Breath Acetone Concentration Measurement Using a Palm-Size Enzymatic Sensor System

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A palm-size enzymatic electrochemical breath acetone sensor has been developed to noninvasively monitor fat metabolism in healthy individuals. Acetone is a product of fat catabolism, and its concentration is indicative of the rate of fat metabolism in the body. Breath acetone concentration has been correlated to pound weight loss due to fat, and was found to be a useful indicator of dietary compliance. Acetone concentrations also increase as a result of exercise, due to the depletion of glycogen stores and increased use of fat stores to supply muscular energy.

An acetone-selective enzymatic system that couples secondary alcohol dehydrogenase (s-ADH) and a nicotinamide adenine dinucleotide (NADH) cofactor to hydrogen peroxide (H_2O_2) formation is utilized for the detection of vapor acetone. Acetone from an exhaled breath is passed over an enzyme-coated electrode sensor and initiates the enzymatic sequence. The H_2O_2 final product is detected using standard chronoamperometry, and the resultant electrochemical current is related to the initial breath acetone concentration. A palm-size handset connects to the disposable integrated mouthpiece/sensor, and performs the electrochemical measurements, data storage, and display. In an IRB-approved human study of dieting participants, breath acetone concentrations measured using the palm-size enzymatic device correlated linearly to those measured in the same breath sample using Gas Chromatography with mass spectroscopic detection (GC-MS) with $R^2 = 0.945$ (n=201). Breath acetone concentrations down to 0.2 ppm (v/v) and up to 17 ppm (v/v) were detected using this handheld device, and the electrochemical current response remained linear across the entire measured range.

The palm-size enzymatic device was used to separately examine the effects of post-exercise ketosis on breath acetone. Breath measurements were taken periodically from two volunteers for several hours after a 325 calorie exercise event. Results showed breath acetone increases from 0.75 to 4.2 and from 1.3 to 3.3 ppm (v/v), respectively, for the two participants. Breath acetone concentrations measured using the enzymatic device correlated linearly to GC-MS measurements with $R^2 > 0.94$ (n=17).

The utility of measuring breath acetone to monitor a combined diet and exercise program was demonstrated in a separate IRB-approved study of 12 participants using analysis of breath bag samples. A 500 calorie diet deficit increased average daily breath acetone concentrations from a baseline value of 0.5 ppm (v/v) to 1.1 ppm (v/v). An additional 200 calories of exercise further increased daily average breath acetone to 1.6 ppm (v/v). Dietary non-compliance was detected the day after diet and exercise ceased, when breath acetone returned close to its baseline concentration. The linear correlation of breath acetone to weight lost was $R^2 = 0.77$.

The measurement of breath acetone can provide important assistive and motivational information to an individual on a weight management or fitness regimen where knowledge of fat metabolism rate is a key metric. The portable enzymatic sensor measures breath acetone concentrations within the sensitivity levels and ranges typically observed individuals on moderate diet and exercise regimens.