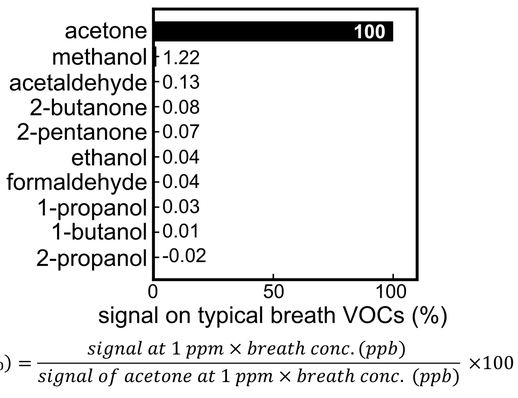
Bio-fluorometric sensing of acetone



FL property of NADH



Selectivity in breath VOCs

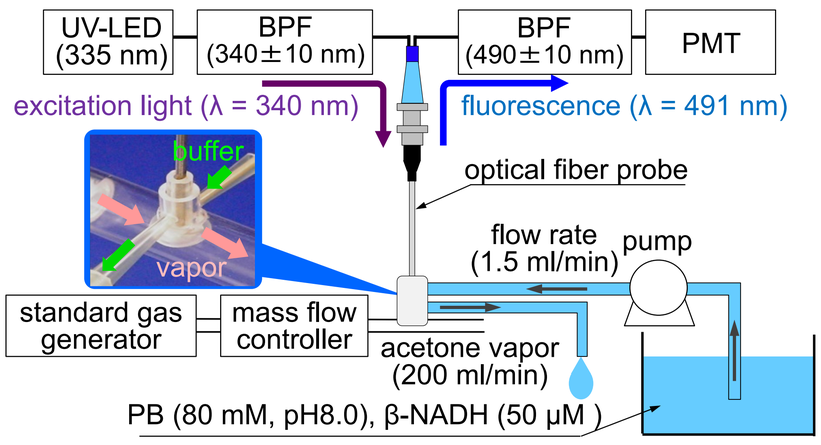


$$signal\ (\%) = \frac{signal\ at\ 1\ ppm \times breath\ conc.\ (ppb)}{signal\ of\ acetone\ at\ 1\ ppm \times breath\ conc.\ (ppb)} \times 100$$

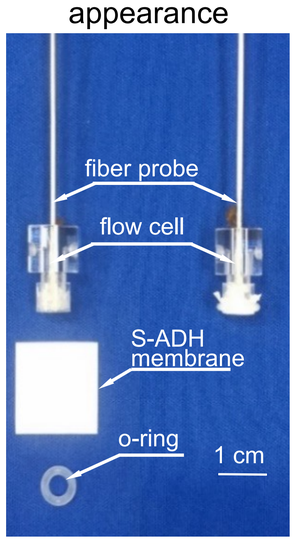
Selective monitoring of acetone is possible.

