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Selective Breath Acetone Detection for Metabolic Health Monitoring

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Summary:
Breath acetone is a promising non-invasive biomarker for monitoring lipolysis and ketosis. We developed a chemiresistive sensor combining WO_3 nanoparticles and Pt–Al_2O_3 catalytic filters for selective, low-ppb acetone detection. This device correlates strongly with clinical reference methods and allows real-time tracking of metabolic states in both humans and animals under fasting, exercise, or pathological conditions.

Keywords: breath analysis, chemiresistive gas sensor, acetone, metabolic monitoring, catalytic filter

Background, Motivation an Objective

Non-invasive breath analysis is increasingly recognized as a valuable tool for metabolic health monitoring. Among volatile organic compounds (VOCs) in exhaled breath, acetone is a robust biomarker for fat metabolism, offering diagnostic insights into states such as fasting, exercise-induced lipolysis, or diabetic ketosis [1–4]. Conventional detection methods like gas chromatography-mass spectrometry (GC-MS) are sensitive but unsuitable for point-of-care or field applications due to their complexity and cost.

In this work, we present a cost-effective gas sensor system using WO_3 nanoparticles for chemiresistive acetone detection, with selectivity enhanced with a Pt–Al_2O_3 catalytic filter. This configuration suppresses common breath interferents such as ethanol and isoprene, improving selectivity. The sensor's performance was validated under controlled metabolic interventions and against established blood ketone biomarkers, highlighting its clinical and veterinary relevance.

Description of the New Method or System

The sensing layer consists of flame spray–synthesized WO_3 nanoparticles deposited on a microheater platform. To mitigate interference from non-ketonic VOCs, a porous Pt–Al_2O_3 catalytic layer is placed upstream, oxidizing competing compounds at low temperatures (<150 °C) while preserving acetone. The sensor operates at ~300 °C and detects acetone in the low ppb–ppm range with minimal cross-sensitivity.

This configuration allows operation in ambient air without pre-conditioning, making it suitable for mobile breath diagnostic devices. The system's temporal resolution enables dynamic profiling of metabolic shifts.

Results

The sensor exhibited excellent linearity and sensitivity to acetone with negligible response to ethanol and isoprene. In animal studies, breath acetone levels increased significantly with different status of the animals, in line with known lipolytic dynamics [2,3]. These signals showed strong correlation ($R^2 > 0.9$) with blood β-hydroxybutyrate concentrations measured concurrently.

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