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Optical Fiber Displacement Sensor Using Concave Mirror For Cholesterol Detection

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***Abstract*—A simple fiber optic displacement sensor is employed to detect the concentration of cholesterol. Mechanism of He-Ne laser beam through an optical fiber bundle and the absorption of laser light on the cholesterol solution, and reflected back by the concave mirror and then reflected beam is guided through an optical fiber bundle that is detected by a silicon detector in the form of the voltage. The principle of propagation of the laser beam is throuhg optical fiber bundel as intensity-based profile through the medium of the cholesterol solution with varying concentrations. The variation of cholesterol concentration is from 0 ppm to 300 ppm. The findings show that increasing cholesterol concentration, decreasing the peak voltage detection linearly with the linearity value of more than 97% and higher sensitivity of 0.08 mV/ppm. The simplicity of design, low cost and high sensitivity promote a well developed sensors to provide useful parameters detecting concentration of cholesterol.**

Keywords—fiber optic sensors; concave mirror; cholesterol solution;

I. INTRODUCTION

Cholesterol is a compound that has a core of four cyclopentano - fenantren rings. In the blood plasma 30% binds to lipoproteins that can increase the solubility in the blood and another 70% of blood it is in the form of cholesterol ester [1]. The cholesterol in the circulating blood is not in a state free, but is in the particles of lipoproteins. Lipoprotein is a complex compound between fat and protein. In serum blood lipoprotein consists of 4 types, namely kilomikron, very low density lipoprotein (VLDL), low density lipoprotein (LDL), and high density lipoprotein (HDL). Kilomikron contains 96% triglycerides, 1.7% protein, 1.75% cholesterol, and 0.6% phospholipids. Kilomikron acts as a carrier of fat from the intestine to places where it is needed. VLDL contains 60% triglycerides, 15% cholesterol, 10% protein, and 15% phospholipids. The VLDL serves as a carrier of endogenous triglycerides from its formation sites to where it is needed. LDL contains 10% of triglycerides; 45% cholesterol, 25% protein, and 20% phospholipids. LDL serves to transport cholesterol from one cell to another where it is necessary for the formation of steroids and steroids. HDL contains 3% triglycerides, 18% cholesterol, 50% protein, and 30% phospholipids [1]. Cholesterol includes a steroidal compound with the formula $C_{27}H_{45}OH$.

The previous research showed that cholesterol could be measured by gold nanoparticles with positive charge which is implemented in sensor, sensitive cholesterol detector [2]. It could be also detected using electrocatalyst principle with cobalt (II) chloride in aprotic medium [3]. In bovine serum, researchers advance the use of other sensors, sensitive electrochemical sensors and selectively using modified silver nanoparticle carbon glass electrodes, for the determination of cholesterol [4]. Also, there was a sensor combining both carbon nanotube layers and nanoparticles based bioenzyme [5]. The use of electrochemical sensors based on molecular film molding on carbon nanoparticles modified electrodes for the detection of cholesterol [6]. However, those sensors are not performed maximally in terms of sensitivity, linear range and detection limits.

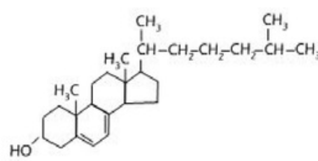

Fig. 1. The compound cholesterol

Another method to count the cholesterol concentration is using the principle of laser beam characters against the material through the fiber optic sensor [7], [8]. The use of optical fiber shift sensors to determine the concentration of many compounds is done such as salt compounds and also temperature measurement[9], [10]. The use of optical fiber sensor is simpler and cheap to use detection the concentration of a material. The optical fiber sensor to determin the salinity of a material is a simple design, low price, and accurate sensitivity measurement results [11]-[13]. The description of research that has been done will be developed a sensor instrument to determine the concentration of cholesterol using fiber optic bundles to guide the laser beam and reflected through a concave mirror.

