Reproducible Measurement of Acetone in Breath Using Selected Ion Flow Tube – Mass Spectrometry*

Selected Ion Flow Tube – Mass Spectrometry (SIFT-MS) is an exciting new analytical technique that can measure volatile organic compounds in breath on-line and in real time to the low parts per billion (ppb) level. Optimization of analytical conditions, determination of dynamic response, and comparison of different breathing maneuvers are important to gain meaningful repeatable data from breath.

Exhaled acetone has been examined as an indicator of blood glucose level and may have applications in monitoring of diabetes and ketogenic diets. This report presents the results of a study to determine the optimal conditions for measurement of exhaled acetone using SIFT-MS.

Methods

A new analytical technique, SIFT-MS, identifies and quantifies Volatile Organic Compounds (VOCs) directly from air in real-time. Based on sound principles of chemical ionization mass spectrometry and precisely controlled ion reaction kinetics, SIFT-MS uses a sequence of three reagent ions to resolve interfering species, differentiate isobaric compounds and produce intrinsically quantitative data without laborious calibration procedures. A Syft Technologies Voice100™ SIFT-MS instrument was used in this work.

1. Dynamic response time

The dynamic response time was measured using an acetone concentration of 425 ppb (similar to that found in normal human breath). A mixture of acetone and nitrogen from a Tedlar bag was sampled 46 times and the mean response time to reach 90% of the acetone concentration was calculated.

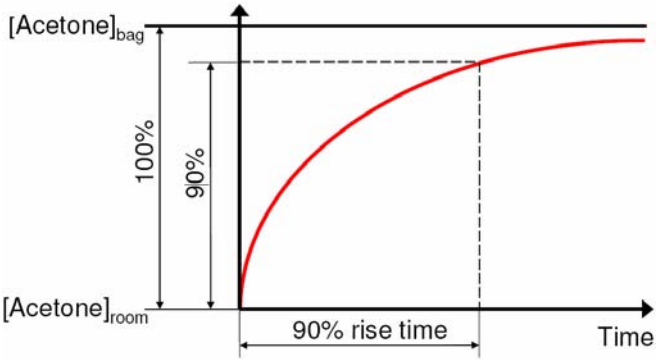

Figure 1. Illustration of the response to a step change in acetone concentration at the inlet of the SIFT-MS instrument. The measured concentration rises more slowly than the actual concentration presented to the instrument's inlet due to the dynamic response characteristics of the analyzer. The 90% response time should be ≤10% of the duration of an exhalation to accurately measure end-tidal concentration.

2. Reproducibility of breathing maneuvers

Using a purpose-built adaptor, the SIFT-MS sample inlet was attached to the side port of a spirometer upstream of its mass-flow sensor. Volunteers performed slow vital capacity maneuvers through the spirometer while breath was simultaneously sampled by SIFT-MS.

Six volunteers experienced in performing repeatable spirometry maneuvers were studied. Each performed six slow vital capacity exhalations into the apparatus – three via mouth and three via nose in random order. We endeavored to meet the usual spirometry repeatability standard of 150 mL between successive tests.

Results and Discussion

The mean dynamic response time for the instrument to reach 90% of the acetone concentration was 506 ± 32 ms (mean ±SEM) (n=36).

All subjects completed the protocol and 18 exhalations via mouth and 18 via nose were analyzed. The spirometry repeatability standard was met. An example of on-line acetone measurement is shown in Figure 2.

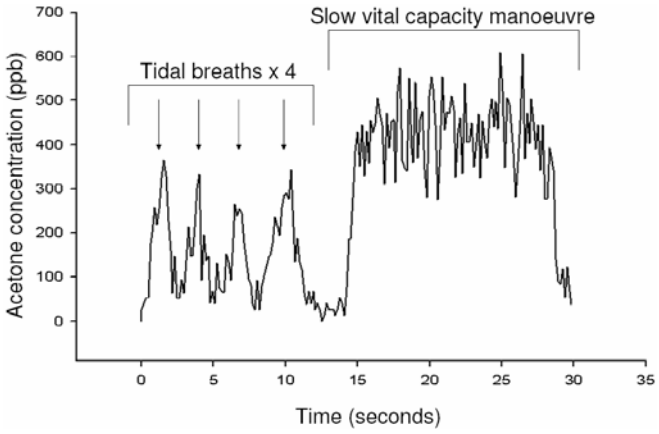

Figure 2. Example of detection of acetone during four tidal breaths then a slow vital capacity maneuver via the mouth.

Exhalations resulted in quantifiable plateau of acetone concentration in 33 of 36 exhalations. Mean acetone concentrations (ppb) for exhalations via mouth and nose are shown in Table 1. There was no significant difference in acetone concentration between exhalations via mouth and nose. Measurements of acetone concentration were reproducible with very low intra-subject coefficients of variation. The intra-subject coefficient of variation for exhalations via mouth was lower than for exhalations via nose.

Slow vital capacity	n	Acetone concentration* (mean ± SE) / ppb	Intra-subject coefficient of variation / %
Mouth	18	471 ± 56	1.8
Nose	18	479 ± 56	4.8
* mean difference 8.0; SE difference 5.2 (p = 0.17)			

Table 1. Mean acetone concentrations for mouth and nose exhalations.

Conclusion

Slow vital capacity breathing maneuvers (>6 s) were appropriate given the dynamic response of the instrument (0.5 s). Slow vital capacity maneuvers resulted in reproducible measurements of acetone concentration. The mean acetone concentration in exhalations via mouth was 471 ppb and there was no significant difference in acetone concentration between breaths via mouth and nose. With appropriate optimization, volatile organic compounds such as acetone can be measured reproducibly in real time in breath using SIFT-MS.

For more information about the unique SIFT-MS technology or this research, please contact your nearest Syft Technologies office or visit www.syft.com.

* *Adapted from a poster presented by J. Dummer, M. Swanney, S. Senthilmohan, K. Ledingham, J. Scotter, C. Frampton, R. Allardyce and M. Epton at the Breath Analysis Summit, Scientific meeting for the international association for breath research (IABR), Cleveland OH, USA, November 1-3, 2007.*

Ethics approval for this study was granted by the Upper South A regional ethics committee, Ministry of Health, New Zealand (URB/08/08/023).

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