IOP Conf. Series: Journal of Physics: Conf. Series **853** (2017) 012008 doi:10.1088/1742-6596/853/1/012008

Cholesterol detection using optical fiber sensor based on intensity modulation

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Abstract. The aim of the research is to detect the concentration of cholesterol by using the principle that a laser beam propagation is guided by optical fiber bundle in term of intensity profile through solution with vary concentrations of cholesterol from 0 to 300 ppm. The mechanism of cholesterol concentration detection is the propagation of He-Ne laser beam with wavelength of 632.5 nm through a fiber optic bundle and a solution of cholesterol, then is reflected by a flat mirror and enters receiving fiber. This signal is captured by a silicon detector (SL-818, Newport) in the form of output voltage. The result showed that the output voltage decrease linearly with the increase of concentration of cholesterol with a sensitivity of 0.0004 mV/ppm and the linearity more than 97%.

1. Introduction

Cholesterol is one component of the fat contained in the cell which is made bylow density lipoprotein (LDL), high density lipoprotein (HDL), total cholesterol and triglycerides. Cholesterol is actually one of the nutrients that are needed by the body in addition to other nutrients such as carbohydrates, proteins, vitamins and minerals. Cholesterol found in the bloodstream or body cells which needed for the formation of the cell wall and as raw material for some hormones. However, if there are excessive cholesterol levels in the blood, it can lead to diseases, including coronary heart disease and stroke. Normal cholesterol should be below 200 mg / dl. It is also a material basis for the formation of steroid hormones. Excessive cholesterol in the body will be buried in the walls of blood vessels and will cause a condition called atherosclerosis; a condition in which the arteries are narrowing or hardening. This kind of condition is the forerunner of heart disease and stroke.

Cholesterol is a compound which has a four-ring core siklopentano – phenanthrene, including fat with very little solubility in water. Levels in blood plasma 150-200mg / ml, are approximately 2x blood glucose levels. In blood plasma, 30% of it which bound to lipoproteins is able to increase solubility in blood. As many as 70% more blood cholesterol is in the form of cholesterol esters. Cholesterol does not dissolve in water but can be extracted from the tissue with chloroform, ether, benzene and alcohol heat. Cholesterol including steroid compounds of formula $C_{27}H_{45}OH$. Cholesterol is an important sterol which are many in nature. From the formula of cholesterol, it can be seen that the hydroxyl groups are contained of C atom number 3 which has a beta position; therefore is connected by a full line.

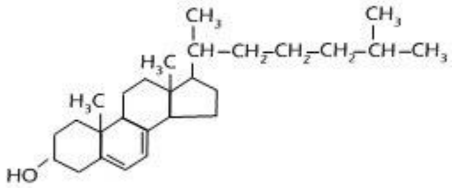

Figure 1. The compound cholesterol

There have been a lot of researches done on the detection of cholesterol levels as sensitive and selective electrochemical sensors use silver nanoparticles which modified glassy carbon electrode to determinate the bovine serum cholesterol [1]. Electrochemical sensor based on the molecular film printed on carbon nanoparticles modified electrode for the determination of cholesterol [2]. A layer of carbon nanotubes and gold nanoparticles bienzyme-based biosensor are usedto detect of cholesterol [3]. High-performance electrochemical biosensor could also be used for the detection of total cholesterol [4]. Cholesterol with amperometric detection using electrochemical oxidation method , electrochemical and optical polymer by using a biosensor are also to detect cholesterol [5]. The downside of sensors such as performance optimization of sensor sensitivity, linear range and detection limit is less than the maximum.

Another way to determine cholesterol levels can be determined by the character of the material through a laser beam fiber optic sensors. Fiber optic sensor method is more simple and inexpensive to be used to determine the concentration of a substance. One example of an optical fiber sensor to determine the salt content in a material is a simple instrument design, low cost, and high sensitivity measurement results [6]. Based on this description, there will be a developed fiber optic sensor research as a model instrument determines the concentration of cholesterol using fiber optic sensor bundle.

2. Experimental setup

The research method used to determine the cholesterol levels were determined by the character of the laser beam to the material through an optical fiber sensor by using a laser beam intensity modulation. Beam of light entering the optical fiber receiver and processed by an optical detector into electrical signals to be displayed on the computer. The experimental results would be obtained a linear relationship between the peak voltage output of the sensor as a function of variations in the concentration of cholesterol and measured parameters and sensor performance include sensitivity, linear range, and linearity.

The device consisted of a He-Ne laser (Thorlabs, 632.5 nm, 5 mW), Fiber bundle, an optical detector 818-SL (Newport), chopper and chopper controller (SR540, Stanford Research Systems, Inc.), Lock-in amplifier (SR510, Stanford Research Systems, Inc.), mirrors the wavelength of visible light (5101-Vis, New Focus), micrometer position (Newport), PC, and other supporting devices.

