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## “Breath Is a New Blood”

### 1. Background

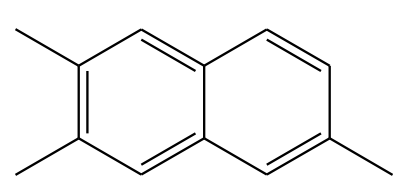
Tuberculosis (TB) is believed to be the main cause of deaths in developing nations. Apart from biomarkers of TB present in urine, blood, skin and sputum, it is found that certain VOC's are present in exhaled breath of the TB patients. An Individual infected with Mycobacterium tuberculosis which causes TB is found to exhaled certain specific VOC's. So detection of these VOC's in the exhaled breath would automatically signal the presence of TB bacteria and hence the person would be diagnosed with TB. This detection needs interaction of these specific VOC's with the chromospheres containing the active sites which would non covalently bind with the each other thus changing the photo physical property of the chromosphere and hence changing the color (colorimetrically). So here we present the colorimetric sensor array made up of such metalloporphyrin along with other commercially available dyes, which combines the earlier analytical techniques of detecting TB in combination with digital imaging and computer applications. The sensor uses the chemo responsive center which is coupled with an intense chromosphere (porphyrins) to detect TB colorimetrically.

### 2. Study Objective:

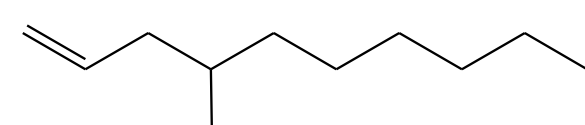
- To develop the colorimetric sensor which will enable TB to be detected non-invasive manner.
- It will be portable and will minimize the cost and time for whole procedure.
- The accuracy of the test for the detection of TB will be better than the reported ones.
- The target patients will be from underdeveloped and developing nations where such fast, accurate and low cost methods are required to detect active TB

### 3. Methodology

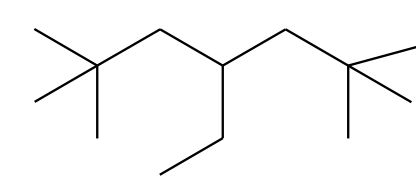
Various volatile organic compounds as the biomarkers of Mycobacterium tuberculosis, selected through the analysis of cultures, and other trials are as follows :-



