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FEN BİLİMLERİ ENSTİTÜSÜ

SURFACE CLEANING BY PLASMA FOR NANOTECHNOLOGY

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MSC. THESIS
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TEZ ONAYI

Mohammed Al-mamoori tarafından hazırlanan **" Surface Cleaning by Plasma for Nanotechnology"**adlı tez çalışması aşağıdaki jüri üyeleri önünde Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü **Fizik Anabilim Dalı**'nda **YÜKSEK LİSANS TEZİ** olarak başarı ile savunulmuştur.

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COMMITMENT

This thesis is written according to the academic and ethical principles involved in the thesis and declare that all reference to the literature used .

Mohammad AL - MAMOORI

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ABSTRACT

MSc. Thesis

SURFACE CLEANING BY PLASMA FOR NANOTECHNOLOGY

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In this study I will explain how the plasma and the hydrogen peroxide can kill bacteria. This process is need 5- 8 phases, it depends on the kind of system.

We designed small system as a symbol of Sterrad 100x system the system consisting air pump, power supply, chemical solution (hydrogen peroxide) and chamber.

I will put the medical tool in the chamber and then I will use (100-500) w for power supply, 50 KHz for power supply and 10^{-3} for pressure. Hydrogen peroxide will diffuse inside the chamber. Finally we analyzed the chamber content by using optical emission spectroscopy.

2015, 29 pages

ÖZET

Yüksek Lisans Tezi

NANOTEKNOLOJİDE PLAZMA İLE YÜZEY TEMİZLİĞİ

Mohammad AL – MAMOORI
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Bu çalışmada plazma ve hidrojen peroksid'in bakterileri nasıl öldürdüğünü açıklayacağım. Bu işleyişin, sistemin çeşidine göre 5-8 aşamaya gereksinimi var .

Biz, sistemli oluşan hava pompası olan Sterrad 100x sistemini sembolize etmek üzere küçük çaplı bir, güç tedariği, kimyasal çözelti (hidrojen peroksit) ve odadizayn ettik.

Tıbbi aleti odaya koyacağım ve güç tedariği için (100-500)w, 50 KHz kullanacağım ve basınç için 10^{-3} kullanacağım. Hidrojen peroksit oda içerisin de yayılacak. Sonuç olarak optik emisyon spektroskopisi kullanarak oda içeriğini analiz ettik.

2015, 29 sayfa

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Mohammed AL-MAMOORI
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LIST OF SYMBOLS

ASP	Auto sterilization plasma
C	Temperature
DC	Direct current
EO	Ethylene oxide
H2O2	Hydrogen peroxide
HPGP	Hydrogen peroxide gas plasma
ICP	Inductively coupled plasma
KHZ	Kilo hertz
LPP	Laser product plasma
MIP	Magnetically induced plasma
NI	Ionized nitrogen
NII	single ionized nitrogen
NIII	Double ionized oxygen
OES	Optical emission spectroscopy
OI, O	Ionized oxygen
OII,	Single ionized oxygen
OIII	Double ionized oxygen
SAL	Sterility assurance level
TV	Television
UV	Ultra violet
W	Watt
^	Lambda

1.INTRODUCTION

1.1. Definition of Plasma

Plasma is al known as the fourth state of matter. It is compose the main part of the universe. The best natural plasma phenomenon known's in Earth atmosphere is lightning. The theoretical result is first shown in about 1750, when Benjamin Franklin suspecting that lightning is an electrical current and conducted experiments with a kite. Also other natural phenomenon is the Aurora Borealis. Natural and human being made plasmas occur over a wide range of pressures, electron number densities and temperatures (Charles, 2003).

Plasma happen naturally, plasmas can also be human made, in the laboratory and the industry. The applications electronics of Plasma can be found in television screens, lasers, lamps of fluorescent, computer and cell-phone hardware and more recently, in applications of medical. The ionized gas was made by of ions, electrons and neutrals called plasma. It is most commonly categorized either on the basis of temperature or electron-number density. Laboratory plasmas can be distinguished into two categories: high-temperature plasma and low-temperature plasma (Hastings et. al. 2000).

1.2. Sterilization Process

We can explain sterilization as any processing that removes all microorganisms clinging to a surface .Sterilization destroys all micro-organisms. That sterilization can kill everything Certainty. The term ‘micro-organisms’ covers a broad spectrum of pathogens, including bacteria, viruses, fungi, prions and endospores. Plasma Sterilization is fast evolving into a sought after method of sterilization in multiple industries: healthcare, medicine etc. plasma has different methods of sterilization such as microwave, inductive and capacitive plasma (Tietjen, et. al. 1992).

