Detection of Breath Biomarkers for Alzheimer's and Parkinson's disease using Quartz Tuning Forks Based Gas Sensors

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Objectives

Detection of two reported volatile organic compound (VOC) breath biomarkers of AD and PD, namely styrene (STY) and propyl benzene (PBZ), using a quartz tuning fork (QTF) based sensors.

- Varying concentrations of analytes ranging from 5-400 ppm were detected.
- Selectivity studies were conducted by using acetone as a control.
- Data collected from sensor was classified using machine learning techniques.

Introduction

By definition, Breathomics is the metabolomic study of exhaled air. The subject can be implemented for early detection of diseases, precision medicine, and analysis of real-time body activity. Breathomics is the integration of an improved collection of breath, fast data analysis, and more reliable classification algorithms [1]. Among these, the development of sensor systems for the targeted detections of VOCs is indispensable for the implementation of the platform. The sensor system must be highly accurate, sensitive, and should not consist of a material which is harmful to humans.

In this work, we present a novel QTF based sensor for the detection of STY and PBZ as these VOCs act as a biomarker of both AD and PD patients [2]. For improving the selectivity, the acquired data were classifed using machine learning algorithms, namely k Nearest Neighbour (kNN).

Methodology

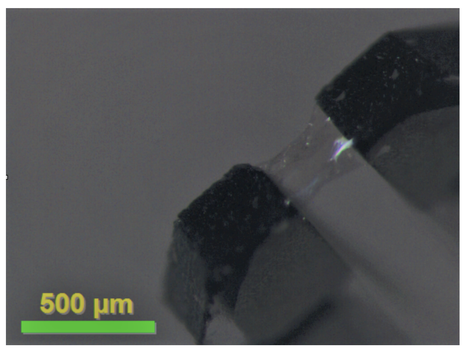

Figure 1:Polymer (Polystyrene) film placed on the times of the QTF

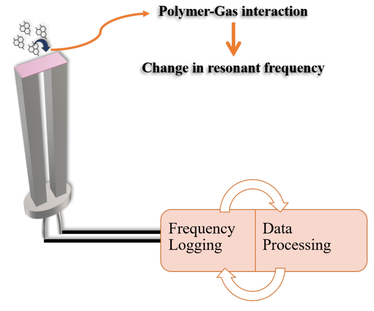

Figure 2:Sensing Methodology

Mathematical Section

The resonant frequency of the QTF can be given by equation 1.

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \tag{1}$$

After interaction of the polymer film with the analyte the change in frequency can be quantified by equation 2.

$$E = \frac{2Lk_{fork}}{A} \triangle f_0 \tag{2}$$

Results

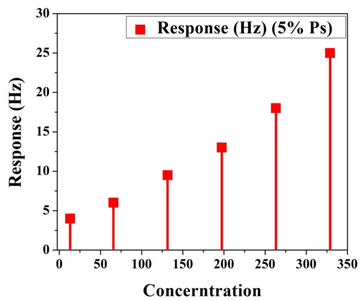

Figure 3:Sensor response for varying concentrations of STY

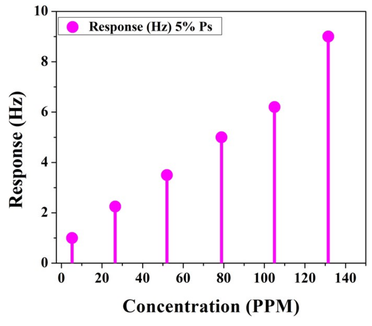

Figure 4:Sensor response for varying concentrations of PBZ

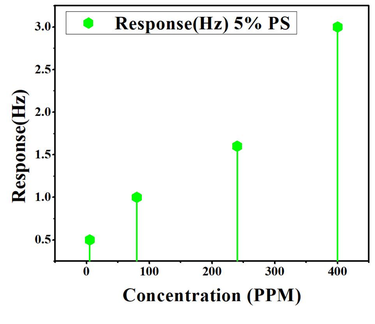

Figure 5:Sensor response for varying concentrations of ACT

Classification using KNN

Table 1:Confusion Matrix for kNN

Predicted ⇓/Actual ⇒	ACT	PBZ	STY	Σ
ACT	90	0	0	90
PBZ	0	185	15	200
STY	2	26	271	299
Σ	92	211	286	589

Conclusion

- Sensor showed good response for both the analyte.
- Low concentrations of STY and PBZ were detected using the sensor.
- Sensor response was classified using KNN with >90% accuracy.

References

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Taking your breath away: metabolomics breathes life in to personalized medicine.
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[2] Ulrike Tisch, Ilana Schlesinger, Radu Ionescu, Maria Nassar, Noa Axelrod, Dorina Robertman, Yael Tessler, Faris Azar, Abraham Marmur, Judith Aharon-Peretz, et al.
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Acknowledgements

SP would like to acknowledge CSIR for the SRF:direct fellowship. BR would like to acknowledge ICMR:SRF for the fellowship. SP, BR, and SD acknowledge the Vice Chancellor of DIAT for his support and encouragement.