Smart Probe for Uric Acid Detection

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ABSTRACT

Currently diseases regarding uric acid are diagnosed by invasive method by taking blood from human body. In this paper we are going discuss about non-invasive method for detection of uric acid using optical source and detector. Source and detector and detector are selected in such way that wavelength of that is sensitive to uric acid transmission spectra. Detection was carried out for human blood serum and system is validated. System can differentiate different samples and results in the form of High, Normal and Low are produced on LCD screen. Based on the Beer-Lambert's law, a linear relationship between the light absorbance and uric acid concentration is expected. This method also used to detect different biomarker by changing wavelength of source and detector.

Keyword: - *Non-invasive, Uric acid, Biomarkers, Infrared, Optical Sensor*

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1. INTRODUCTION

For Diagnosis of diseases affecting by uric acid present in blood like kidney diseases, gout etc. it is necessary to find out uric acid in blood. Now a days for that detection uricase method is used which invasive method. To overcome invasive method by non-invasive method we are implementing optical method for uric detection. Since there is a direct correlation between blood uric acid level and risk for complications, it would be ideal for patients to have an easy method to measure their uric acid level frequently and comfortably to prevent recurrence of complications due to hyperuricemia. Therefore, it is important to evaluate current diagnostic methods and understand the advantages and disadvantages associated with each method. As a potential solution to aforementioned limitations, the purpose of this project was to design and explore a near-infrared spectroscopy based sensor to measure the uric acid levels in the solution that would potentially mimic the composition of the human blood. There are three goals to this project: first, to build a cost-effective IR-based sensor which would respond differently depending on the concentration of the sample of interest; second, to identify if the prototype device can measure uric acid concentration in a linear fashion; and third, to have the device properly distinguish and measure uric acid levels amongst other constituents, which would be albumin protein for this project. Verification of aforementioned goals can be used to check the feasibility of the prototype as a potential portable, noninvasive and cost-effective device to measure uric acid levels in the blood.

Successful implementation and verification of the prototype carries major significance in that the portable, non-invasive, and cost-effective nature of this project will potentially be a major benefit to patients who are either at risk for, or suffer from, complications associated with hyperuricemia. The sensor will be small in size so it will allow patients to carry it to monitor their uric acid levels as needed. With an ability to monitor uric acid levels, patients can take appropriate adjustments (e.g., through diet) early on to prevent severe gout attacks. A significant cost reduction is expected as well because infrared-based sensors can be built very cost effectively and, like any other types of electronics, it can be used continuously without any additional cost.

In the human body uric acid is the end-product of purine metabolism. It is excreted by the kidney. Increases of uric acid in the serum plasma or urine can be due to the overproduction of purine containing molecules or to insufficient excretion. The concentration is increased in various renal diseases, with increased cell lysis in the presence of tumors, leukemia, toxemia of pregnancy. Prolonged elevation of the concentration leads to gout.

$$\text{Uric Acid} + H_2O \xrightarrow{\text{Uricase}} \text{Allantoin} + H_2O_2$$

$$H_2O_2 + 4\text{AAP} + \text{DHBS} \xrightarrow{\text{Peroxidase}} \text{Red Quinoneimine} + H_2O$$

Uricase converts uric acid to allantoin and hydrogen peroxide. The hydrogen peroxide formed further reacts with a phenolic compound and 4 aminoantipyrine by the catalytic action of peroxidase to form a red coloured quinoneimine dye complex. Intensity of the colour formed is directly proportional to the amount of uric acid present in the sample.

