UV photoacoustic sensor for breath analysis: Pilot study of Asthma and COPD

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Introduction

- Research and development have been progressing for the past several years to diagnose diseases by breath analysis.
- The techniques like CT scan, MRI, PET, etc. are very expensive and beyond the reach of a majority of population, since they will be available only in multi-specialty hospitals in big cities.
- A solution to this problem is the development of cost-effective, highly non-invasive breath analysis setup for the detection of cancers markers (Volatile Organic Compounds (VOCs)) ,which can be used not only in big multi-specialty hospitals, but which can also be conveniently used by trained technicians in small hospitals or clinics, community health care centres, and medical camps organized by major hospitals and charitable organizations.
- Photoacoustic spectroscopy is one of the widely accepted methods for the detection and identification of molecules in gaseous phase due to its high sensitivity and ease of operation.
- When a non-stationary light is allowed to pass through the sample, expansion and contraction of heat leads to the generation of acoustic wave, which is known as the photoacoustic effect.

Methods

- Photoacoustic sensor was designed, printed and assembled for the detection of VOCs.
- Microphone followed by lock in amplifier (MFLI 500 kHz from Zurich instruments is used as the detector of PA sensor. The sample insertion module is locally assembled.
- PA signal recorded in frequency domain using LABONE (Version 20.1) software.
- Quadruple pulsed Nd-YAG laser (266 nm) is used as the non-stationary light source in PA setup as shown in figure 1.
- Breath samples from asthma, COPD and normal subjects has been collected from Department of Respiratory Medicine , Kasturba Medical college, Manipal.

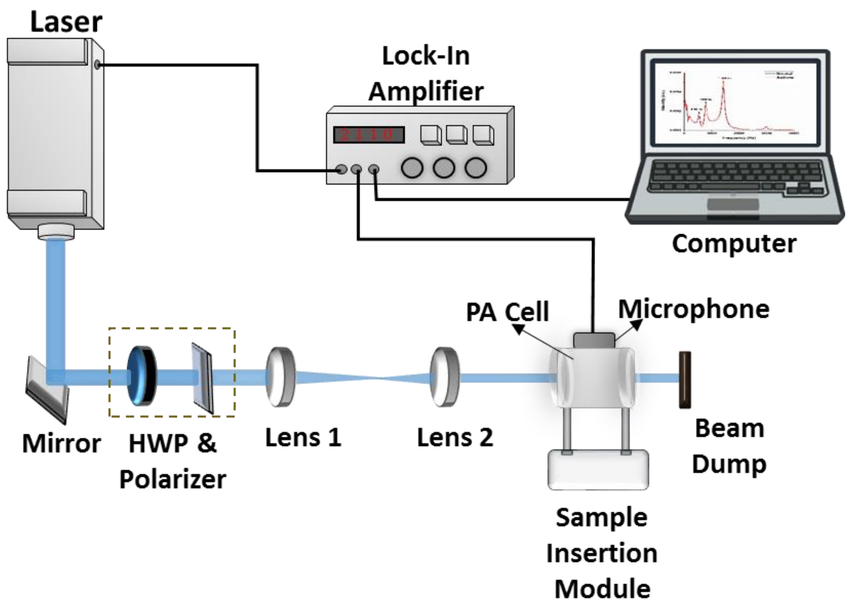

Figure 1: Schematic diagram of PA gas sensor experimental setup.

Results

- PA signal of 24 asthma, 25 normal and 20 COPD patients has been recorded using PAS setup.
- All samples were recorded in a lab temperature of 20^0C and humidity of 56%.
- Averaged PA signal of asthma, normal, and COPD breath samples and the descriptive statistics are shown in figure 2.
- Principal component analysis has been carried out to find out the classification between asthma and normal and COPD samples. Score plot representing PC1 vs PC2 is shown in Figure 3.
- A Match/No Match analysis using Mahalanobis distance and sum of squared Differences of simulated and actual signals (Spectral Residual) using a calibration set of normal samples have given sensitivity of 88% and specificity of 89%.
- Mahalanobis distance vs spectral residual obtained from Match/No Match study with normal calibration set is shown in figure 4.

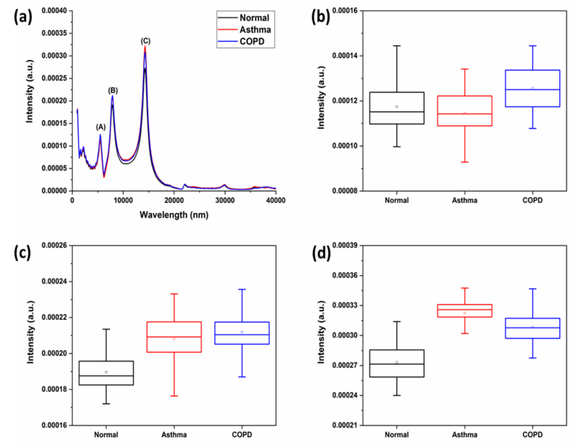

Figure 2: Photoacoustic signal (averaged) of asthma and normal samples in frequency domain.

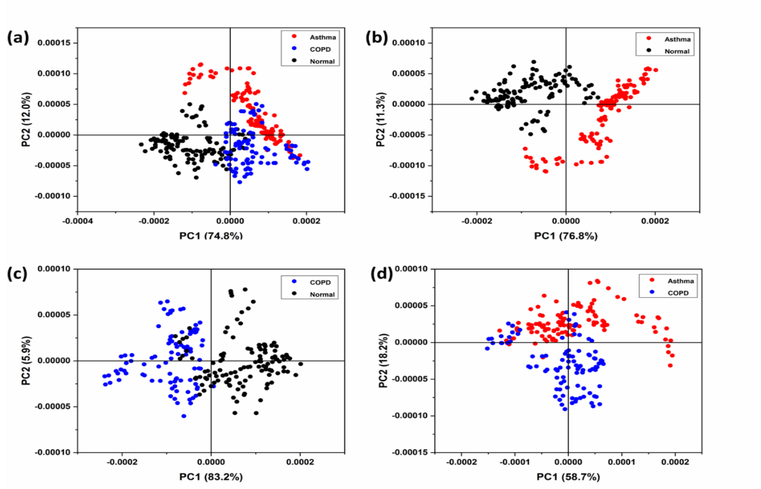

Figure 3: Score plot obtained from the principal component analysis.

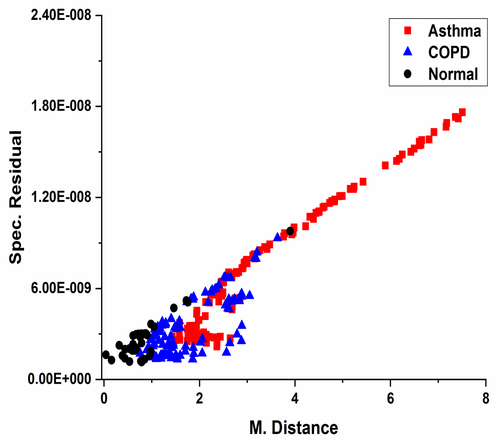

Figure 4: M distance vs. spectral residual plot Match/No match results for Normal calibration set.

Conclusions

- A photoacoustic breath analysis experiment has been carried out with asthma, normal and COPD samples.
- Multivariate analysis such as PCA and Match/No Match study has been performed. The sensor has got a sensitivity of 88% and specificity of 89%.
- UV Photoacoustic spectroscopy followed by multivariate analysis can be used for the diagnosis of asthma and COPD.

Reference

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