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Optical Fiber Biosensor to Measuring the Blood Viscosity

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Abstract

Optical fiber biosensor for measuring Packet Cell Volume concentration (PCV) of human blood depending on the attenuation of light is designed and implemented during this work. Its present a simple and accurate method to measure blood viscosity. Three lasers' wavelengths have been used in this system. These lasers are He-Ne laser with (632nm) wavelength, (5 mw) power, laser diode with (532nm) wavelength, (20 mw) power and another laser diode with (430nm) wavelength, (20 mw) power. The system works by transmitting light through an optical fiber to the sample; the amount of light absorbed by the analyte is detected through a second fiber.

Keywords: optical fiber sensor, biosensor, packet cell volume (PCV), light attenuation.

جهاز استشعار الألياف البصرية لقياس لزوجة الدم

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الخلاصة

في هذا العمل تم تصميم وتنفيذ جهاز استشعار يعتمد على الالياف البصرية لقياس تركيز حجم الخلايا المضغوطة في دم الانسان بالاعتماد على توهين الضوء. يمثل الجهاز وسيلة بسيطة ودقيقة لقياس لزوجة الدم. في هذا الجهاز تم استخدام ثلاث اطوال موجية من ضوء الليزر والتي هي ضوء ليزر الهيليوم- نيون (632 نانومتر) وبقدرة (5 ملي واط) ودايود الليزر ذو الطول الموجي (532 نانومتر) وبقدرة (20 ملي واط) وكذلك تم استخدام دايود الليزر ذو الطول الموجي (410 نانومتر) وبقدرة (20 ملي واط). يعمل الجهاز عن طريق ارسال الضوء الى العينة عن طريق الليف البصري وكذلك استلام الضوء الخارج من العينة والكشف عن كمية الضوء المتنص عن طريق ليف بصري اخر.

الكلمات المفتاحية : مستشعر الاليلف البصرية، المستشعر البايولوجي، حجم الخلايا المضغوطة، توهين الضوء

Introduction:

The relevance of biosensors is growing rapidly in a wide number of research fields, as well as in industrial services and biomedical applications. Health, pharmaceutics, food control, and veterinary and other science sectors require the development of diverse and specific sensors. These devices may be based on different detection methods, electrical, optical, chemical, or mechanical. The optical fiber sensor is one of the most attractive biosensors, with a number of advantages such as high sensitivity, low-cost, high selectivity, light-weight, remote sensing capability, and electromagnetic immunity [1]. The intrinsic advantages of the optical fibers, such as high compactness and potential miniaturization, as well as high compatibility with optoelectronic devices (both sources and detectors) and, last but not least, multiplexing and remote measurement capability as the signal is spectrally modulated [2].

Optical sensors detect changes in optical parameters that depend upon the physicochemical parameters of the investigated environment. Optical fibers offer a convenient method for the implementation of optical sensing, by directing light to, and collecting light from, the measurement region, so called extrinsic sensors or by using the fiber itself as the transducer, so called intrinsic sensors. In general, OFS operate by measuring changes in light propagation caused by external stimuli ranging from physical parameters (strain, pressure, temperature) to biochemical parameters (analyte concentration, chemical composition) [3].

electroactive interference problems often appear in electrochemical sensors because some endogenous reducing species (e.g., ascorbic and uric acids) and drugs (e.g., acetaminophen) are electroactive. The limitation can be overcome by using optical fiber sensor technology due to its well-known immunity to electromagnetic interferences [3, 4].