II. EXPERIMENT SETUP

The detection method for counting cholesterol concentration is based on the principle of the laser beam's character toward the solution through an optical fiber sensor by using intensity modulation. The light beam that penetrated the optical fiber of the receiver and processed by the optical detector into the electrical signal was displayed on Lock-in amplifier. it was obtained relationship between the maximum voltage of sensor output as a function of cholesterol concentration variation and was measured paramater and performance involving linearity, sensitivity, and linear range.

Tools used for the detection of cholesterol concentrations using He-Ne lasers, Fiber optical bundles, silicon detectors, chopper, chopper drivers, Lock-in amplifiers SR510, concave mirror, micrometer and other supporting devices. The experiment begun with characterizing the shift sensor to find out the shift of the fiber bundle sensing channel to the concave mirror, then cholesterol concentration can be detected by setting up the experimental instrument as shown in Fig. 2.

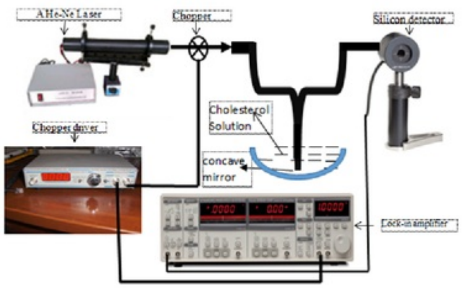

Fig. 2. Experimental setup for optical fiber displacement sensor using concave mirror

Detection of cholesterol concentrations using a concave mirror begun when an optical fiber bundle had been placed squeezing with a mirror at tight distance. The optical fiber bundle was set on a micrometer shifted every 50 µm. The output voltage of the detector was measured when the shift position was changed, so that the obtained data was the output voltage of the detector as a function of the optical fiber bundle shift. Cholesterol concentration detection was performed on various concentrations including 0 ppm to 300 ppm.

III. Results and Discussions

Fig. 3. presents that the output of voltage from detector functions as a displacement measurement on seven cholesterol samples with concentrations ranging from 0 ppm to 300 ppm. It describes different output voltage for each cholesterol concentration. The lower the voltage output is measured, the higher the cholesterol concentration is available. In other words, changes in the concentration give increasement to the differences in voltage output.

Fig. 3 shows the displacements curves exhibit a two peaks voltages and a minimum voltages. The advance of concave mirror is to provide more than one of peak signal and the analysis of results in more easier.

The measurement of the output voltage is measured when the He-Ne laser is reflected and guided by the detector receiving fiber. The optical fiber bundle is placed on a 50 µm displacement micrometer. At each position the output voltage shift of the detector is measured and the data obtained is the voltage of the detector as a function of the optical fiber shift bundle, thus obtaining the maximum and minimum output voltage from each variation of cholesterol concentration. As for the output voltage value of cholesterol concentration variation there are two maximum peaks and a minimum voltage as in Table I.

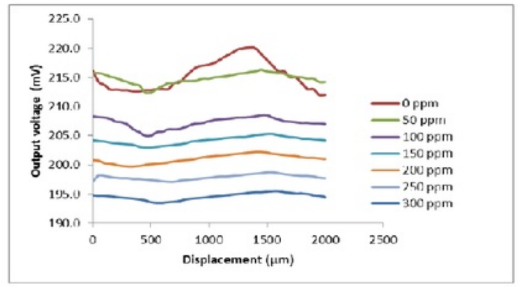

Fig. 3. Variation of output voltage againts the displacement for various concentration

TABLE I. Data Of Maximum And Minimum Output Voltage From Variation Of Cholesterol Concentration

Cholesterol Concentration (ppm)	First maximum peak voltage (mV)	Output minimum voltage (mV)	Second maximum peak voltage (mV)
0	216.1	212.6	220.1
50	215.7	212.4	216.3
100	208.3	205.0	208.5
150	204.2	203.0	205.3
200	200.8	200.0	202.2
250	197.2	197.4	198.7
300	194.8	193.5	195.5

Fig. 4. presents that the intensity of reflected light is a voltage versus displacement of the reflecting concave mirror from the fiber optic probe at various concentrations in this research. Fig. 4. also shows that the first maximum output voltage has 0.0774 mV/ppm sensitivity and 97.34%.linearity.

