Monitoring Lipolysis by Compact (Filter-Sensor) Detector during Exercise

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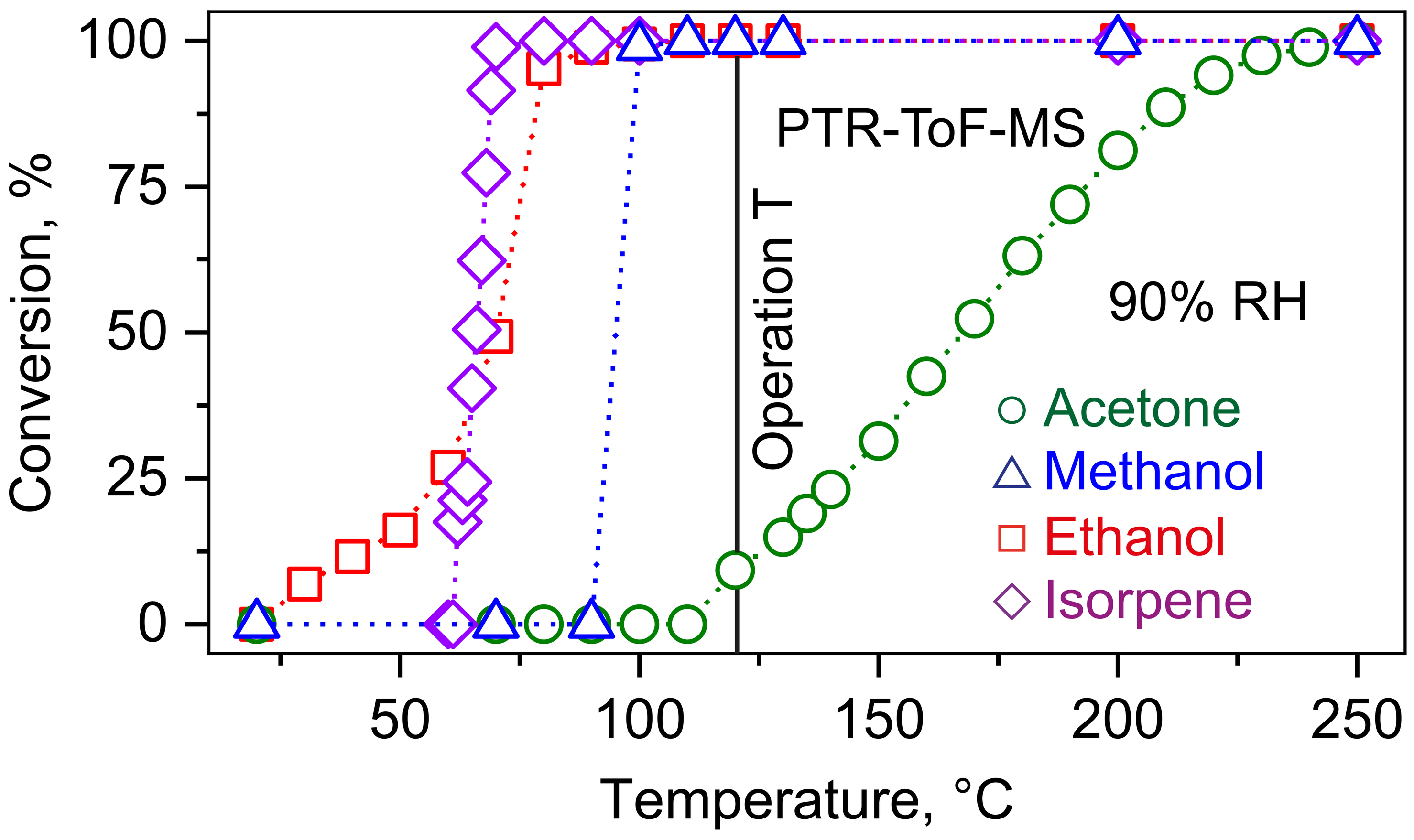
Motivation

Mobile health technologies can provide information to routinely monitor metabolic diseases (e.g., diabetes, obesity) and optimize their treatment (e.g., exercise or dieting). Most promising is to trace breath **acetone** and track **lipolysis** (body fat burning)[1]. Yet, accurate acetone quantification is difficult with compact detectors in the presence of interferants. Upstream catalytic filters[2] that combust interferants (e.g., ethanol[3]) to non-responsive species can address this challenge.

