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Measurement of Blood Glucose Using the Behavior of Fluorescence in Human Epidermis

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Fluorescence helps in supervising events happening in epidermal. To detect the glucose level in the human body, a non-invasive method is proposed by exciting a target in its excited state. Preferred targets are Tryptophan of the human skin which is excited by fluorescence rays of a particular wavelength, and act as bio amplifiers or bio-reporters. The fluorescence radiation that is directed to the skin, excites the glucose containing components of Tryptophan. In turn, this helps to develop a clinically effective noninvasive technology that could help in accurate measurement over the blood glucose level.

Key words: Fluorescence, Tryptophan, Epidermal and non-invasive.

Tryptophan is an important amino acid that helps in estimating the activities of the microenvironment. The excitation of tryptophan residues leads to the emission of folded protein[4]. Amino acid pays a way for the treatment or prevention of any metabolic disorder by acting as a modulator[2]. The purpose of the paper is to develop a clinically effective non intruding measurement of blood glucose level of human using the tryptophan florescence.

With initiation of invasive glucometer, monitoring of blood glucose levels can be done at their home itself, But the cost and pain makes invasive glucose monitoring a greater inconveniences. The noninvasive[6] pain free approach would come up with clinically effective blood glucose monitoring.

Regular testing of glucose, sufficient control, reduces complication &low cost health monitor are achieved using Non-invasive methods. Study & exploration had been conducted by many researchers in the past, and have used optical detection and optical scanning methods like Polarimetry, Raman spectroscopy, Photo acoustic spectroscopy, Mid-Infrared (MIR) spectroscopy using an Attenuated Total Reflection (ATR) prism, and Near- Infrared (NIR) spectroscopy.

Polarization Change[5] works on the basics of transverse of the polarized light in a optically active solution (e.g.: chiral molecules). The change observed in polarization due to glucose is represented as the first proposed non invasive technique. The technique can be used in visible light for all its work expect for the disadvantages of scattering properties which leads to in accurate measurement.

Non invasive blood glucose concentration monitoring are done through NIR spectroscopy[8] .The use of NIR technology over MIR is that it has high penetration depth due to its shorter wavelength. This penetration capability helps in observing blood glucose in capillaries fluid & tissue .It also supports higher signal to noise ratio ,use of broadband light source instead of monochromatic source .the main disadvantages of NIR is light is partially observed and spread due

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to its contact with chemical component present in the tissue. Glucose concentration is measured from the variation of the length intensity that is both transmitter and received.

Fluorescent spectroscopy[3] helps in analyzing the fluorescence of the sample. The fluorescence intensity changes with the concentration of the glucose in the solution .Visible light is more sufficient for studying fluorescence in tissue ,but while using UV rays scattering effect is more ,which leads to the use of Raman Spectroscopy[7] were a particular laser beam is used to evaluate the sample. However instability nature of laser wavelength impose a limit in the glucose measurement while using mid –infrared spectroscopy approach where we used 2500 to 10000 nm spectrums. The scattering effect is lowered and increases absorption. While compared with NIR approach. However, Mid-infrared rays possess poor penetration in nature. From the afore-mentioned discussions, it is concluded that

- With rapid growth in the diabetic inhabitants, a noninvasive approach for the blood glucose measurement is been appreciated by the medical sciences.
- Most commonly, non-invasive methods are using optical detection or optical scanning methods. These methods include polarimetry, Raman spectroscopy, photo acoustic spectroscopy, Near -Infrared (NIR) spectroscopy, Mid-Infrared (MIR) spectroscopy using an Attenuated Total Reflection (ATR) prism
- Heterogeneous glucose distribution in skin is the major stumbling block for the accurate measurement of the above mentioned procedures.
- Penetrating characteristics of infrared light rays are not appreciable along with the presence of other interfering light observers during the measurement of the blood glucose level.
- Most of the methods available in the present market are invasive in procedure to measure the blood glucose. Currently available non invasive blood glucose reading system has to be improved in terms of accuracy and also it is necessary to support for continuous monitoring in home as well as in health care centers.

MATERIALS AND METHODS

The proposed method inherits a non-invasive glucose monitoring equipment useful within the living. The equipment consists of a radiation source, capable of exposing radiation to a particular portion of the external or internal surface of a patient. In the proposed design, a specially designed fluorescence lamp is used as the source of radiation. The surface, on which the radiation is directed, can be the gums, the eyeballs or area around the eyelids, but more possibly, the skin.

The source has a wavelength of λ_0 =295 nm which helps in exciting the subject and obtain the glucose level of the subject this indication can be a quantitative or relative measurement if the concentration of the subject. The equipment further measures the amount of radiation received once after the radiation excites the target. The receiver's measurement is sent to a logic unit were it is computed the radiation were it is divided not a glucose itself but a reflection of the skin or tissue.

The selected target has to be a component or a compound or a molecule that reflects any environmental alterations in the tissue. The radiation re-emitted by the target will be in the range of 270nm-1100nm, which is discovered to have correlation with the blood glucose level. Fluorescence signal emitted by the target and the detector detects the emission .The emission correlates with the blood glucose of the patient.

