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POLYMER-MODIFIED QUARTZ TUNING FORKS FOR BREATH-BIOMARKER SENSING

INTRODUCTION

Human beings exhale numerous volatile organic compounds (VOCs) whose levels range in parts-per-million (ppm) or parts-per-billion (ppb). The air that is inhaled goes into the alveoli in the lungs where the metabolic excretable products diffuse into the inhaled air and then it is rejected in the form of exhaled air. Therefore, exhaled breath carries the fingerprint of the endogenous metabolic processes. Alterations in the levels of these exhaled compounds may serve as indicators or biomarkers of diseases[1]. The VOCs detected here are acetaldehyde, a biomarker of acute respiratory distress syndrome, lung cancer, and chronic pulmonary disorder and acetone, a biomarker of diabetes, lung cancer, and heart failure.

Low concentration gas detection is usually carried out by expensive techniques like chromatography-mass -spectrometry (GC-MS), proton transfer reaction mass spectrometry (PTR-MS),and differential mobility spectrometer (DMS) at high temperatures[2]. So, here, we propose polymer-nanostructure modified Quartz Tuning Fork based sensors as an economical, room-temperature operational gas sensing alternative.

MATERIALS FOR QTF MODIFICATION

5-weight percent polystyrene-blended nanostructures were used to modify QTFs in this work. TiO_2 nanoparticles were synthesized using a sol-gel method[5]. WO_3 nanorods were synthesized using a hydrothermal process[6].

CHARACTERIZATION

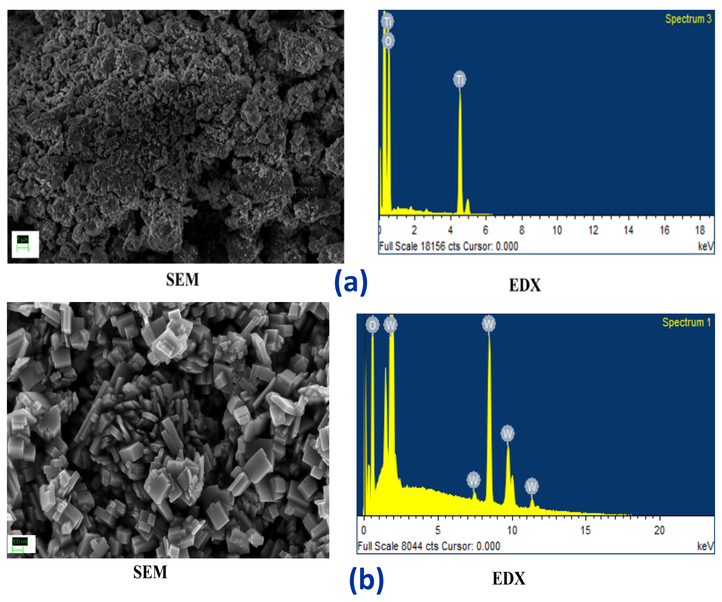


Figure 2. Morphology and elemental composition of (a) TiO_2 nanoparticles and (b) WO_3 nanorods

QUARTZ TUNING FORKS[3,4]

- Single crystal quartz mechanical oscillators
- Resonant frequency, f, 32768 Hz
- A change in f upon interaction with gases is the sensor response.

About

Sensing Principle

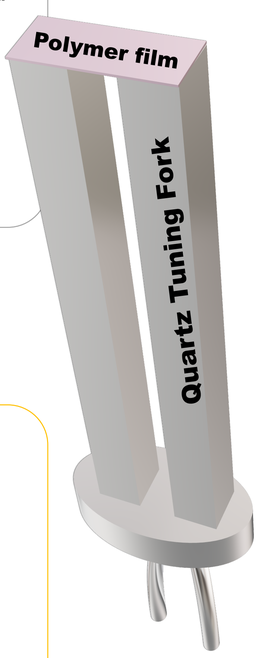
- A bare QTF resonates at $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$
- A spring-loaded polymer modified QTF resonates at a higher frequency, $f = \frac{1}{2\pi}\sqrt{\frac{k+\Delta k}{m+\Delta m}}$

Properties

- High stability
- Larger Q factor
- Low power consumption
- High thermal stability

Advantages

- Costs $0.05/piece
- Operates at room temperature
- Modifiable (improved sensitivity and selectivity)



RESULTS

Breath samples collected with ethical consent were spiked with known amounts of acetaldehyde and acetone.

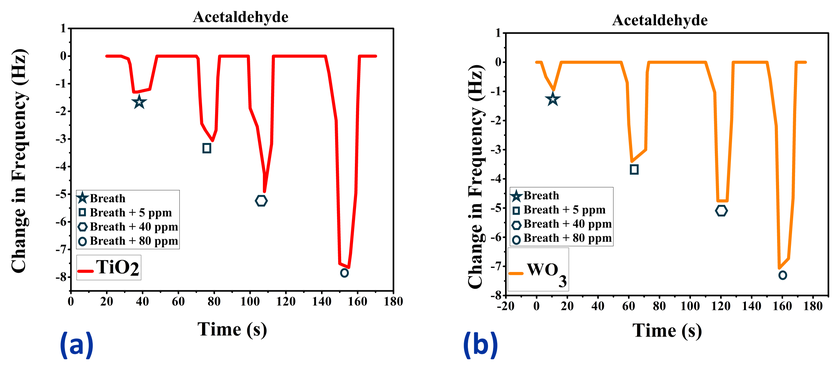


Figure 3. Sensor response of pure and acetaldehyde-spiked breath for (a) TiO_2 -PS and (b) WO_3-PS modified QTFs

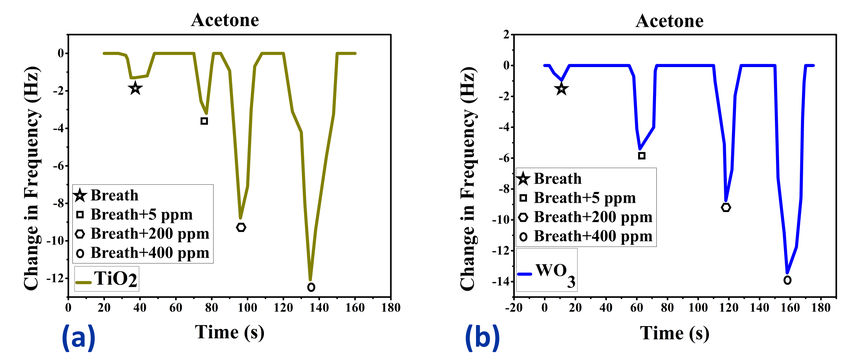


Figure 3. Sensor response of pure and acetone-spiked breath for (a) TiO_2 -PS and (b) WO_3-PS modified QTFs

CONCLUSION

Sensor response shows that both sensors give comparable response to 5 ppm acetaldehyde spiked breath while WO_3-PS gives a higher frequency change to 5 ppm acetone. The created sensors can differentiate between varied ppm level concentrations of VOCs and has an isolated response to pure breath, thereby are suitable candidates for gas sensing.

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