Optical fiber Biosensors can be classified into different groups depending on the method of signal transduction: optical, electrochemical, thermometric, piezoelectric or magnetic. Optical biosensors are the most commonly reported class of biosensors. Optical detection is performed by exploiting the interaction of the optical field with a biorecognition element. Optical biosensing can be broadly divided into two general modes: label-free and label-based. Briefly, in a label-free mode, the detected signal is generated directly by the interaction of the analyzed material with the transducer. In contrast, label-based sensing involves the use of a label, and the optical signal is then generated by a colorimetric, fluorescent, or luminescent method [5,6]. Both fiber-optic and non-fiber-optic sensors experience additional interest ever since it was recognized that one of the advantages of optical sensing is based on the possibility of “sterile sensing”: biological samples, food, or bioreactors may be sensed through the walls of a (glass or plastic) container without the need of opening it or inserting a probe, both processes been known to be associated with a high risk of contamination [6]. In this work optical fiber biomedical sensor was designed and implemented for testing the packet cell volume (PCV) concentration. This system is based on light attenuation technique.

Experimental work

The set-up of that used to measuring PCV concentration consists of: Light source (laser): Three types of lasers have been used in this system selected according to the absorption spectrum of the PCV. These lasers are He-Ne laser with (632nm) wavelength, (5 mw) power, laser diode with (532nm) wavelength, (20 mw) power and another laser diode with (430nm) wavelength, (20 mw) power. Tow optical fibers and Optical detector.

Single drop of blood was taken to smear preparation slide to get PCV thin film. The sample (slide) prepared as smear preparation method has been sandwiched between light source and detector. The sample should be isolated from the environment, for this purpose two delivery optical fiber units are used. The sample (slide) is mounted in casted polymer piece. Figure (1) shows the experimental configuration. The laser beam approaches to the sample (slide) using optical fiber bundle. By another optical fiber bundle the light passes through the sample toward the photon detector.

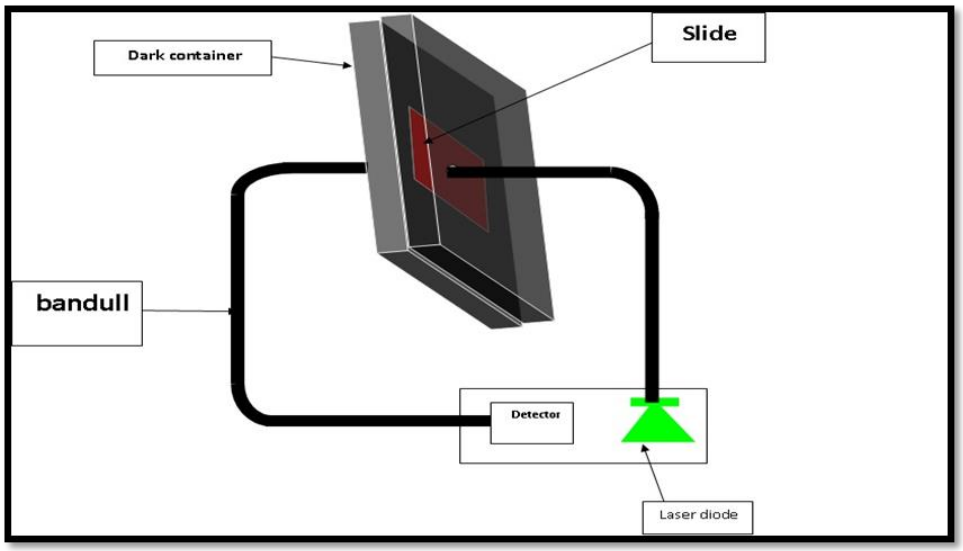

Figure (1): The schematic diagram of slides system setup

Results and discussions

Percent study shows the sensitive of PCV value in the human blood to three types of laser lights (410, 532 and 632) nm. Depending on PCV standard values using the same slide method Table (1) shows the PCV mean of patients and normal individuals.

Table (1) PCV mean of patients and normal individuals

Gender	Normal range [7]	Samples	
		Normal	Patient
Male	40-52	42.433	54.4666
Female	35-44	35.775	47.725

Figure (2) shows the efficiency of green laser light (λ=523nm) for diagnosis of samples significantly ($p< 0.05$), the mean value of I/I_0 is 0.7545 for the patient women group, while in normal individual I/I_0 is 0.95525.