The first step was to characterize the shift sensor to determine the fiber bundle sensing channel shift to a flat mirror. Set-up characterization of the fiber bundle as sensor shift and subsequent detection of cholesterol concentration by making set-up as shown in the following figure 2:

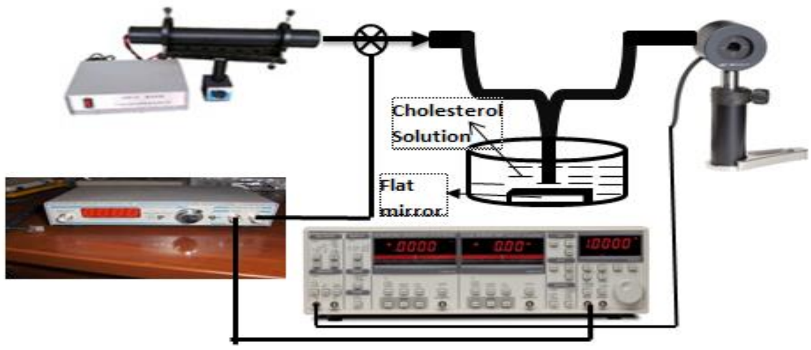

Figure 2.Setupfor fiber optic sensor determines the concentration of cholesterol using fiber bundle

Detection started when the fiber bundle was placed coincides with the mirror on the shift z = 0. The fiber bundle was placed on a micrometer position which was shifted every 50 µm. At each position shift detector output voltages were measured to obtain data such as output voltage detector as a function of shifting fiber bundle. The detection was done on several other variations of concentrations between 0 ppm, 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm, 300 ppm.

3. Results and discussions

Figure 3 showed a graph of the output voltage detector as a function of shifting fiber bundle for each concentration ranging 0 to 300 ppm. The figure showed the relationship changes in cholesterol concentration variations of the maximum output voltage at each concentration; the higher the concentration of cholesterol, the lower the measured output voltage detector.

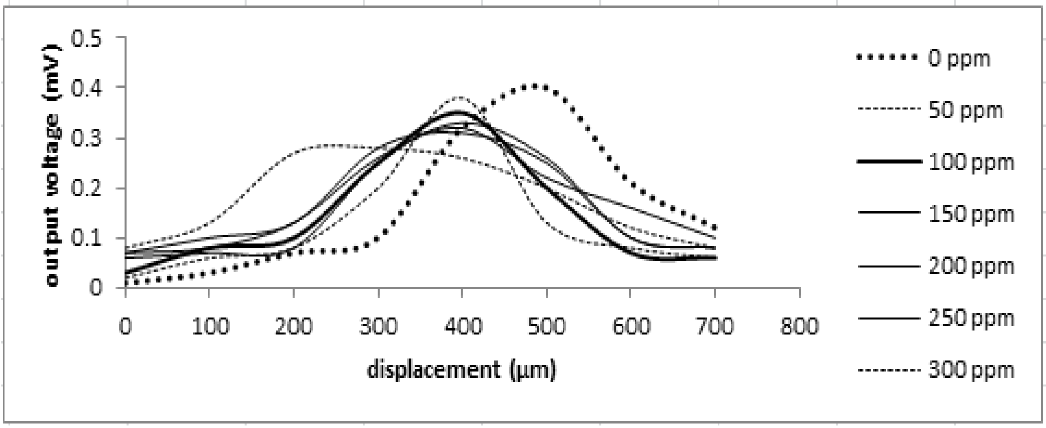

Figure 3. Output voltage against displacement for various concentration of cholesterol

Data detection output voltage detector began when fiber bundle placed the mirror coincided with the shift z = 0. The fiber bundle was placed on a micrometer position shifted every 50 µm. At each position shift detector output voltages were measured to obtain data such as output voltage detector as a function of shifting fiber bundle, so as to obtain the maximum output voltage of each of the various concentrations of cholesterol. The maximum output voltage value of variations in the concentration of cholesterol as in table 1.

Table 1.Maximum output voltage of the concentration of cholesterol

Data	Concentration (ppm)	output voltage(mV)
1	0	0.4
2	50	0.38

Data	Concentration (ppm)	output voltage(mV)
3	100	0.35
4	150	0.33
5	200	0.32
6	250	0.31
7	300	0.28

Figure4 showed that the peak voltages or light intensity showed a decrease linearly with the increase in the concentration of cholesterol with a sensitivity of 0.0004 mV/ppm and 97.5% of linearity.

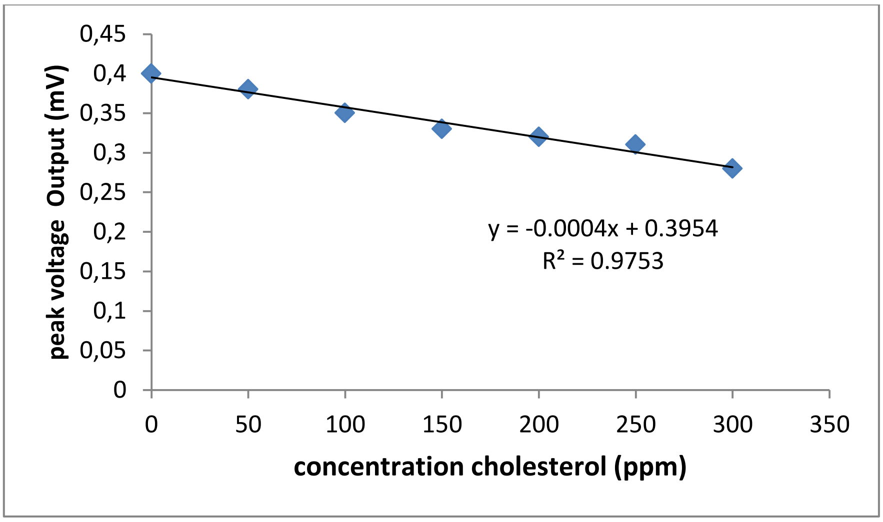

Figure 4. Peak voltage versus concentration of cholesterol

4. Conclusion

Optical fiber sensors based on intensity modulation for the concentration of cholesterol detection was presented. The results showed that the detection of the peak voltage decrease linearly with the increase in concentration of cholesterol with a sensitivity of the sensors 0.0004 mV/ppm and the linearity more than 97%.

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