Fabrication of Porphyrin Based Colorimetric Sensor for the Detection of Liver Cirrhosis Biomarker

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1. Abstract

The early detection of liver cirrhosis biomarkers is crucial for timely medical intervention and improved patient outcomes. In this study, we present the fabrication of a novel colorimetric sensor based on porphyrin derivatives for the specific and sensitive detection of a prominent liver cirrhosis biomarker. The sensor design capitalizes on the unique optical properties of porphyrins, allowing for a rapid and visually detectable response upon biomarker binding. The synthesis and characterization of the porphyrin receptor are detailed, highlighting its structural and spectroscopic properties. The sensor's performance was evaluated using RGB analysis demonstrating exceptional selectivity and sensitivity towards the target biomarker. Importantly, the sensor's response mechanism is elucidated, shedding light on the underlying molecular interactions. The proposed porphyrin- based colorimetric sensor offers a promising avenue for the early diagnosis of liver cirrhosis, paving the way for point-of-care applications and enhancing disease management.

2. Rationale

Due to Invasive, Costly, Time consuming nature of diagnosis of Liver Cirrhosis, the alternative methods which would be easy and cost effective and could be performed in a self-testing manner is the need of the hour. Like the testing should as easy as the pregnancy test kits.

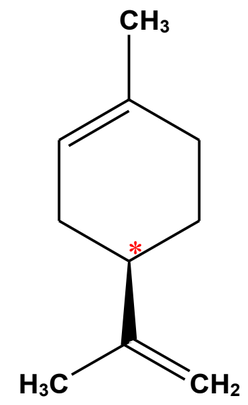
As per study by T Sukaram et. al. people with liver cirrhosis/cancer are not able to digest limonene properly hence their breath contains appreciable amount of D-limonene which is present as most of the food additives and citrus fruits. So presence of D-limonene in the liver cancer patients can be taken as a gold standard of early liver cirrhosis or cancer.

So a colorimetric sensor array doing the diagnosis in non-invasive , fast and less costly manner would bring paradigm shift in the field.

3. Study Objective:

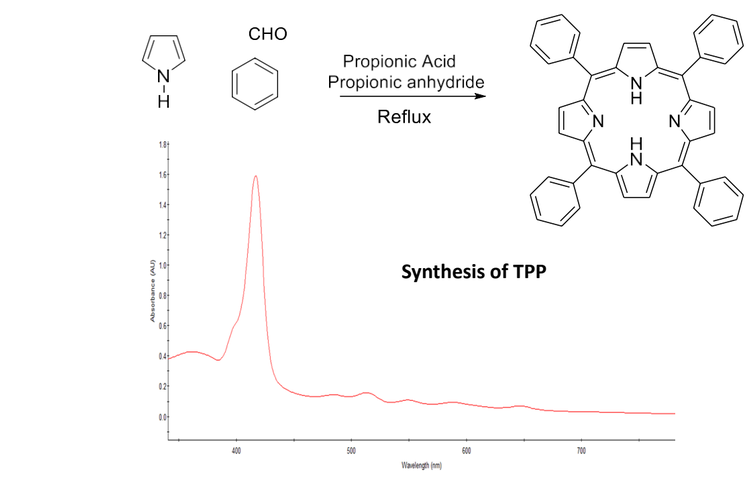
- Identify suitable porphyrin compounds with the potential to interact with the targeted liver cirrhosis biomarker. Modify the porphyrin structures to optimize their sensitivity and selectivity for the biomarker of interest
- Synthesize the modified porphyrin compounds and thoroughly characterize their chemical structures using spectroscopic and analytical techniques. Confirm the successful modification and structural integrity of the porphyrins.
- Investigate the interactions between the modified porphyrins and the specific liver cirrhosis biomarker. Assess the RGB change porphyrin-biomarker complex formation.
- Optimize the conditions that induce colorimetric changes in the porphyrin upon binding with the biomarker. The optimization of the device to achieve the most noticeable and reproducible color changes and data would be analyzed.