2. LITERATURE SURVEY

Fabrication of an optical chemical sensor based on immobilised tris (1,10-phenantroline)-iron(III) complex (ferriin) onto modified polyvinyl alcohol (PVA) membrane for the determination of uric acid (UA) is described. The immobilised ferriin will be reduced to tris (1,10-phenantroline)-iron(II) complex (ferroin) in the presence of UA, which in turn causes change in colour from colourless to the red. The colour change could be related to the concentration of UA in the samples. The PVA as a solid support matrix has been modified using hydrogen sulphate in order make the membrane harder, elastics and resistant toward water. Therefore the membrane can be easily handled as a strip and work properly in aqueous samples particularly clinical samples (e.g. urine and serum). The ferriin membrane has been employed as a disposable strip that can be placed inside cuvette test for a simple spectrophotometric measurement at wavelength 510 nm. For clinical applications, calibration curves were obtained for UA over the concentration range at 0-0.6 mg/ml in slightly acid condition (pH 6) with a detection limit (3/spl sigma/) of 1.55 mg/ml. The interference from reductant molecules, which often are present in clinical samples (e.g. ascorbic acid, urea etc), are investigated. The practical utility of the present ferriin membrane is demonstrated by measuring UA in human urine samples. The results obtained by the ferriin membrane are compared with those obtained by a standard method.

A novel strategy for highly sensitive electrochemical detection of uric acid (UA) was proposed based on graphene quantum dots (GQDs), GQDs were introduced as a suitable substrate for enzyme immobilisation. Uric oxidase (UOx) was immobilised on GQDs modified glassy carbon electrode (GCE). Transmission electron microscope, scanning electron microscopy, cyclic voltammetry and electrochemical impedance spectroscopy techniques were used for characterising the electrochemical biosensor. The developed biosensor responds efficiently to UA presence over the concentration linear range 1-800 μM with the detection limit 0.3 μM. This novel biosensing platform based on UOx/GQDs electrode responded even more sensitively than that based on GCE modified by UOx alone.

3. WORKING PRINCIPLE

By using uric acid infrared spectroscopy characteristics, infrared wavelengths between 1400 to 1700nm are emitted on uric acid samples and detector senses non-absorbed Infrared light. The detected NIR signal gets amplified and filtered to maintain a high signal to noise ratio (SNR) over the wavelengths of interest. Finally, a digital signal processing was used to process the data Based on the Beer-Lambert's law, a linear relationship between the light absorbance and uric acid concentration is expected.

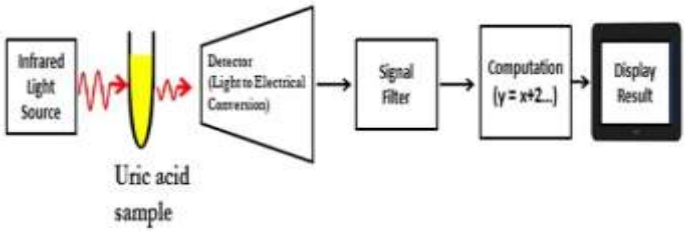

Fig. 1Working Principle of optical probe

4. SYSTEM DESIGN

In this module detector is placed opposite to source of IR which is shown in fig 2 and assembly of source and cuvette is placed between detector and source as we take readings on human serum to hold the test tube cuvette is introduce. 5V supply is given to source as well as 5V supply is given to detector. Output of detector is voltage as concentration of uric changes output voltage of detector is change. Change in voltage of detector is given to controller and controller is programmed to show uric acid concentration of human serum in terms of High, Normal or Low which is shown on LCD screen.

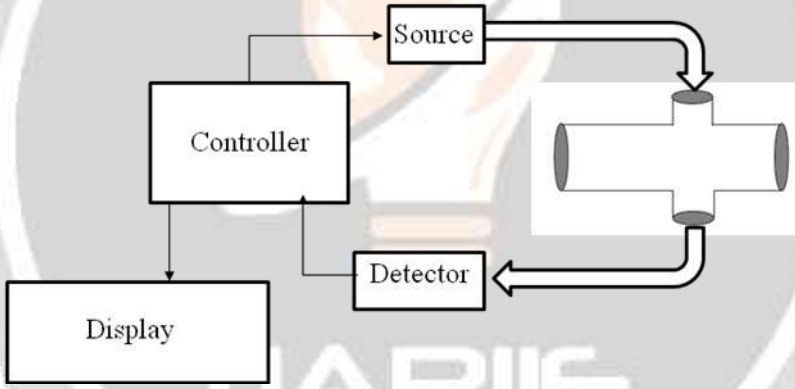

Fig.2 Probe module

5. Experimentation

The uric acid transmission spectra is recorded using IR spectrophotometer. The transmission spectrum is shown in figure 3 which indicates a peak at wavelength around 1650nm. In order to detect uric acid concentration, optical detector which is sensitive in the range 800 nm to 1750 nm is choosen.

