BILIRUBIN SENSING AND A CROSS SENSITIVITY EVALUATION WITH CO_2 AND O_2 USING OPTICAL FIBER SENSOR

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ABSTRACT

This paper describes an optical fiber sensor for the monitoring of bilirubin concentration and commonly called jaundice. An open path optical technique is used to analyze the absorption lines of bilirubin within the Ultra Violet/ Visible region. By using a wavelength corresponding to a bilirubin absorption peak, the Beer-Lambert Law can be used to relate the concentration of bilirubin surrounding the sensing portion to the amount of absorbed light. In the initial experiment, the absorption cross section for MAS bilirubin a product from Thermo Scientific was investigated and compare with theoretical data. an empty cuvette was used to measure incident intensity when the light passes through the empty cuvette. Then a cuvette was filled with bilirubin sample before measured the transmitted intensity. The theoretical absorbance of bilirubin shows maximum absorption in the range of 400 nm to 500 nm. The experimental result shows the absorption line for measured MAS bilirubin is in similar pattern and the maximum absorbance shows in range 400 nm to 500 nm. Cross sensitivity evaluation would be carried out to study the cross sensitivity of bilirubin absoprtion spectrum with other human blood molecules like oxygen (O_2) and carbon dioxide (CO_2) to yield the best wavelength for the absorption.

Key words: Bilirubin, Absorption, Fiber optic, Jaundice

INTRODUCTION

Jaundice or yellowish pigmentation of the skin is a common condition for most newborn. It is caused by increased levels of bilirubin in the blood and severe cases can lead to brain damage [1]. Therefore, a close monitoring of bilirubin level is vital for the child future survival. Current technologies allow us to determine the value of bilirubin using several methods, both invasive and non-invasive. Non-invasive methods for bilirubin concentration measurement are attractive by their evident advantages such as real time monitoring, immunity to the infection, possibility to control the concentrations of bilirubin providing painless measurement as often as necessary [2]. Therefore a new method of bilirubin detection using spectroscopic method is proposed.

For the purpose of fundamental studies, the research project of the jaundice monitoring is focused on the study of spectroscopy of the bilirubin molecules absorption. The absorption

spectrum of the bilirubin must be thoroughly studied and the optimum wavelength for absorption must be determined and verified and compared with the theoretical data. Initial stage of experiments also includes the absorption cross sensitivity studies with other human blood molecules such as CO_2, O_2, hemoglobin, etc. This is to avoid any reading interference which can provide imprecision in the measurement of bilirubin level in the blood system.

Various methods have been developed for bilirubin analysis in clinical samples. The most commonly used methods for bilirubin analysis is the diazo reaction in which bilirubin reacts with diazotized sulfanilic acid. The diazo reaction of bilirubin is highly selective and accuracy in the determination of the bilirubin concentration but interferes with other heme containing proteins (e.g. haemoglobin) and pigments [3]. Other analytical methods such as voltammetry, polarography, and fluorometry have also been used for bilirubin analysis [4]. While providing higher sensitivity, these methods are less selective than the diazo reaction. Electrochemical amperometric sensors and fiber optic sensors that make use of bilirubin oxidase have been recently fabricated and applied for bilirubin analysis in aqueous solutions and blood [5]. In these sensors, bilirubin oxidase is immobilized in a membrane that is attached to the surface of a carbon electrode or to the distal end of a fiber optic sensor. The measurement of the decreasing level of molecular oxygen when bilirubin is oxidized by the enzyme serves as an indirect indication of the bilirubin concentration. This analytical method suffers from interferences of electro active species and is characterized by a relatively long response time [6].

Each molecule has its own unique absorption and reflection spectrum. For the bilirubin absorption detection, the Beer-Lambert Law was utilized. The Beer-Lambert law describes the relationship between absorbance and concentration of an absorbing species and its general form is shown in equation (1).

$$\frac{I}{I_o} = e^{-\sigma N l} \qquad (1)$$

Where I is the transmitted intensity, Io is the incident intensity, l (cm) is the distance that the light travels through sample, σ (cm2/Molecule) is the absorption cross section and N (Molecules/cm3) is the concentration of the absorbing médium

In this paper, an initial experiment is carried out to study the absorption cross section of bilirubin molecules using UV-Visible application and to obtain the optimum wavelength that shows maximum absorbance for bilirubin molecules and evaluate the cross sensitivity with other blood molecules.

MAIN RESULTS

The absorption of CO_2 and O_2 were compared with bilirubin absorption in the spectral region of interest, as shown in Figure 1.

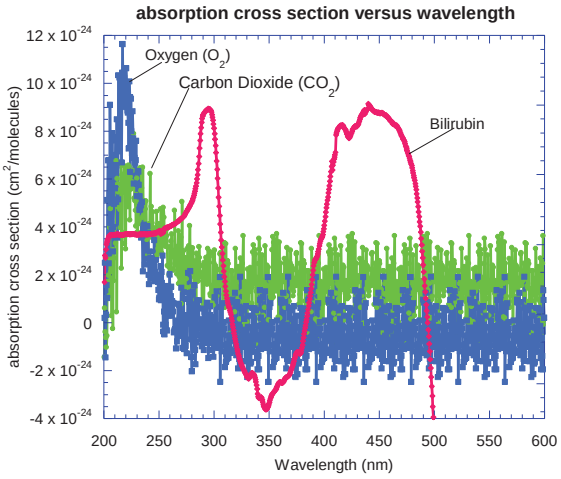

Figure 1. Cross sensitivity with O_2 and CO_2.

CONCLUSION

A novel optical fibre sensor for non-invasive jaundice monitoring is focused on the study of spectroscopy of the bilirubin molecules absorption. The absorption spectrum of the bilirubin must be thoroughly studied and the optimum wavelength for absorption must be determined and verified and compared with the theoretical data. Thus, it has been demonstrated that the UV-Visible range is well suited for the measurement of bilirubin. Future work will focus on cross sensitivity of bilirubin with other component of blood such as hemoglobin. This is to avoid any reading interference which can provide imprecision in the measurement of bilirubin level in the blood system.

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REFERENCES

1. Rai, A. K., Rai, S. B., Rai, D. K. and Singh, V. B. Spectroscopic studies and normal coordinate analysis of bilirubin. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 58(2002), 2145-2152.
2. Yap, S. H., Mohammad, I. and Ryan, C. A. Avoiding painful blood sampling in neonates by transcutaneous bilirubinometry. *Irish Journal of Medical Science* 171(2002), 188-190.
3. Doumas, B. T., Wu, T. W. and Jendrzejczak, B. Delta bilirubin: absorption spectra, molar absorptivity, and reactivity in the diazo reaction. *Clinical Chemistry* 33(1987), 769-774.
4. Malloy, H. T. and Evelyn, K. A. (1937). The determination of bilirubin with the photoelectric colorimeter. *Journal of Biological Chemistry* 119(1937), 481-490.
5. Klemm, J., Prodromidis, M. I. and Karayannis, M. I. An enzymic method for the determination of bilirubin using an oxygen electrode. *Electroanalysis* 12(2000), 292-295.
6. Fevery, J. Bilirubin in clinical practice: a review. *Liver International* 28(2008), 592-605.