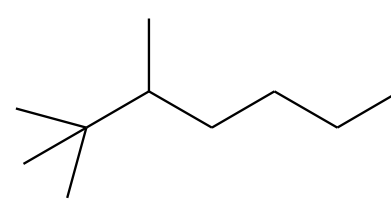
2,2,6-trimethylnaphthalene



2,2,3-trimethylheptane



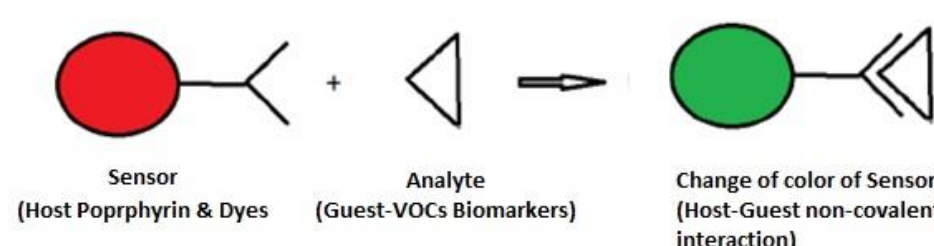
4-ethyl-2,2,6,6-tetramethylheptane



2,2,3-trimethylheptane

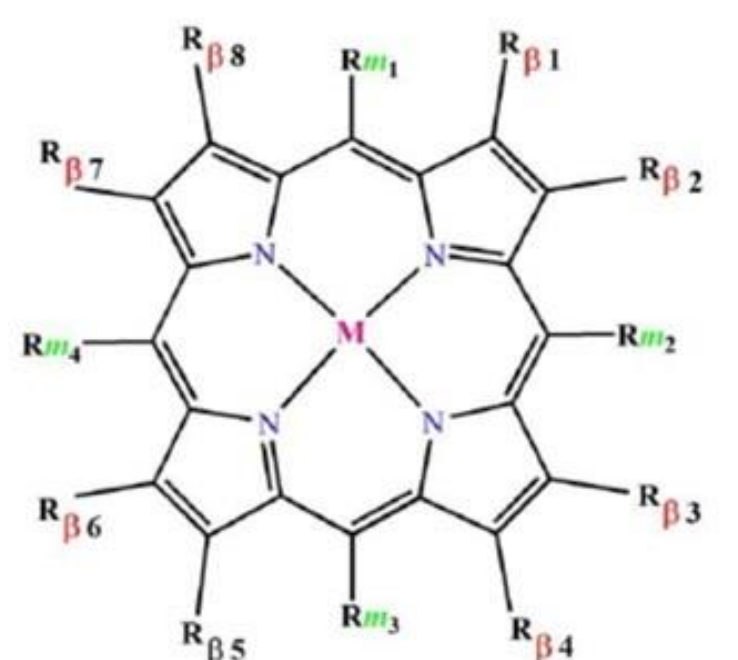
### 4. Molecular Recognition

Most of the chemical sensor works in the principal of Molecular recognition. It involves a particular type of interaction between two or more molecules, in which the analyte changes the photo physical characteristics of the host molecules i.e., Sensor component. Most of the times the interactions are highly specific.



### 5. Metallo- Porphyrins as a template for sensor:-

Porphyrins are a robust class of molecules that plays a very vital roles in biology. Hemoglobin, Chlorophyll, Cytochromes, Vitamin B<sub>12</sub> etc.. are the few example showing the presence of porphyrin core in nature.



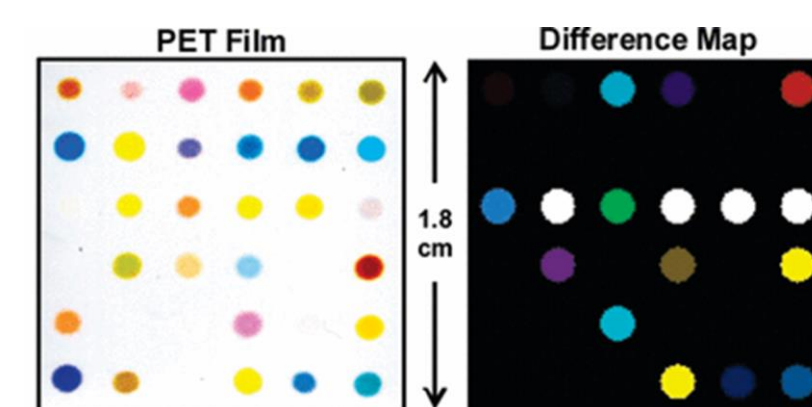
M = H<sub>2</sub> / Metal ion  
Rm(1-4) / Rβ(1-8) = organic ligands or functional group

### 6. Colorimetric Sensor Device



Fig.1. A TB patient Volunteering For the device testing at STNM Hospital, Gangtok, Sikkim, India.

### 7. Colorimetric Sensor Array



- In the experiment conducted by the authors they used porphyrin based sensor plates comprising of 25 indigenously synthesized coded porphyrin elements
- A single breath test was done on 94 participants, 64 pulmonary tuberculosis patients (case) and 30 healthy volunteers (control).
- In overall impression from combined data, to differentiate pulmonary tuberculosis (P-TB) cases from healthy controls by authors sensor array, they could reach up to sensitivity of 85.42 percent, specificity up to 78.89 percent and positive predictive value up to 86.23 percent.

### 8. Use of Machine Learning in Data Analysis

Results for Stochastic Gradient Descent

Sl.No	Actual	Predicted
1	1	0.9
2	1	0.8
3	0	0.6
4	0	0.2
5	1	1.0
6	1	1.0
7	1	1.0
8	1	1.0
9	0	0.1
10	0	0.3
11	0	0.1
12	1	1.0
13	1	1.0
14	1	1.0

