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Study the Effect of the Homemade Nitrogen Laser System in Medical Field

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Abstract

A high power N₂ laser of the three stage-Blumlein circuit designed, which consist two identical electrodes, four capacitors and three spark gaps which designed discharge geometry with minimum inductance. This system gives a maximum energy 18 mJ with a pulse time 6.65 ns and wave length 337.1 nm. The distance between spark gap terminals has large effect on the output energy. The ideal distance were 11 mm between the terminals for the first spark gap and 4 mm between the terminals for the second spark gap, the distance between the terminals of the spark gaps has a significant effect on the resulting energy, where the energy decreases when the distance between the terminals of the first and second spark gaps exceeds or Less than from the optimum distances. The effect of N₂ laser on the viability of Staphylococcus that isolated from wounds, the samples of bacteria were irradiated with 337.1 nm .N₂ laser using 10 pulses/second repetition rates at 10,15 minutes exposure times. The results showed that the viability of bacteria decreased with increasing the exposure time to N₂ laser.

Keywords: Nitrogen laser, Staphylococcus aureus, Bacterial susceptibility.

دراسة تأثير منظومة ليزر نيتروجين محلية الصنع في المجال الطبي

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الخلاصة

تم في هذا البحث تصميم منظومة ليزر نيتروجين باستخدام دائرة بلوملين ذات ثلاث مراحل والتي تتكون من اثنتين من الاقطاب الكهربائية المتطابقة واربعه متسعوات وثلاث فجوات قدح والتي تم تصميمها هندسيا مع اقل قيمة للحث. أن هذه المنظومة تنتج اعلى طاقة 18 ملي جول مع زمن نبضه 6,65 نانوثانية وبطول موجي 337,1 نانومتر، أن المسافة بين اقطاب فجوات القدح له تأثير كبير على الطاقة الناتجة، ان المسافة المثالية بين اقطاب فجوة القدح الاولى كانت 11 ملليمتر و لفجوة القدح الثانية 4 ملليمتر ، حيث نقل الطاقة عند زيادة او نقصان المسافة بين اقطاب فجوات القدح الاولى والثانية عن المسافة المثالية. تم دراسة تأثير ليزر النيتروجين الناتج من هذه المنظومة خلال هذا البحث حيث تم تسليط شعاع الليزر على بكتريا المكورات العنقودية المعزولة من الجروح بفترات زمنية من التعرض بحدود 10 و 15 دقيقة وبمعدل تكرار 10 نبضة لكل ثانية، لقد بينت النتائج ان نمو ونشاطية البكتيريا يقل مع زيادة فترة التعرض لشعاع ليزر النيتروجين.

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1. Introduction

There are many previous literatures that described the effect of both coherent and incoherent electromagnetic light radiations on the immune response. Some of these projects shown that exposure to UV light will induce systemic immune on resistance of the damage from foreign substances. Cellular immune response is the important factor that share to the elimination of antigen from infective area [1, 2]. Optical treatment and sample preparation is possible without any mechanical connects, i.e. sample treatment in a closed, disinfected environment without any danger of contamination, the evaporation or infection. the biological creatures are transparent for the some type of laser wavelength and the active laser energy is centered on the minute focal spot, it is even possible to work inside a living cell [3, 4].

UV-light cause the damages to DNA, which stop the microorganism from DNA transcription and replication by forming thymine dimers which leads to cell death [5,6]. One of source UV radiation the laser which displays three important characteristics: it is coherent (all the wave group are exactly in the same phase, in time and in space), collimated (the radiation beam is parallel), and monochromatic (all photons have the one wavelength)[7]. To understand the interaction between laser light and biological tissues , the physical parameters of the biological creatures must be related to the parameters of the laser type, the extent of the effect depend on the features of the tissue, which are determined by the structure, water content, and blood circulation, that is, absorption, scattering, reflection, thermal conductivity, heat capacity and density, as well as on the parameters of the laser beam, that is, its power density, energy, number of pulses, and wavelength [8].

Some of literatures mentioned that a pulsed N₂ laser with emission wavelength 337.1 nm was used for photodynamic detection of tumor tissues and mentioned about the using of N₂ laser as a source in the photodynamic therapy of brain tumors[9, 10].TEA(Transverse Excited Atmospheric) N₂ laser transverse arrangement mode of electrodes is used for the discharge because of its more efficient. An ignition system in the form of spark gap is used to short the Blumlein circuit. The optimization of the configuration of spark gap, and effects of spark gap inductance during its resistive phase period on the performance of N₂ laser system are optimized [11].