4. The Liver- Cirrhosis Biomarker

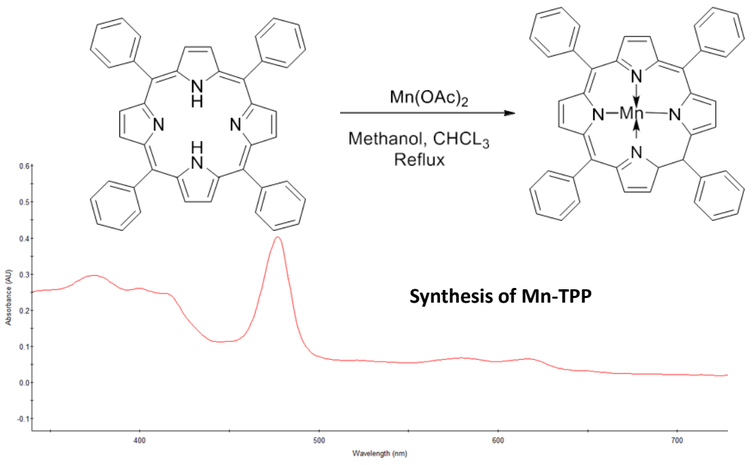


D-Limonene

5. Synthesis and Characterisation of Porphyrins and its Metal Derivative(Sensor Elements):-

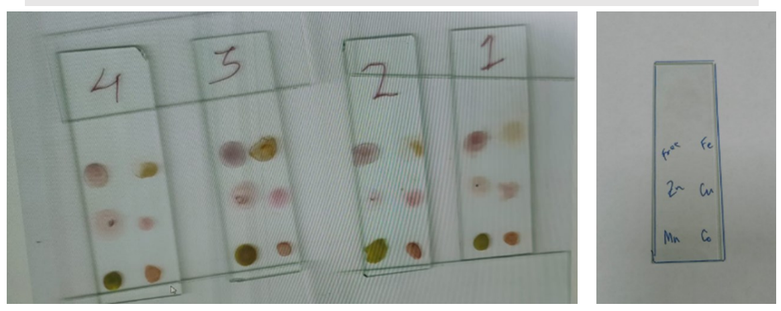


Synthesis of TPP



Synthesis of Mn-TPP

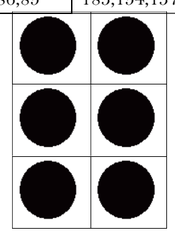
6. Fabricated Sensor Element



7. Color Difference Map of Colorimetric Sensor Array

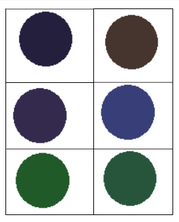
Source: Water **Slide No:** 5

Before Exposure		After Exposure		Difference	
197,182,197	212,205,201	190,180,193	206,199,192	7,2,4	6,6,9
208,202,218	218,194,214	201,195,211	217,196,213	7,7,7	1,2,1
166,151,82	199,172,153	190,186,85	183,154,137	24,-35,-3	16,18,16



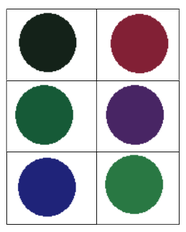
Source: Lemon **Slide No:** 4

Before Exposure		After Exposure		Difference	
210,195,250	242,123,194	174,164,189	172,176,148	36,31,61	70,53,46
258,154,286	269,191,263	206,196,209	213,253,143	52,42,77	56,62,120
173,58,52	199,194,189	205,148,92	160,109,129	32,90,41	39,85,60



Source: Sweet Lime **Slide No:** 2

Before Exposure		After Exposure		Difference	
172,146,163	165,163,151	192,180,188	295,195,204	20,34,25	130,32,53
185,145,160	132,189,208	207,235,215	204,152,108	22,90,55	72,37,100
175,160,167	145,136,127	144,125,46	186,180,194	31,256,121	41,120,67



8. Data Analysis

It was found that there is considerable RGB difference between before and After exposure to Limonene from Sweet Lime and Lemon.

Free base TPP, Cu-TPP and Mn-TPP has shown less RGB difference than Fe-TPP, Zn-TPP and Co-TPP. Among them Fe –TPP and Co-TPP has shown considerable color change on exposure. This is probably due to the presence of reactive vacant sites in these metal TPPs due to which they are interacting with the Biomarker and hence changing the color considerably. Similar is the case for activity of Hemoglobin and Vitamin B12 which contains Fe and Co at their porphyrin cores and hence coordinates with incoming species effectively showing the properties.

The other important result form the study is that when the senor was exposed to water vapor , there is no change in color of the sensor which means the device can differentiate between the Health and Cirrhosis Patients. Also even patients exhales water along with the Biomarker and hence water might not interfere in the Diagnosis of patients.

9. Future Aspects:

The work can now be extended to field survey, where cirrhosis patient may be asked to breath in the chamber contain the sensor element. If the color change is nakedly visible by eye its well and good , otherwise an app can be developed which can process the images and can give the results in seconds.

In either of the case, the study has high probability of success which can result us in fast, cost effective, non-invasive diagnosis device for early detection and monitoring of liver cirrhosis with high sensitivity and specificity. The product is highly feasible to be commercialized. The student and guide explores for funding possibility of the research with State, National , Private and International funding agencies.

References:

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