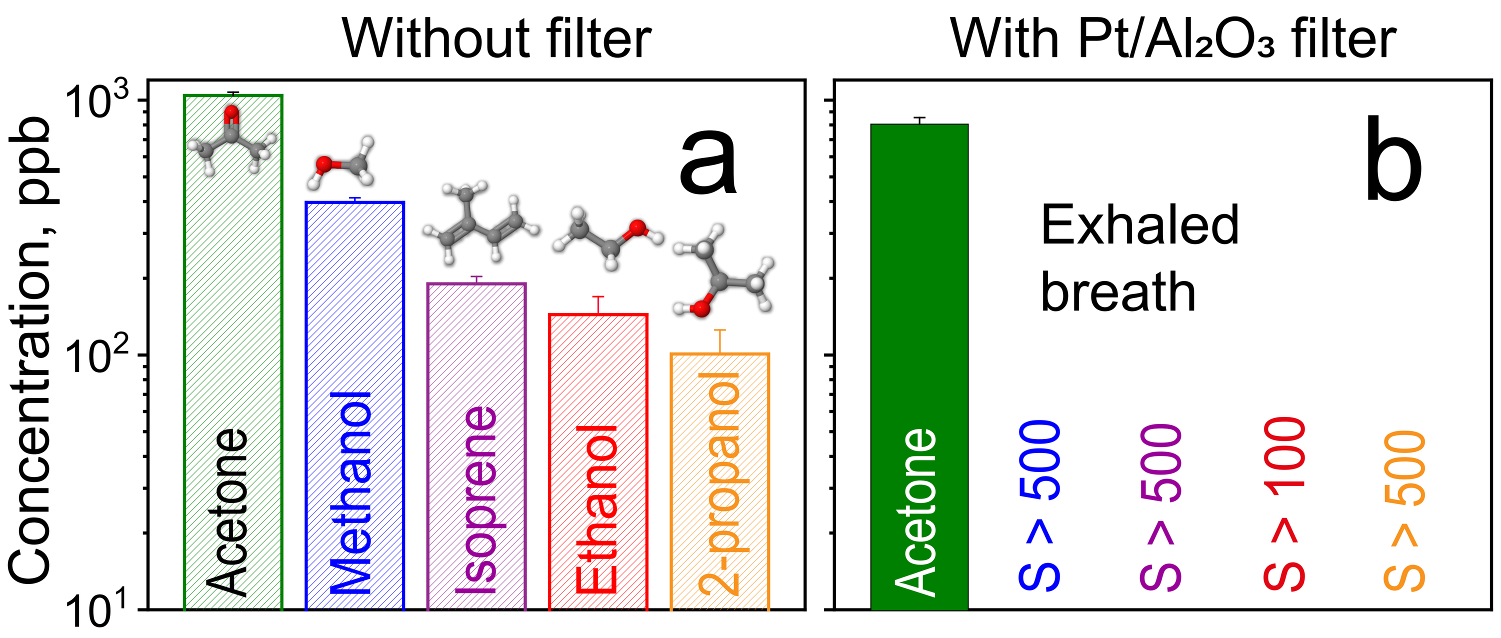
A low-cost and highly selective detector[2,4] is presented that quantifies accurately end-tidal acetone during exercise and rest[4]. It combines a flame-made 0.2 mol% Pt-containing (**Pt/Al_2O_3**) **catalyst** with a chemoresistive 10 mol% Si-containing (**Si/WO_3**) **sensor**[5].

The detector is robust against high ethanol and isoprene concentrations, as validated by mass spectrometry. Most notably, it accurately tracked individual lipolysis dynamics, as confirmed by blood ketone measurements. It can be integrated readily into handheld devices[2] for personalized metabolic assessment.