The basic idea of this work is to detect the glucose level of the patient by exciting the target and observing the amount of radiation emitted by the target. Mostly we prefer tryptophan which can act as a bio amplifier or bio reporter when exposed to fluorescence ray. This process flow scenario is clearly shown in figure 1.

The Lambert-Beer law account for the changes that happen in light intensity on sample light path using a specific wave number (v), of the wavelength, This incident is represented as follows:

$$A[v] = -\log I[v] / I[v] \quad ...(1)$$

Where,

I[v] is referred as light intensity of the medium

I is the amount of light intensity at the specific wave number [v].

A is Absorption.

For glucose molecule identification, the near and mid infrared is applied. The fluorescence radiation from the source is directed to the physiological system (skin). The source radiation is passed through a wavelength selector (monochromator), before reaching the skin surface. The wavelength selector selects wavelength of range 800nm-1800nm and this wavelength is allowed to fall on the skin. The fluorescence radiation that is directed to the skin, excites the glucose containing components of blood (Tryptophan). The excited target re-emits fluorescence radiation. The re-emitted fluorescence radiation lies in the wavelength range of 270nm-1100nm. This re-emitted fluorescence radiation is detected using a fluorescence detector. The output of the fluorescence detector is given to the embedded controller, which converts the emitted radiation into measurable signal an in turn, it is correlated with the blood glucose level of the body.

RESULTS AND DISCUSSION

In figure 2, due to the Exposure to the fluorescence radiation, with the increase in wavelength of the radiation there is a increase in

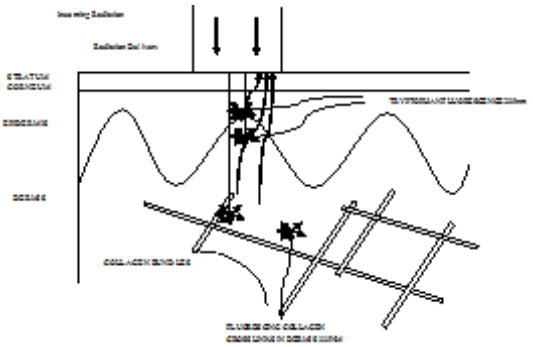

Fig.1. Process flow– Fluorescence based blood glucose measurement

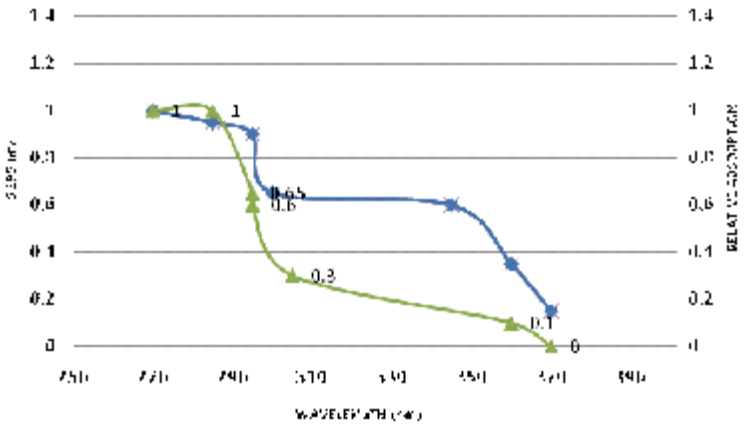

Fig. 2. Florescence radiation absorption by epidermis Vs Wave length

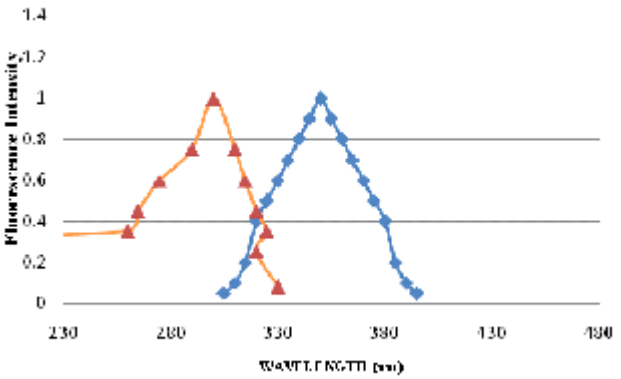

Fig. 3. Florescence radiation wavelength Vs Intensity

the fluorescence of the tryptophan moieties. The action spectrum detecting increase in fluorescence of the tryptophan moieties in skin is shown as a plot between, relative absorption by the epidermis and S295 nm.

In figure 3, the fluorescence phenomenon of tryptophan moieties has a maximum excitation of at 295 wavelengths (nm) and a maximum emission range of 345 nm in the skin. The characteristics of the fluorescence Intensity (A.U) on human skin are plot with wavelength (nm).The fluorescence intensity is kept to one in order to display the characteristics shape of the excitation & emission curves. The information is obtained with the help of fiber optic probe contact on the skin. The orange line indicates fluorescence Excitation spectrum and the blue line indicates fluorescence Emission spectrum.

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