Fiber-optic acetone gas sensor for screening of DM via breath monitoring

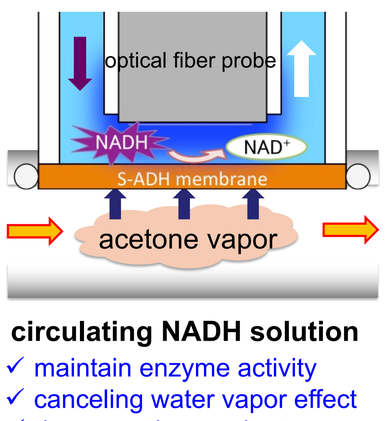
Acetone gas measurement system



appearance



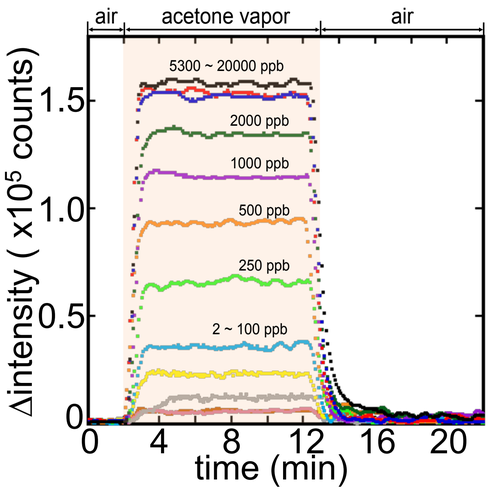
monitoring functionality

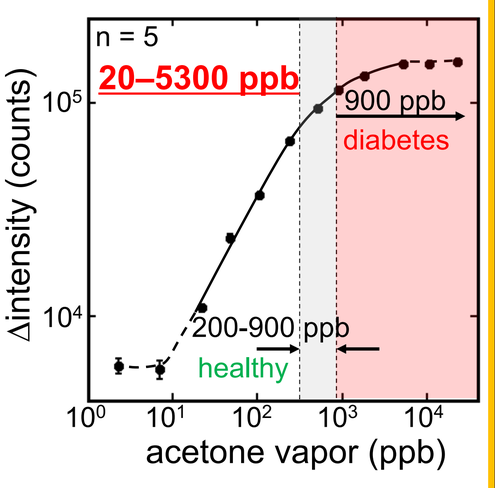


circulating NADH solution

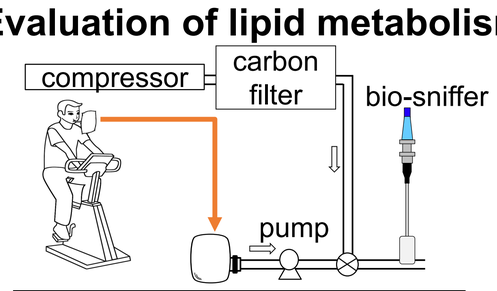
- ✓ maintain enzyme activity
- ✓ canceling water vapor effect
- ✓ rinse reaction products
- ✓ supply NADH into the flow-cell

Characteristics of acetone biosensor





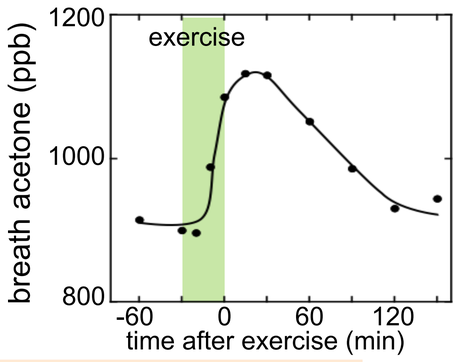
Evaluation of lipid metabolism



gender	age	BMI	fasting time
male	30	20.4	6 h

(Tokyo Medical and Dental University, Institutional Review Board, Approved: No. 2014-01)

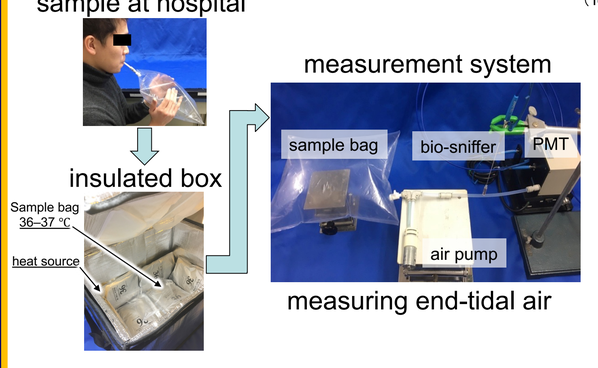
Time course of breath acetone



Real-time monitoring of lipid metabolism through breath acetone

Screening of DM by measuring breath acetone

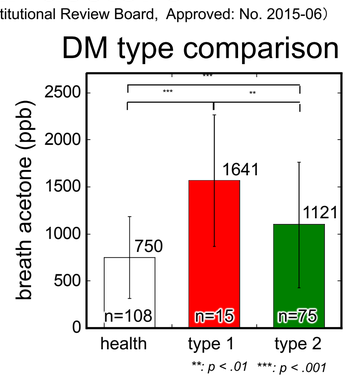
(Tokyo Medical and Dental University, Institutional Review Board, Approved: No. 2015-06)