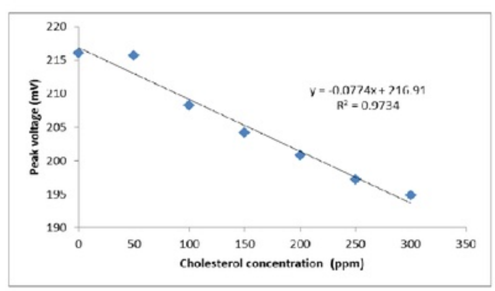

Fig.4. Voltage (mV) as function concentration of cholesterol (ppm) for displacements using concave mirror first maximum peak voltage

Fig. 5. presents that the minimum output voltage with a sensitivity of 0.0659 mV/ppm and a linearity of 96.92%. The concentration of cholesterol was varied from 0 ppm to 300

ppm and the voltage reduces linearly with concave mirror from 212.6 mV to 193.5 mV for the displacements.

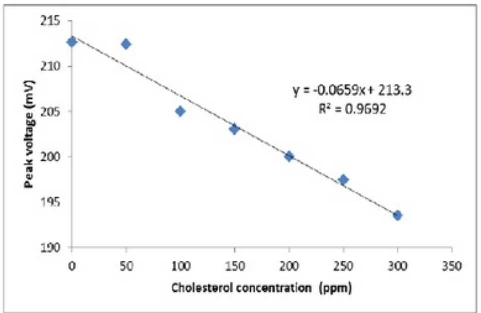

Fig.5. Minimum voltage (mV) as function concentration of cholesterol for displacements

Fig. 6 shows the peak voltages and their positions, respectively, against the concentration of cholesterol for both displacement measurement using concave mirror. The concentration of cholesterol was varied sample from 0 ppm to 300 ppm and the voltage reduces linearly with concave mirror from 220.1 mV to 195.5 mV for displacements. Fig. 6. shows that the second maximum output voltage shows a linear decrease in the concentration solution with a sensitivity of 0.0824 mV/ppm and a linearity of 97.57%.

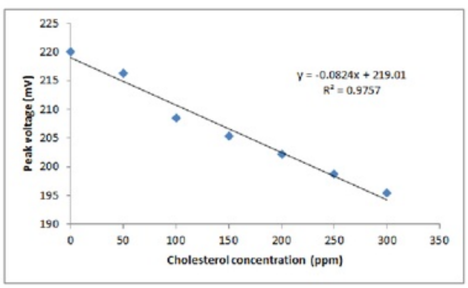

Fig.6. Voltage (mV) as function concentration of cholesterol (ppm) for displacements using concave mirror second maximum peak voltage

TABLE II. PERFORMANCE OF CHOLESTEROL SENSOR USING CONCAVE MIRROR

Parameter	Value		
	First maximum peak voltage	**Minimum voltage**	**Second maximum peak voltage**
Sensitivity (mV/ppm)	0.08	0.06	0.08
Linearity (%)	> 97	> 96	> 97
Linear range (ppm)	0 - 300	0 - 300	0 - 300
Resolution (ppm)	1.759862	3.43880	2.94575
Standard Deviation (mV)	0.140789	0.206328	0.23566

The results of data analysis determine the concentration of cholesterol using this concave mirror is in accordance with the results obtained by theoretical analysis by Samian *et al* [14] and Rahman *et al* [15].

IV. CONCLUSION

A simple intensity modulated sensor is demonstrated as a instrument to measure cholesterol solutions with concentration variying from 0 to 300 ppm by using optical fiber bundle displacement sensors is presented. The findings show that increasing cholesterol concentration, decreasing the peak voltage detection linearly with the higher a sensitivity of of 0.08 mV/ppm and a linearity value of more than 97% and showed high performance sensitivity parameters and accurate.

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REFERENCES

[1] Budiyanto Moh, Suhariningsih, Moh Yasin, "Cholesterol Detection Using Optical Fiber Sensor Based On Intensity Modulation" Journal of Physics : Conference Series, Vol. 853 No. 012008, 2017.