Staphylococcus aureus is one of a typical Gram-positive bacterium, which has a thick cell wall compared to another type of gram-negative bacteria[12]. discovered in 1880's has been showed to be a pathogen which causing infections such as minor skin infections and after -operative wound infection. Almost all species of staphylococci may be present in the margins or conjunctiva as ordinary commensals without causing disease and they may cause severe eye contagion which may result in blindness[13].

2. Experimental Setups

2.1 Designed of laser system

The TEA N₂ laser system setup which is consist from four main parts capacitors, spark gaps, resistors and laser channel.

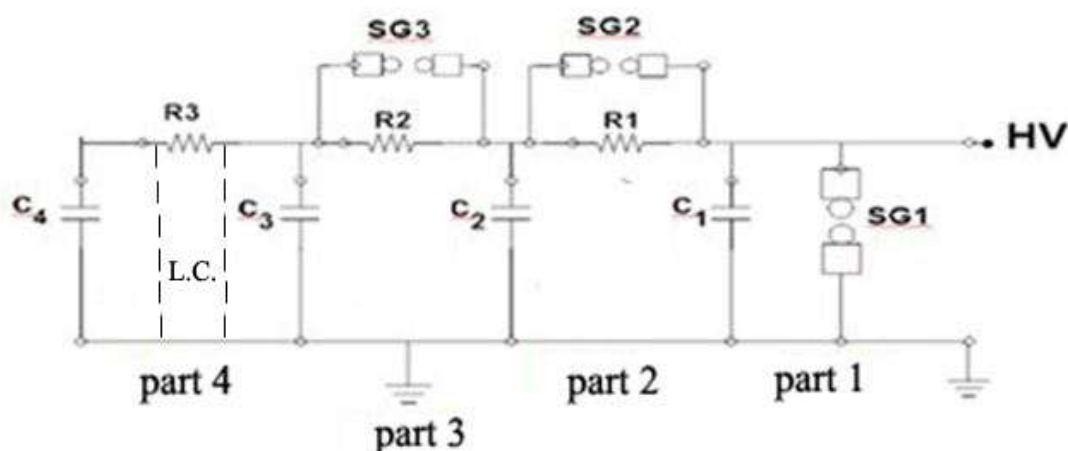


Figure 1- Schematic diagram of electrical circuit of N₂ laser system.

In Figure-1 showed four parts to operate this system, in part1 C1 to the ground via the first spark gap SG1, part2 connect C2 into C1 via the second spark gap SG2, part3 connect C3 into C2 via the third spark gap(SG3), and part4 connect C4 into C3 when the laser channel fires, The four parallel plate capacitors are electrically connected through three resistors with value 390Ω . A high DC voltage source is connected to the first capacitor through first spark gap, which charged through resistors.

A four of parallel plate capacitors C1, C2, C3 and C4 of total capacity 7.58 nF are formed from the two copper plates and a common foil of epoxy as a dielectric. The laser channel is formed between the parallel identical electrodes that made from brass metal which attached C3 and C4. The geometrical construction of free running spark gap optimized by employing various shapes of brass screws, i.e. circular ends in Perspex vacuum , whose one terminal is connected to the common copper while second terminal to upper plate C1. To obtain the uniform electric discharge between the electrodes, the alignment of the two electrodes and the edges are cleaned and optimized to micro level.

As the applied voltage arrived the threshold value of breakdown through first spark gap, the discharge occurs across the first spark gap which short the capacitor C1 while at the same time, the resistors kept the voltage in the other capacitors C2, C3 and C4 highly charged. This process continuous at these capacitors until final discharge that accurse between laser channel, therefore a high potential difference appeared between the electrodes which produced high electric field to accelerated the electrons and collision with N_2 molecules to pump to the upper lasing level.

2.2 Medical application by N_2 laser system

One type of bacteria isolated was obtained, Staphylococcus Aureus, a Gram-positive from Ramadi Teaching Hospital. These isolated was diagnosed using Vitek device and the bacterial isolated saved in Nutrient agar slant at refrigerator temperature until use. The samples were transferred from a medium containing the bacteria (previously isolated) to a transparent 1.5ml tube under sterile conditions that were kept in the refrigerator until they were used for irradiation. Three samples were prepared for the purpose of irradiation, these bacteria placed in each tube up to 0.3ml of isolated bacteria. After the preparation of the samples, the N_2 laser system was prepared in terms of arrangement and cleaning, and then we installed the carrier carrying the tubes of the container to the bacteria. Then the first tube was placed on the carrier directly to the laser channel to ensure arrive the greatest possible radiation from the laser on the tube.