sample population

Control subjects
- Breath samples : 108
  - male : 79
  - female : 29

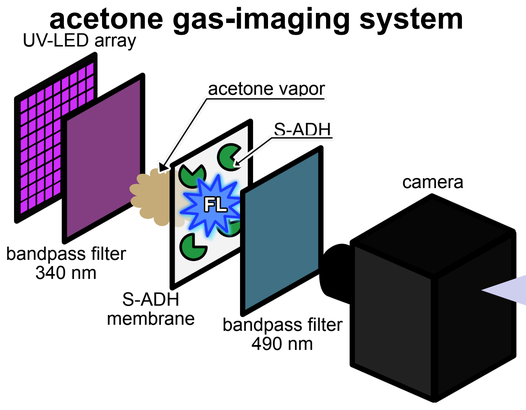
DM patients
- Breath samples : 90
  - type 1 : 15
  - type 2 : 75

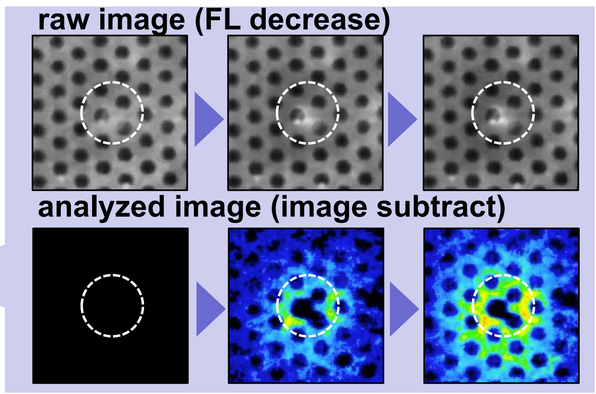


Breath acetone measurement enabling rapid screening of DM

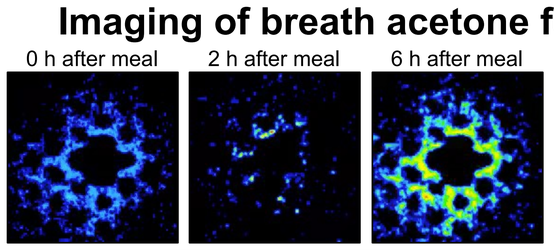
New "dimension" of gas sensing

acetone gas-imaging system



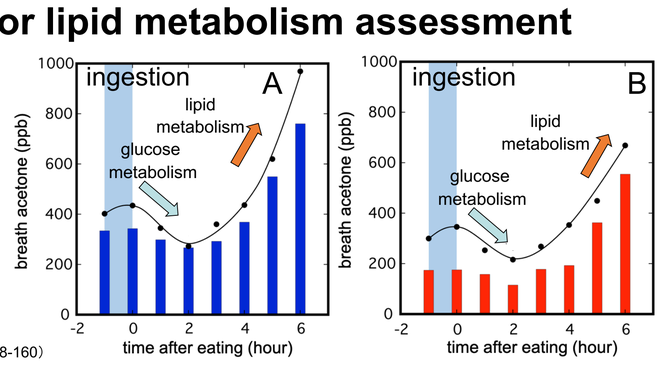


Imaging of breath acetone for lipid metabolism assessment



	gender	age	BMI	fasting time
A	male	24	19.8	4 h
B	female	22	20.9	4 h

(Tokyo Medical and Dental University, Institutional Review Board, Approved: No. M2018-160)



Gas-imaging system allows image-based facile evaluation of lipid metabolism

SUMMARY

- The high-sensitive and high-selective acetone bio-sniffer with flow-cell was developed.
  calibration range: 20–5300 ppb, response time: 35–70 s, reproducibility: 97.3%
- Spatiotemporal change of acetone gas was imaged by bio-fluorometric gas-imaging system.
  calibration range: 50–2000 ppb, response time: 20 s
- Real-time monitoring of lipid metabolism and DM classification were demonstrated.

Breath Biopsy Conference (1-2 Nov. 2022, Online)