Results highly show sensation of green light with highly blood viscosity for men group. The ratio I/I_0 was 0.753 for patient group, there's significant difference ($p<0.05$) from the normal individuals, which mean I/I_0 was 0.985667.

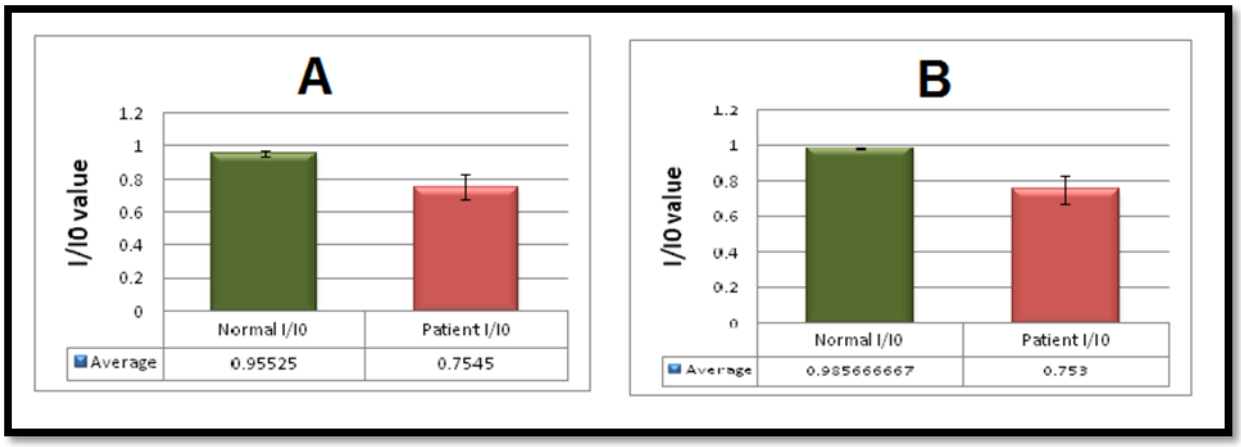

Figure (2): I/I_0 value of PCV, at (λ=532nm) depending on attenuation for (A) female and (B) male

Results highly indicate efficiency for diagnosis blood viscosity in women when using the violet laser light (410 nm), where the ratio of I/I_0 is 0.029333, while in normal case is 0.812333.

The transmittance of men groups I/I_0 equal to 0.274667 and 0.208 for patient and normal cases, respectively. The statistical analysis confirms that the difference between patients and normal women were highly significant ($p<0.05$) while no effect on the diagnosis of men group as shown in figure (3).

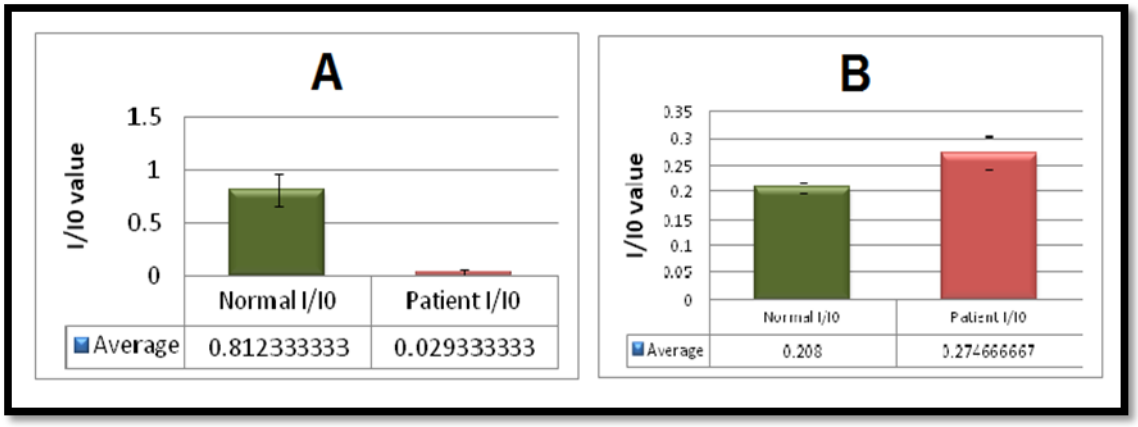

Figure (3): I/I_0 value of PCV, at (λ=410nm) depending on attenuation for (A) female and (B) male

