Studying the effect of laser irradiation with different wavelength on absorbance of normal human blood

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Abstract:

The optical effects of laser irradiation on whole human blood were studied. The normal blood samples were taken from healthy persons and the blood samples were exposed to laser beam. Three wavelengths of continuous wave (CW) for diode pumped solid state lasers (DPSSL S) were used to irradiate the blood samples. The wavelengths are (632 nm, 532 nm, 473 nm and 405 nm) and output varied between (3.9, 50, 20 and 4.5) mW respectively. The laser exposure time fixed between (5 and 10) min for each wavelength. Laser radiation has a great role in the absorption properties of the normal human blood after being compared with absorption spectrum of a non-irradiated sample.

Keywords: Laser Irradiation, Absorbance spectra, Normal human blood, un-radiated sample

Introduction:

Laser beam radiation has been widely used in a variety of applications, such as, physical, chemical, biological, and medical fields [1], [2]. The advantage of using the laser beam in these fields is due to its distinctive characteristics. The laser emits intense, monochromatic, and coherent beam. Furthermore, the laser beam can be easily controlled and its highly collimated nature enables it to be focused into a small area to provide high incident intensity [3]. Investigation of the effects of interaction of laser radiation with biological tissues and blood is of great interest and has received considerable attention [4], [5].
It is shown that the laser beam irradiation is most useful in the biomedical applications and can be effectively used for the biological and medical treatments [6], [7]. It has been found that the laser beam can produce some optical and chemical effects when it interacts with the biological tissues and the human blood. These effects, in turn, will cause significant changes in the optical parameters of these biological tissues and human blood, such as, absorbance, transmittance, reflectance, absorption coefficient ($\alpha$), and refractive index ($n$) [5], [8]. It is found that these changes depend on the structure of the human body tissues, as well as the wavelength and the flounce (the dose) of the applied laser beam. There are several techniques can be used to examine the changes in the optical properties of the biological tissues and human blood and also to measure their parameters [9], [10]. Among these techniques, is the UV-Visible absorption spectroscopy, which is a simple, quick, non-destructive, and relatively accurate technique of analyzing biological materials [11]. With this technique, the absorption spectra of the biological tissue or the human blood samples are analyzed and recorded, before and after exposing to the laser beam, using a spectrophotometer. Although there are some of studies have been performed, using different techniques, to examine the changes in the biological parameters due to the interaction processes inside the biological tissues[13], but still more studies are needed to extend our knowledge and understanding about the responses of the biological tissues and blood to the laser radiation [12]. Such studies are essential to get further information regarding the chemical and physical properties of the biological tissues and human blood[14],[15].

**Experiment:**

Human blood samples were collected from 7 healthy persons, (5)ml of blood were taken from each person. These blood samples were collected in glass tubes containing Ethylenediaminetetraacetic Acid (EDTA) as an anticoagulant. The sample of the normal blood was divided into two tubes of samples with (2.5)ml to each tube for irradiation process and (2.5)ml used as un-irradiated sample (control sample), as shows in figure (1).

![Figure (1) : Experiment diagram](image-url)
Four continuous (CW) lasers that have different wavelengths 632 nm (red beam), 532 nm (green beam), 473 nm (blue beam), and 405 nm (violet beam), with different output power (3.9, 50, 20, and 4.5) mW respectively in fixed exposure time (5 and 10) min for each wavelength were used in this study.

The laser with (632 nm, 3.9 mW) was placed vertically at (7 cm) from the surface of blood and then the laser beam incident normally on the sample of blood and irradiated at fixed exposure time (5, 10) min separately.

From each tube before and after irradiation is taken a small drop of blood by capillary tube and deposited on glass slide to make a film on it and then the same process repeat for each wavelength.

The absorption spectra of un-irradiated and irradiated healthy blood film were taken by using double beam spectrophotometer (Cecil CE-7200) with range of wavelength (190 – 1100) nm.

Results and discussion:

Four groups of normal blood were irradiated with four wavelength of laser beam (632, 405, 473, and 532) nm for different output power (3.9, 4.5, 20, and 50) mW at fixed exposure time for each group. One sample of blood were left without irradiation and used as control sample. Fig (1) show the relation between wavelength and absorbance for wavelength (632 nm and 3.9 mW) at different exposure time (5, 10) min, from this figure it is clearly seen the absorbance of healthy blood sample affected by irradiated of laser beam and the magnitude of absorbance increased when the time of exposure increased from (5 min to 10 min) but this increasing is slight due to the low power of the laser.
Fig (1) : Absorbance spectra non radiated and irradiated blood sample for (632 nm, 3.9 mW) at (5 and 10) min

Fig.(2) shows the absorption spectra of blood sample for (non radiated – irradiated ) with the laser beam of wavelength ( 405 nm , 4.5 mW ) for different exposure time (5, 10) min. The values of absorbance of non-radiated blood sample (control sample) is clearly seen have a smaller value than absorbance of irradiated samples for two different exposure time, this means when exposing the blood sample to the laser beam, the absorbance will change and increase.

![Absorbance spectra non radiated and irradiated blood sample for (632 nm, 3.9 mW) at (5 and 10) min](image1.png)

Fig (2) : Absorbance spectra non radiated and irradiated blood sample for (405 nm, 4.5mW) at (5 and 10) min

From Figs (1), (2) and by comparison between them, the absorbance of irradiated sample increasing with the same range because of convergence of output power which leads to an increase in the same rate of absorbance values.