After the laser system was operated at an energy limit of 18 mJ. The samples were irradiated with different exposure periods of 10 minutes and 15 minutes for each type of bacteria. After irradiation, the bacteria were kept in the refrigerator until they were planted in the feeding media. The bacteria were planted separately in plastic plates. Staphylococcus aureus was planted in dishes containing a blood-feeding medium (Blood Agar) under sterile environmental conditions where the bacteria was cultured in a planning manner and then placed in the incubator for 24 hours.

3. Results and Discussion

3.1 The output energy of N_2 laser system

he homemade model high-tension voltage dc power supply used as an electrical pumping source in range from 12kV to 24kV. The important values which effect on the output energy applied voltage from power supply , inerelectrode distance , distance between spark gap electrode and N_2 gas flow through laser channel.



Figure 2- N₂ laser beam.

The best value of energy was 18mJ thus the laser beam showed in Figure-2, at the optimum values were ,the flow of N₂ gas at the best value was 13L/min, the value of the voltage which applied to the system was 24kV and the distance between the electrodes at 3.5mm, but the effect of changing the distance between the spark gap electrodes was examined with the stability of other parameters. The variation output energy as a function to the spark gaps distance showed in Table-1 and Figure-3, the spark gaps Can be considered a type of capacitors that used to stored and discharge the charges when the breakdown voltage arrived then these switches considered important factor in and step of electric discharge.

Table 1-Variation the energy as a function to change terminals distance for SG1 and SG2.

Distance(mm)	Energy (SG1)mJ	Energy(SG2)mJ
1	--	--
2	--	3.1
3	--	12.7
4	0.77	17.2
5	1.3	8.9
6	5.8	1.4
7	9.9	--
8	14.3	--
9	18	--
10	15	--
11	6.3	--

When the gap between the spark terminals are very less, the population inversion can't occurred because of the inadequate excitation of molecules, but the distance between the spark gap terminals of the SG1 is greater than the distance between the terminals of the SG2 showed in Table-1, because the charges that are discharged from the C1 are greater and therefore need more space to delay the discharge in the SG2.

Figure-3 showed the variation in energy as a function of the distance between the terminals of the first spark gap (SG1) and second spark gap (SG2). The distance between terminals for SG1 began from 4mm to 11mm to produce energy but for SG2 the distance began from 2mm to 6mm,therfor the distance for SG1 larger than SG2 because the charges transition with large voltage but in SG2 to be

smallest. From this figure, the energy at the small distances is minimum value because the discharge and charge process is fast so that the of breakdown of the dielectric between the terminals is easy due to the electric field is high, which does not lead to the charging of capacitors, and arrived a small current within the laser channel and the reverse distribution process does not take place.

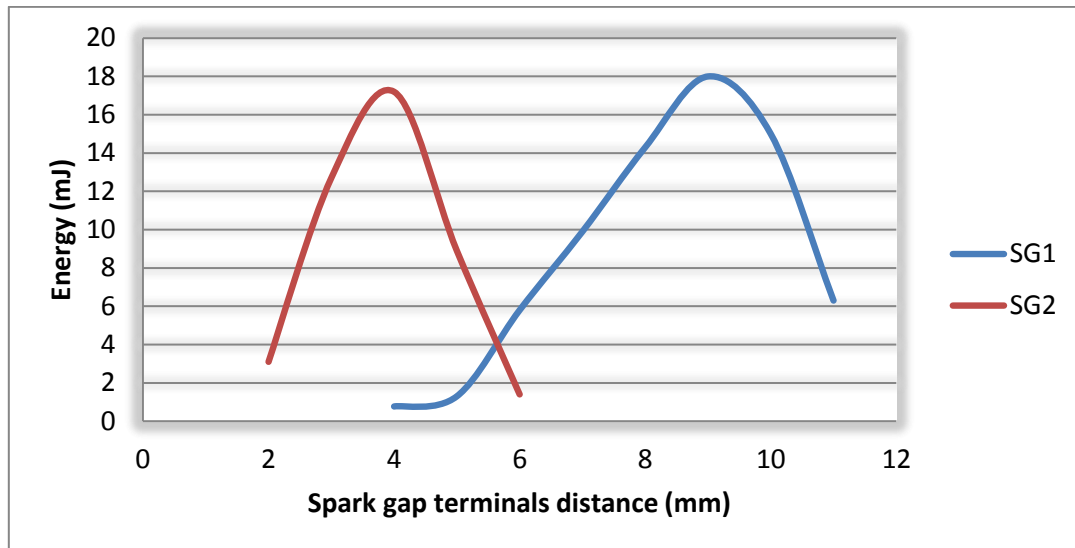


Figure 3-Variation energy as a function of distance terminals for first and second spark gaps.