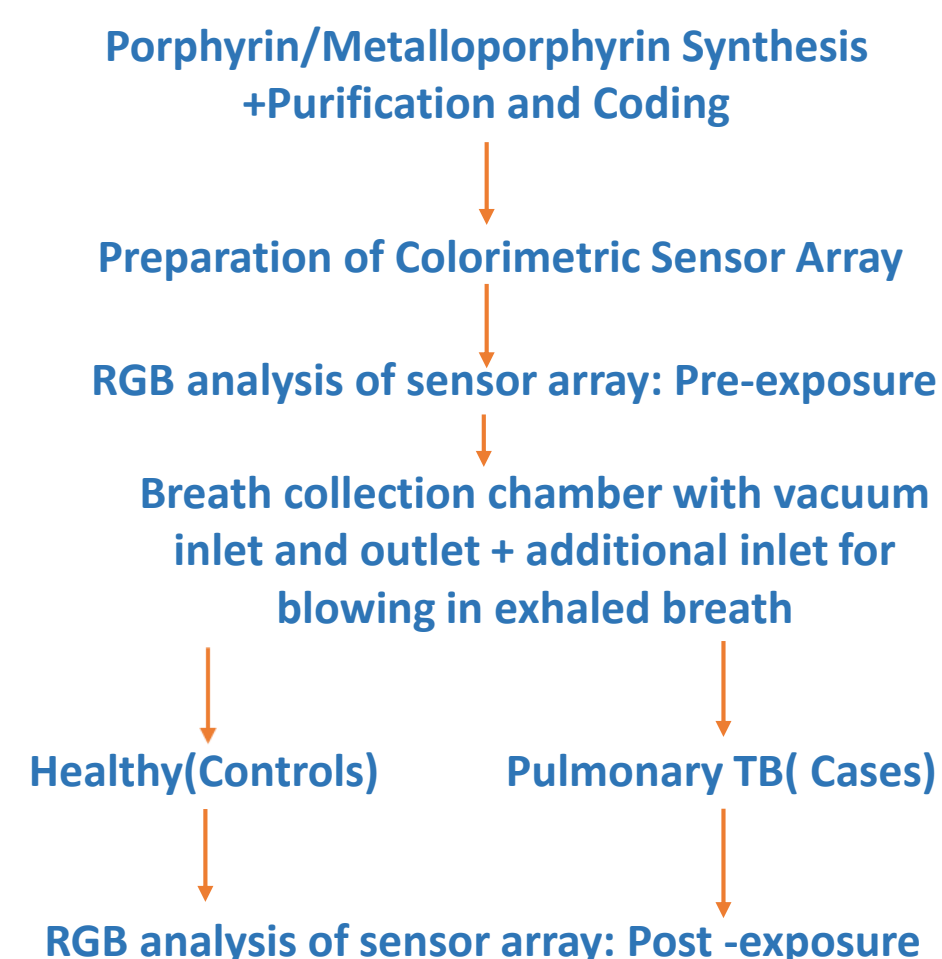
Accuracy=92.857 %,  
Sensitivity=100%,  
Specificity= 80%

Results for Probabilistic Neural Network

Sl. No	Actual Values	Predicted Values
1	1	1
2	1	1
3	0	0
4	0	1
5	1	1
6	1	1
7	1	1
8	1	0
9	0	0
10	0	0
11	0	0
12	1	1
13	1	1
14	1	1

Accuracy=85.71 %,  
Sensitivity=88.88%,  
Specificity= 80%

### Flowchart



### References:

1. 'Diagnosis of pulmonary diseases by the analysis of exhaled breath with a colorimetric sensor array'. Ph.D. Thesis by Prof. Ranabir Pal, Sikkim Manipal University, 2013.
2. 'A colorimetric sensor array for odour visualization' N. A. Rakow & K. S. Suslick, Nature, Vol- 406 , 2000
3. "Colorimetric Sensor Arrays for Volatile Organic Compounds" M. C. Janzen, J. B. Ponder, D. I. P. Bailey, C. K. Ingison, and K. S. Suslick\*, Anal. Chem. 2006, 78, 3591-3600
4. "The Optoelectronic Nose: Colorimetric and Fluorometric Sensor Arrays" Z. Li, J. R. Askim, K. S. Suslick\*, Chemical Review, 2018,

### 9. Possible extensions of the study:

This pattern recognition analysis will help us reach a new screening test that is highly selective as well as simple, rapid, inexpensive and non-invasive viable method of diagnosis for tuberculosis. The study could be specifically desing to detect other COPD, Cancers, Covid etc..