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Infra Red – Light Emitting Diode and Photodiode Pair in Measuring Blood Glucose Level Based on Transmittance Method

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Abstract: *The clinical diagnosis based on biofluid composition in blood plasma is an essential method for detecting pathology. Biofluid in the blood plasma of organism contains an interstitial fluid such as glucose is percursor the source energy in the synthesis process. Blood glucose metabolism is fluctuating and has a biomarker normality threshold. This research to confirm the performance of IR-LED wavelength 1450 nm and 1600 nm and exclude biochemical reagent processes, blood sampling, infection, and medical waste. Continuous measurement of glucose disease can improve quality of life and reduce the risk of systemic diseases. The transmittance method with an incident wavelength certain has maximum penetration depth in the body tissue. The mechanism of transmittance includes incident light in blood glucose with specific wavelengths and a photodiode detected. Transmittance is voltage, then converted to analog values into digital readings. The research has conducted in the Laboratory of Physics Material Electronic-IPB University. Sample preparation used cuvette with the design system modular modified based on reference and pearson correlation for data analysis. The scatter diagram shows the results of the IR-LED 1600 nm has good performance and can be a light source device in non-invasive biomarkers.*

Keywords: *Biomarker, Glucose, Transmittance.*

1. Introduction

Andreas Marggraf finds glucose in 1747 through a process of isolation on a raisin. The chemical structure glucose found by Emil Fischer with the term D-glucose or dextrose 2,3,4,5,6-Penta-hydroxy-hex-aldehyde as a conventional identified with a chemical formula $C_6H_{12}O_6$ is energy be an important precursor of in the process of the

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synthesis of adenosine triphosphate (ATP) (Shendurse and Khedkar, 2016). Physical characteristics of glucose, crystal, white, molecular weight 180.16 g mol^{-1}, melting point 146^0C-150^0C, density 1.5620 g cm^{-3} at temperatures of 18^0C and soluble in water or phyrimidine (Yanez, 2018).

Glucose distributed to body cells through blood with the circulatory system. The normality is 70 mg/dL-140 mg/dL as the value of reference in diagnosis enforcement. The blood glucose levels have fluctuated can raise systemic disease metabolism (Law et al, 2018). Blood vascular is a source of information on the condition of the human body, pathology, failure the system organs or effect reaction use of a drug (Pande and Joshi, 2013; Bruen et al, 2017). Clinical diagnosis glucose is very important for managing risk factors for the occurrence of systemic disease metabolism (Craig at al, 2014). Systemic disease metabolism is the category of noncommunicable diseases. The process of the treatments is sustainable in a long time and including chronic and/or catastrophic, has resulted in complications, permanent disability, and death. The prevalence of deaths reached 73% population in the world (World Health Organization, 2018).

Determine the diagnosis only be achieved by a medical professional, but the investigation routine can be carried out by an individual. Method of diagnosis blood glucose level the most often used is pulsatile, the process of its use need strip test and fingerprick (Pande and Joshi, 2013; Skudo, 2016; Samuelson and Garber, 2018). Fingerprick technique needs a lancet to extract the quantity of blood on capillary blood vessels and extracted on a strip test glucose meters (Anas et al, 2012). Process of its use intermittent, uncomfortable and painful, need a blood sample, need lancet and strip test once used, raises the risk of infection due to a chemical reaction between blood with an active substance on strips, as well as medical waste (Samuelson and Garber, 2018). Based on World Health Organization there are medical waste 85% noninfectious and 15% infectious world (World Health Organization, 2017).

A patient could do the blood glucose level measurement by applying a non-invasive transmittance method is a form of technological development indicators measurement objectively as a guide in stating normality, pathogens and

pharmacological response on biological systems. The transmittance method needs light emitting diode (LED) with wavelength s incident light 1450 nm and 1600 nm as penetration on system body tissue called optical window because it can cause molecules vibration the bond of CO, CC, and CH (Nybacka, 2016). Wavelength includes in a category near-infrared (NIR) having excess sensitivity high, low cost and technology are standard (Srivastava et al, 2013). This research study aims to verify the performance or ability of source of light LED wavelength spectrum 1450 nm and 1600 nm in non-invasive biomarker to detect biomimic blood glucose with various concentration.

2. Research Method

The research team has conducted experimental research from December 2018 to May 2019 in the Laboratory of Electronic Material Physics, Department of Physics, IPB University. The sample used in research is Lyphocheck (whole blood control) characterization as having any blood glucose levels of 50 mg/dL, 70 mg/dL, 90 mg/dL, 110 mg/dL, 130 mg/dL, 150 mg/dL, 170 mg/dL, and 190 mg/dL from Bio-Rad Laboratory. Standard model and the incident light using NIR-LED wavelength 1450 nm and 1600 nm detected by photodiode FDGA-05 InGaAs, provided by Thorlab Inc (Robiah et al, 2017). Measure the glucose concentration in the mode used cuvette with an LED twin table model. The relation between the value of concentration blood glucose level and LED detection value is calculate by statistical method Pearson correlation with ZunZunSite3.