Before applying the optical system for uric acid concentration in human serum, the system is first validated using distill water and standard uric acid sample with concentration of 6mg/dl.

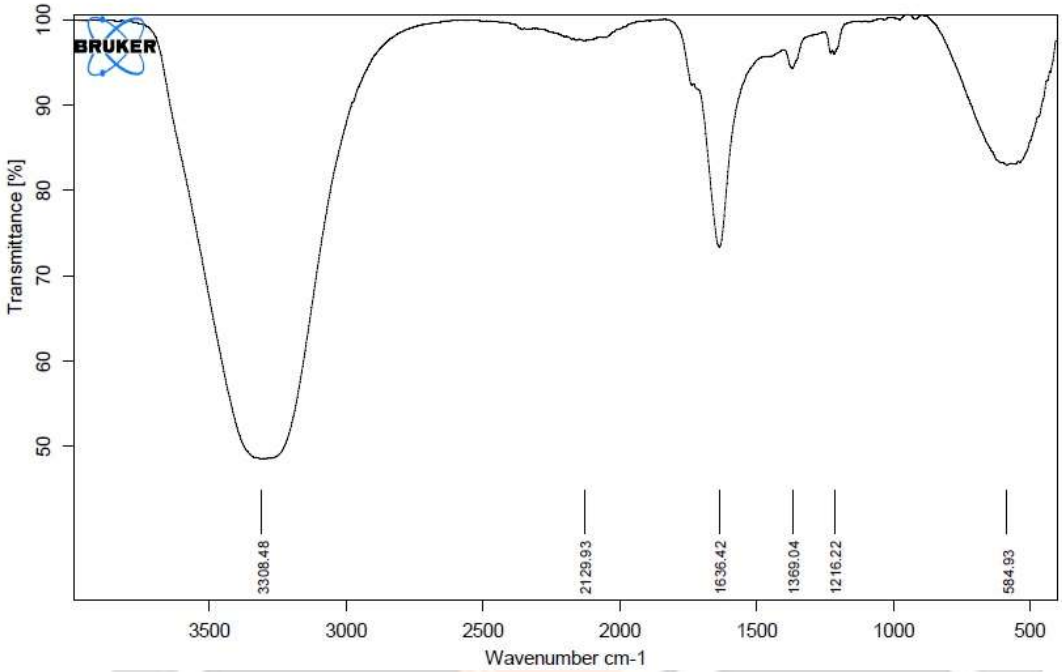

Fig. 3 Transmission spectra for uric acid

6. RESULT

The optical probe is used to test concentration of uric acid in human serum as well as of standard sample in terms of High, Normal and Low. The system is tested for human serum samples whose results of are shown in table 1.

Sr.No	Actual Uric acid sample(mg/dl)	Display
1	6.4	Normal with reference to normal human uric acid range
2	6.8	Normal with reference to normal human uric acid range
3	8.1	High with reference to normal human uric acid range
4	Blank	Low with reference to normal human uric acid range
5	Standard Uric acid (6mg/dl)	Normal with reference to normal human uric acid range
6	Distill water	Low with reference to normal human uric acid range

Table. 1 Output of the probe for different uric acid samples

According to above results, it can be concluded that as the uric acid concentration change with reference to human uric acid concentration range, the display indicates it with good accuracy.

7. FUTURE SCOPE

Such product is not available in Indian market , due to which , when it will be in the market it will be in big demand as it is non-invasive type. It will be in big demand especially for children and those who are having fear of getting injected , so it will be very friendly for such persons. No need to wait for the report as the result will be displayed

without any time delay. As result will be digital and immediate no risk of information interchange which would be very popular.

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