The absorption spectra of control blood sample and the irradiated blood sample with the laser beam of the wavelength (473 nm, 20 mW) for different irradiation times is shown in Fig.(3). The absorption value of irradiated sample increases significantly during the second time of exposure (10 min) because of the high increase in output power of the laser beam.
Fig (3) : Absorbance spectra non radiated and irradiated blood sample for (473 nm, 20mW) at (5 and 10) min

Fig.(4) shows the absorption spectra of control and irradiated blood sample with laser beam of wavelength (532 nm, 50mW) for different exposure time (5,10)min .The absorbance of irradiated sample for different times (5,10)min increasing from (5 min) to (10 min) where the peak of absorbance in (5,10) min at (415nm) but these values increasing gradually because of an increasing in time of exposure.
The absorbance of irradiated in figs (1),(2),(3) and (4) by comparison with absorbance of control sample of healthy blood affected by laser beam for different wavelengths , output power and exposure time and these factors influence on absorbance spectra .

**Conclusions:**

The Results illustrate important information about the change in the absorbance spectra between normal healthy blood sample (control) and irradiated normal healthy blood sample .

There are clear difference between absorbance spectra for all wavelength and output power at second period of exposure time (10 min ) because of an increasing in output powers of laser radiation were used and this illustrate in table (1) :

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**Fig (4) : Absorbance spectra non radiated and irradiated blood sample for (532 nm ,50mW) at (5 and 10) min**

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Table (1): Relation between output power and absorbance

| Output power (mW) | Wavelength (nm) | Time of exposure (min) | Peak of absorbance |
|-------------------|-----------------|------------------------|--------------------|
| 3.9               | 632             | 10                     | 2.39               |
| 4.5               | 405             | 10                     | 2.48               |
| 20                | 473             | 10                     | 2.7                |
| 50                | 532             | 10                     | 3                  |

References:

[1] N. Rubinov, "Physical Grounds for Biological Effect of Laser Radiation", J. Phys. D: Appl. Phys., 36.19 (2003) 2317-2330
[2] M. S. Strikman, K. Spartalia, and M.W. Cole, Applications of Modern Physics in Medicine, (Princeton University Press, 2014).
[3] O. Svelto, Principles of Laser, 5th Edition, (Springer Science + Business Media LLC, New York, USA, 2010).
[4] P. Di Giacomo, S. Oriando, M. Dell Ariccia, and B. Brandimare, "Low Level Laser Therapy: Laser Radiation Absorption in Biological Tissues", Appl. Phys., 112 (2013) 71-75.
[5] S. L. Jacques, "Optical Properties of Biological Tissues: A Review", Phys. Med. Biol., 58 (2013) 37-61.
[6] V. H. Ghadage and B. N. Zaware, "Study the Effect of He-Ne (He-Ne) Laser Irradiation on Normal Human Blood In vitro Using FTIR Technique", IOSR, J. Pharmacy and Biological Sciences, 13 (2008)1-5.
[7] H. Ma, Y. Yang, and S. Cherng, "Interaction of Excimer Laser with Blood Components and Thrombosis", Life Science (2008) 19-26.
[8] J. K. Barton, D. P. Popok, and J.F. Black, "Thermal Analysis of Blood Undergoing Laser Photocoagulation", IEEE J. Quant. Electron., 7 (2001) 936-943.
[9] Salam Hussein Ewaid et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 790 012075
[10] Y. Cui, Z. Guo, Y. Zhao, Y. Zheng, Qiao, J. Gai, and S. Liu, "Reactive Effect of Low Intensity He-Ne Laser Upon Damaged Ultra Structure of Human Erythrocyte Membrane in Fenton System by Atomic Force Microscope" Acta Biochimica et Biophysica Sinica, 39 (2007) 484-489.
[11] Salam Hussein Ewaid et al 2020 J. Phys.: Conf. Ser. 1664 012143.
[12] T. Chelidze, "Dielectric Spectroscopy of Blood", J. Non-Crystalline Solids, 305 (2002) 285-294.
[13] M. Qiany, J. Chen, Z. Junliang and L. Welzhou, "In Vitro Effects of He-Ne Laser Irradiation on Human Blood: Blood Viscosity and Deformability of Erythrocytes", Photo Medicine and Laser Surgery, 22 (2004) 477-482.
[14] Salam Hussein Ewaid et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 722 012008
[15] Sadiq H., Kaiser N., Wajeja A. Aldayem, Kaiser M., "Antibacterial effect of silver nanoparticle on Pseudomonas aeruginos bacteria", International journal of chem tech research, vol.9,No.11 pp 382-390, 2016.
[16] Sadiq H., Dakhel ghani omran, Wajeha A. Aldayem, zaman hameed, "The effects of laser 532nm with 4mW and 650 nm with 135 mW on physical properties of human serum proteins in vitro", Journal of physics: conference series, 2021.

[17] W. A. Hendrickso, "X -Rays in Molecular Biophysics", Physics Today, 48 (1995) 42-50.

[18] K. Wilson, and J. Wlaker (Eds.), Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition, (Cambridge University Press, Cambridge, UK, 2018).

[19] Salah, A. (2020). The New Combination of Semi-Analytical Iterative Method and Elzaki Transform for Solving Some Korteweg-de Vries Equations. Al-Qadisiyah Journal Of Pure Science, 25(1), Math. 23 -26.

[20] Ali, W., & R. Annon, M. (2020). Biological Effective of organic solvent extracts of Mirabilis jalapa Leaves in the Non-cumulative for mortality of Immature stages Culex quinquefasciatus Say (Diptera : Culicidae). Al-Qadisiyah Journal Of Pure Science, 25(1), Bio 1-6.

[21] Sami Abd ali, mohammed, Shaker Hussein, A., & mohammed hadi, H. (2020). Study The Current Density-Voltage (J-V) Characteristics of α-Fe2O3 Thin Film Prepared by Spray Pyrolysis Technique. Al-Qadisiyah Journal Of Pure Science, 25 (1), Phys 1-7.