[2] Xiangmin Miaoa, Zhiyuan Cheng, Zongbing Li, Po Wangb, "A novel sensing platform for sensitive cholesterol detection by using positively charged gold nanoparticles" Biochemical Engineering, Vol. 117, pp. 21 – 27, 2017.

[3] Alisa N. Kozitsina, Andrei V. Okhokhonin, Anatoly I. Matern, "Amperometric detection of cholesterol using cobalt (II) chloride as an electrocatalyst in aprotic media" Electroanalytical Chemistry, Vol. 772, pp. 89 – 95, 2016.

[4] Siriwan Nantaphola, Orawon Chailapakul, Weena S, "Sensitive and selective electrochemical sensor using silver nanoparticles modified glassy carbon electrode for determination of cholesterol in bovine serum" Sensors and Actuators, B 207, pp. 193–198, 2015.

[5] Xiaojun Cai, Xia Gaoa L.W, Xianfu Lin, "A layer-by-layer assembled and carbon nanotubes/gold nanoparticles-based bienzyme biosensor for cholesterol detection" Sensors and Actuators, Vol. 181, pp. 575–583, 2015.

[6] Jian Ji, Zhihui Zhou, Xiaolian Zhao, Jiadi Sun, Xiulan Sun, "Electrochemical sensor based on molecularly imprintedfilm at Au nanoparticles-carbon nanotubes modified electrode for determination of cholesterol" Biosensors and Bioelectronics, Vol. 66, pp. 590–595, 2013.

[7] Faria J.B, "Modeling The -Branched Optical Fiber Bundle Displacement Sensor Using a Quasi-Gaussian Beam Approach" Microwave and Optical Technologi Letters, Vol. 25 No.2. pp. 138-141, 2000.

[8] Faria J.B, "A theoretical analysis of the bifurcated fiber bundle displacement sensor" IEEE Trans on Inst and Meas., vol. 47, pp. 742-747. 1998.

[9] Hida N, N. Bidin, M. Abdullah, M. Yasin, "Fiber Optic Displacement Sensor for Honey Purity Detection in Distilled Water" Optoelectronics and Advanced Materials, Vol. 7, No. 7. pp. 565 – 568, 2013.

[10] Rahman H. A, S. W. Harun, Saidin N, M. Yasin, H. Ahmad, "Fiber Optic Displacement Sensor for Temperature Measurement", IEEE Sensors Journal Vol. 12, No. 5, pp. 1361 – 1364, 2012.

[11] Yasin M, Y. G. Yhun Yhuwana, M. Khasanah, H. Arof, N. Irawati, S. W. Harun, "Intensity based optical fiber sensors for calcium detection" Journal Optoelectron Adv. Mater. Rapid commu. 3 (5), pp. 1529 – 1533, 2015.

[12] Yasin M., H. Ahmad, K. Thambiratnam, A. A. Jasim, S. W. Phang, S. W. Harun, "Design of Multimode Tapered Fibre Sensor for Glucose Detection" Optoelectronics and Advanced Materials Vol. 7, No. 5. pp. 371 – 376, 2013.

[13] Yasin M., Harun S.W., Kusminarto, Karyono, Ahmad H, " Construction of fiber optic sensor for micro-displacement measurement based on refelctive intensity modulation techniuque" 2nd Jogja International Physics Conference, 6-8 September 2007, Gadjah Mada University, Yogayakarta.

[14] Samian, A. H. Zaidan, Moh. Yasin, "Detection of Rhodamine B levels in destilled water based on displacement sensor using fiber coupler and concave mirror" Journal Optoelectron 18 (11-12), pp 988 – 992, 2016.

[15] Rahman H. A, S. W. Harun, M. Yasin, H. Ahmad, "Fiber Optic Salinity Sensor Using Fiber Optic Displacement Measurement with Flat and Concave Mirror" IEEE Journal of Selected Topics in Quantum Electronics, Vol. 18, No. 5, pp. 1529 – 1533, 2012.

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