Catalytic Conversion of Interferants

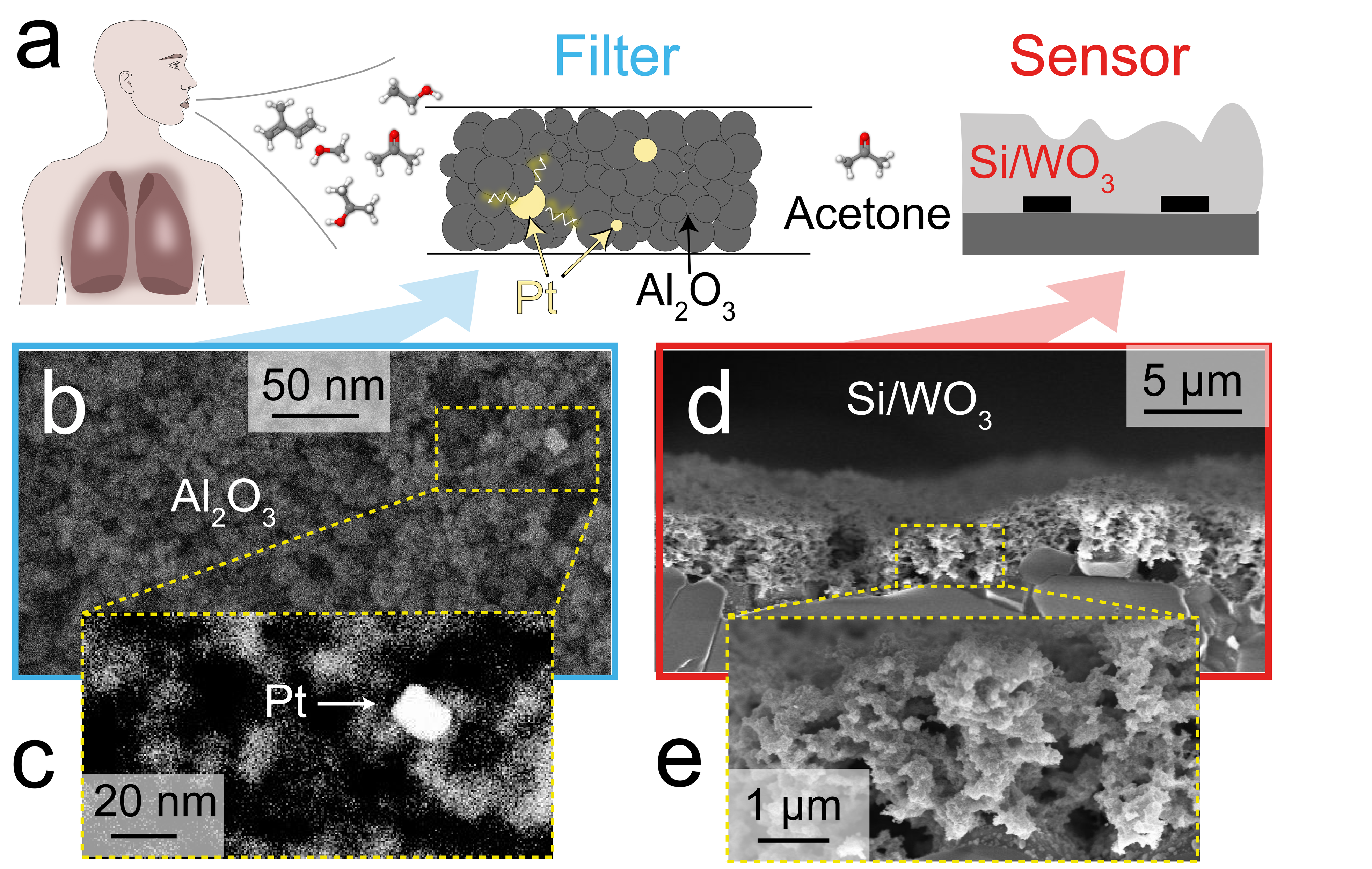


Conversion of 1 ppm methanol (triangles), ethanol (squares) and isoprene (diamonds) in synthetic air occurs well before acetone's (circles) that enables highly-selective detection of acetone[5].