Figure (4) shows no significant sensation for the difference of PCV average between patients with highly blood viscosity and normal individuals of women and men to the red laser light (532 nm). I/I_0 value for normal women 0.72525 and for patient are 0.6855, while I/I_0 ratios are 0.669 and 0.613333for patient and normal men, respectively.

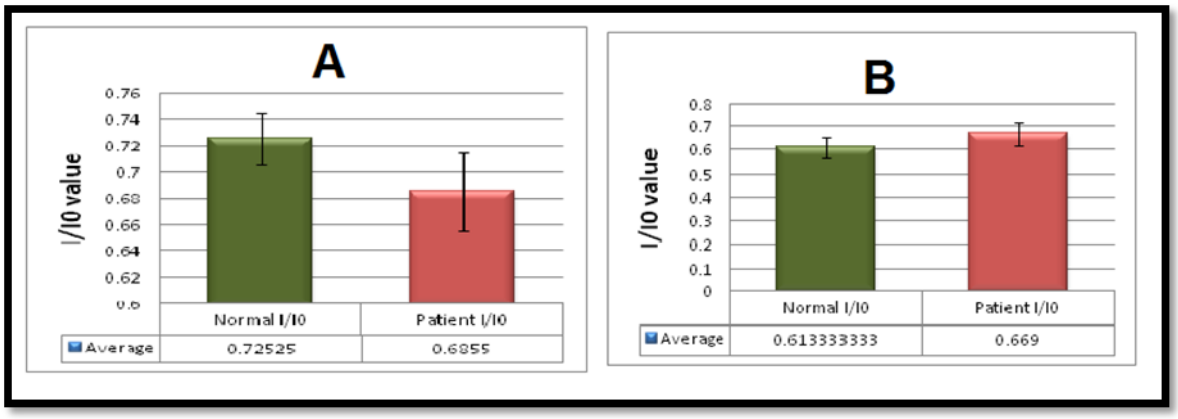

Figure (4): I/I_0 value of PCV, at (λ=632nm) depending on attenuation for (A) female and (B) male

Blood is composed of billions and billions of RBCs and Hb molecules, so the averaged saturation can take on any values from 0 to 100%. How well Hb is saturated with O2 depends mainly on the "partial pressure" of oxygen in the blood [8]. The higher the saturation (SO2) [9]. The dependence is described by an S-shaped "sigmoid" curve, common in the biologic sciences. This particular curve is called the Hemoglobin-Oxygen Dissociation Curve Hb absorbs O2 in the lungs (to form HbO2). As the RBC travels to the tissues, the HbO2 releases oxygen. The relation between concentrations of O2

and the saturation very strong and it changes with partial pressure. All measurement (absorbance and transmitted) should be done on the cardiac outlet.

The activity of present device for saturation sensing affected by two important factors. First related to the device component, and the light wavelengths. Each wavelength has different features give its ability to pass the organic materials, such us energy, or intensity differs from light to another.

The second factor related to the samples, as the samples' freshness, hemolysis, bilirubin contains for each sample, and the ability to absorb quantity of light used in this study [10].

Conclusion

From the above results we conclude that the light wavelength λ=532nm was very important in viscosity (saturation) diagnosis by using the blood film method for women and men, while the violet wavelength (410 nm) indicate highly efficiency for diagnosis blood viscosity in women but not useful to diagnosis the blood viscosity cases in men group. The study, proves that the λ=532 nm, doesn't affect to diagnosis the saturation cases.

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