3. Results and Discussion

3.1. Non-Invasive Biomarker Measurement Reference

Modulated instrumentation of NIR spectrophotometry has an excellent performance to monitor blood glucose levels continuously. NIR-LED and photodiode wavelength range used 1450 nm and 1600 nm, provided by Thorlabs Inc. The wavelength selected by the fundamental of vibration bond molecule and expanding best optimal wavelength testing for glucose using different LEDs from 1450 nm and 1600 nm, because of the price of device low cost (Nybacka, 2016; Robiah at al, 2017). The management result data using SQLite database software system developed

Qt Software. Development Kit (SDK) to confirmed relation wavelength LED and the concentration of blood glucose level measuring (Robiah at al, 2017).

3.2. Research Analysis Mathod

Process of measuring data using ZunZunSite3 obtained R-Squared 0.99, Root Mean Squared Error (RMSE) 0.0009822 based on a polynomial equation. The RMSE value to evaluate the accuracy of the results and degree of error measuring LED on blood glucose concentration.

$$z = a + bx^0y^1 + cx^0y^2 + dx^0y^3 + fx^1y^0 + gx^1y^1 + hx^1y^2 + ix^1y^3$$

Figure 1. Polynomial equation from ZunZunSite3

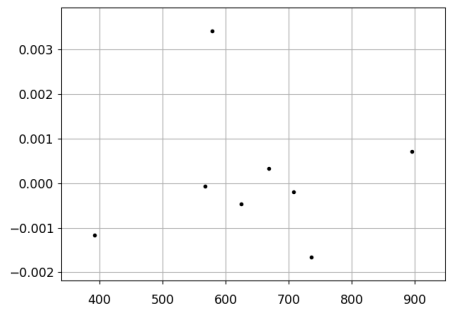

Figure 2. Scatter plot diagram of percent error LED wavelength 1450 nm

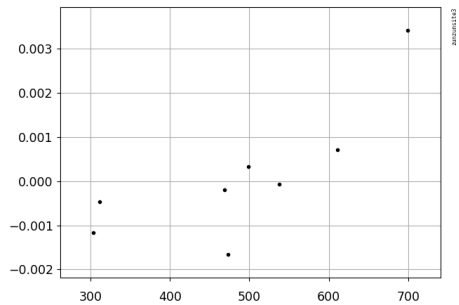

Figure 3. Scatter plot diagram of percent error LED wavelength 1600 nm

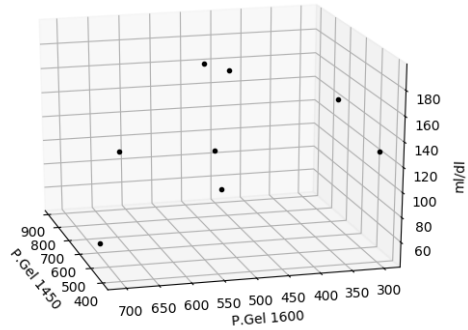

Figure 4. Scatter plot diagram of percent error LED wavelength 1450 nm and 1600 nm on the concentration of blood glucose

3.3. Wavelenght and Measurement Investigated

The spectrum of wavelength at 1600 nm is able to penetrate the body's tissues reaching a range of 1-100 mm. The level of depth penetration is influenced by the wavelength value. Absorption of the wavelength 1600 nm range from 0.9 blood plasma and 0.1 water. The spectrum of 1600 nm wavelength can be a choice of non-invasive biomarkers with high sensitivity and low cost. The use of a large wavelength spectrum allows increased depth penetration (Pande and Joshi, 2013; Srivastava et al, 2013). Based on the literature it can be concluded that the study of 1600 nm LED wavelength is much better than the 1200 nm LED wavelength (Robiah et al, 2017). The best measurement is currently made the auricle, skin, and curricular tissue. The different sites body's measurement requires appropriate probe design and calibration for a human blood glucose level (Pande and Joshi, 2013; Srivastava et al, 2013).

3.4. The Solution Proposed

Blood glucose measurement using the method of pulsatile microcirculation repeatedly can cause inflammation, infection, and discomfort of the patient because the process of using it requires blood samples in capillaries as extract quantities. This method cannot be used as a centralized diagnosis tool because there is a noise factor in the biofluid component which is the concentration of blood plasma constituents. This research is limited to only measuring the performance of wavelengths of 1450 nm and 1600 nm but has not carried out in-vivo measuring, noise differences in the body's composition, and sensitivity to internal or external factors (Pande and Joshi, 2013;

Craig et al, 2014; Samuelson and Garber, 2018). In-vivo measuring can be performed on the left and right fingers or the index, middle and sweet fingers because the area does not affect or correlation the results of the blood glucose level measurement in the short or long period of time (Lestari, 2017; Ajrina, 2017).

4. Conclusion, Implication and Limitation

4.1. Conclusion

The reference source for wavelengths to measure blood glucose level still need to be investigated even more. Based on processing data using ZunzunSite3 confirmed that the wavelength of 1600 nm has better and optimal performance compared to the wavelength of 1450 nm on applied in measuring various blood glucose concentrations.

4.2. Implication and Limitation

The wavelength of 1600 nm can be a light source device in non-invasive biomarkers. Researchers should do further investigation regarding the level of sensitivity, the influence of the complexity of the biofluid human body and in-vivo measuring.

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This research has complied and conducted in teams. BP, RPJ, I, and HA design the whole research study, implemented the hardware device, software, running the whole research. RPJ, I, and HA design data transformation and design the probe and electronic device. RJP testing the system and non-invasive biomarker. BP provides information about medical testing equipment, observed the study and prepared manuscript.

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