The energy increases at the distance between the terminals of the spark gaps increases because the inductance of the dielectric between the electrodes begins to decrease so that the storage charges in the terminals becomes larger, which lead to charge of the capacitors more and ensure arrive the higher current to the laser channel. The energy increases rapidly until it reaches the best value at a distance of the SG1 (9mm) and a distance (4mm) for the SG2. At this time the third spark gap with constant value at 1mm distance between its terminals this small value due to small discharged charge between C_3 and C_2 .

3.2 Activity of N_2 laser in medical field

In our project used N_2 laser Staphylococcus isolated from the urinary tract, were irradiated by N_2 laser with exposure time 10 minutes and 15 minutes, at output energy 18mJ, pulse time is 6.65ns and wavelength is 337.1 nm. The effect of irradiation is evident in Figure-4 Staphylococcus aureus is treated with a time period of 15 minutes while Figure-5 had an irradiation time of 10 minutes and with 10 pulses/second repetition rates.



Figure 4- Staphylococcus aureus with 15 min exposure time by N_2 laser.

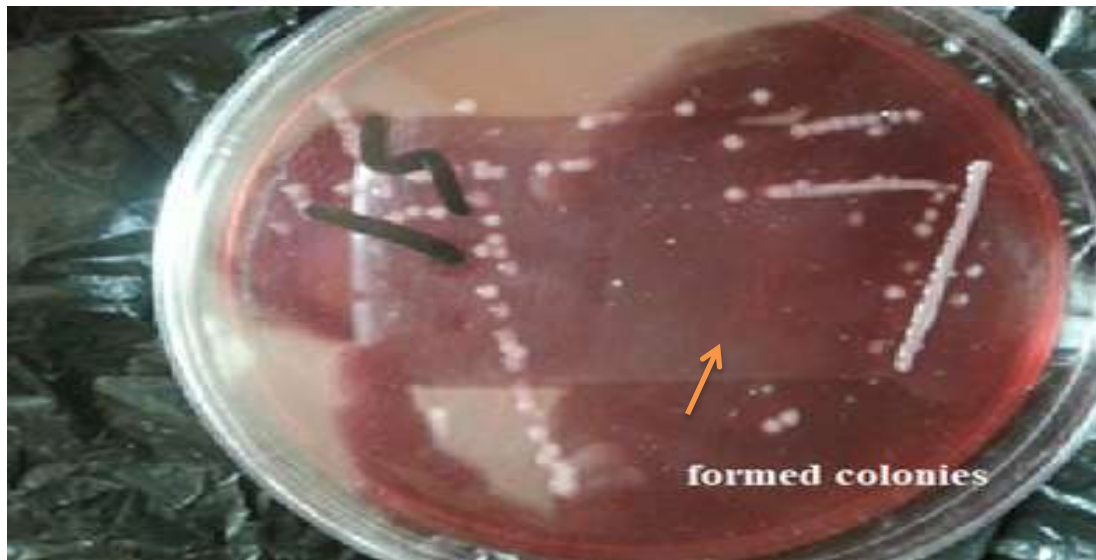


Figure 5- Staphylococcus aureus with 10 min exposure time by N₂ laser.

Therefore the colonies formed with longer time exposure (15 minutes) was less than the growth of the colonies formed with shorter time exposure(10 minutes),thus that the longer the irradiation time lead to formed lees colonies because the killed bacteria become larger while some bacteria were not affected by the radiation the reason may be either the bacteria turned into resistant bacteria or that irradiation was not ideal to expose all bacteria in the tube to laser radiation

While in Figure- 6 normal growth of the bacteria is observed when it not exposed to laser radiation and the colonies formed were more than the two previous forms exposed to N₂ laser radiation



Figure 6- Normal growth of staphylococcus aureus without exposure by N₂ laser.

The reason for the weak growth of bacteria when exposed to laser radiation is that ultraviolet radiation affects the purines and Pyrimidines that are present in the DNA and RNA which absorbs this radiation. A clear effect in the growth of bacteria, where the greater the irradiation period the less the growth of bacteria and this means that the resulting laser has change the effect of these two types of bacteria from resistance to sensitivity.

4. Conclusion

In this research, a three stage-Blumlein circuit nitrogen laser system was designed with three spark gaps, when the distance increased or increased more than the ideal distances of the terminals for both spark gaps SG1 and SG2, the energy reduce due to the increasing in induction, while the distance between the terminals of the first and second spark gaps reduced the energy also reduce because the capacities are not sufficiently charged,

The Irradiation with N₂ laser beam at 337.1 nm was to decrease growth staphylococcus aureus, irradiation. The results of irradiation processes prove have the significant effect on bacteria and this effect is showed the decreasing numbers live bacteria with increased dose or exposure period. The method of sterilization by N₂ laser is more effective in killing the bacteria and the possibility of obtaining more killing compared to the methods other sterilization.

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