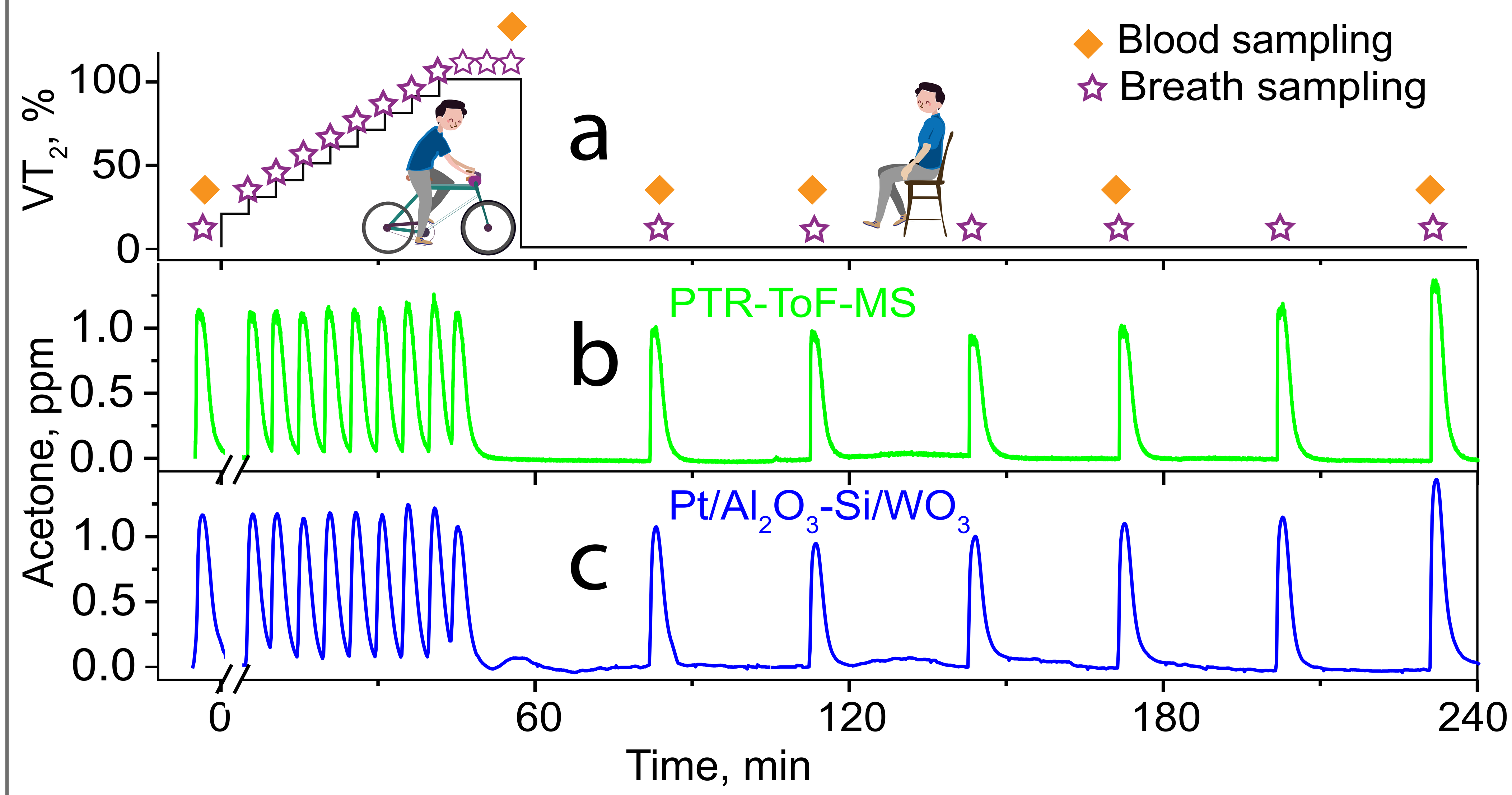
Interferants in breath (a) are removed by the catalytic filter (b) except acetone, resulting in excellent selectivity (S).

Filter-Sensor Detector Enables High Selectivity



(a) A packed bed of catalytic Pt/Al_2O_3 nanoparticles pre-separates exhaled breath by selective conversion of interfering molecules over acetone. (b) The filter consists of high surface area flame-made Al_2O_3 particles (c) decorated with Pt clusters. (d) High sensitivity is enabled by the porous morphology of the sensing film with a magnification in (e).

Monitoring Breath Acetone during Exercise and Rest

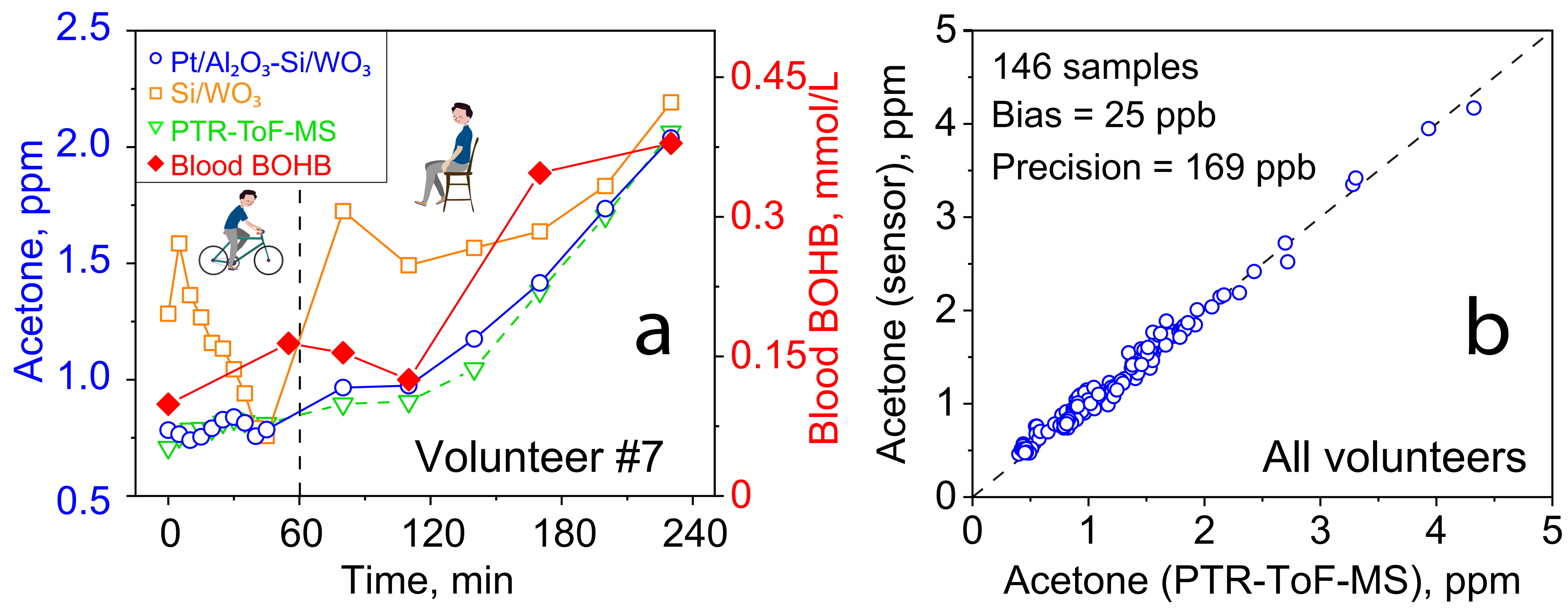


(a) Exercise protocol standardized to the second ventilatory threshold (VT_2): The ramped VT_2 exercise ($0 < t < 60$ min) is followed by a resting phase ($t > 60$ min). Breath acetone is quantified with comparable time resolution by PTR-ToF-MS (b) and the Pt/Al_2O_3-Si/WO_3 detector (c).

Conclusions

- Catalytic filter converts interferants (e.g., isoprene and ethanol) selectively over acetone.
- Fast response dynamics allow to resolve even short breath acetone.
- The detector quantifies breath acetone in excellent agreement with PTR-ToF-MS and in line with blood BOHB

Accurate Breath Acetone Detection



(a) End-tidal acetone increases during exercise and rest, indicating enhanced lipolysis, as detected by the Pt/Al_2O_3-Si/WO_3 detector (circles) and PTR-ToF-MS (triangles) and in line with blood β-hydroxybutyrate (BOHB, diamonds). Without filter, the Si/WO_3 sensor (squares) is interfered by isoprene and ethanol.
(b) Excellent agreement between the acetone detector and PTR-ToF-MS is achieved for all volunteers.

References

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