1.3. What is Nanotechnology?

It is generally knows that Nanotechnology is an engineering branch that deals with things smaller than 100 nanometers, especially with the individual molecule's manipulation. Furthermore, Nanotechnology mainly means the matter, it is also tiny and ranging about (10^{-9}) m. There are some hidden physicals properties of nature in nanotechnology that exist at the atomic level. The core or origin of this matter is reducing the size. In other words, there is changing for chemical and physical of properties of matter. In the newly come years the study of Nanosystem increased not only for the reason of properties unique but also that we are able to use it in many new technologies. In addition, Nanotechnology and nanoscience are fields that is considered closely associated with economic growth income. There is still comparatively a little work done about how research organizations ways this rising field of science as well as technology. Whereas there are whole lot of studies arguing the future potential or possible dangers and risks of research. The development in nanotechnology may not be understood by many people and also to what this technology lead or head to. Many say successful innovations, creativity and inventions that shift the way how we live do arise to be a departed conclusion. But is there really one mode of knowledge generation and translation that applies to firms of nanotech industry? What do we really know about patterns of renewal in Nanotechnology and nanoscience? Can we really speak of successful discoveries in the area? Can we already see an emerging nanotech industry?
(Meyer, 2007).

The discovers that some Scientists have come to is materials at small dimensions, small particles thin films etc. Nanotechnology maybe has different momentous properties than the same materials at larger scale. Through interpreting these differences and learn the ways to control the assembly of small structures so we come to a countless possibilities for amended devices, structures and materials. Nanotechnology includes many different views. However, most generally agreed that there are three important things:

1- Control the structure and composition on the nanoscale in order to control the properties.

2- Due to its small size, it has a rare properties

3- Nanotechnology is measured in 100s of or less so, it is a small size.

Features of nanostructures objects with nanometer scale are neither new nor the first created by man. For instance nanostructure is found in the way plants and animals have developed. Due to the features of nano, we found similarity among Nanoscale materials catalysts, porus materials and some of minerals, soot particles they have unique and special features. The new about nanotechnology is that we have the ability now at minimum partially understand and control these structures and properties to make new functional materials and devices. We have entered the era of engineering nanomaterial's and devices. Nanotechnology became such an important thing that jumped into our lives and came to be useful in many fields. Thanks to the Nanoscience, almost every human-made object nature will change in the next century. There are two ways to recognize the researching of nanotechnology and the environment. The first is the influence of nanomaterial's on the environment and human health whereas the second is how nanomaterial's can be used to benefit the environment. The resources recorded here cover both sides of the topic (Collins et.al. 2011).

The word nanotechnology is new. It consists of the prefix "nano" which refers to a billionth (10^{-9}) nanotechnology. It deals with the different dimensions' structures of the matter's order which is in its role as old as life. Therefore, plasma was one of the states that had a relationship with nanotechnology (Charles et. al. 2003).

1.4. What Is Plasma?

Plasma is an electrically neutral ionized gas, it consist of free separately electrons and ions; different from solids, liquids and normal gases. There are more types of plasma that we will explain through this chapter. The question here is, when does this ionization occur? It happens when the temperature is hot enough and it balance between collisional ionization and recombination. Plasma interpret an electrically neutral gas in an electric discharge; distinctly different from solids and liquids and normal gases. In other words, a plasma is one of the four basic states of matter, the others being solid, liquid, and gas. Plasma has non similar properties apart from the other states.

The gaseous state of hot ionized material mainly consisting of ions and electrons. We can find plasma when heating a gas or subjecting it or put it to a strong electromagnetic field applied with a laser or microwave generator. This process will either decreases or increases the number of electrons, producing positive or negative charged particles which is called and known as ions, and is followed by the separation of molecular bonds if there are any (George et. al.1990).

Plasma does not have a definite shape or volume unless enclosed in a container. Unlike gas, under the influence of a magnetic field, it may form structures such as filaments, double layers and beams. In addition to that, the entity of a significant number of charge carriers makes plasma electrically conductive so that it responds strongly to electromagnetic fields.

Plasma can be found in three criteria:

1-Plasma frequency: The electron plasma frequency is larger if it's compared to the electron-neutral collision frequency. Electrostatic interactions dominate over the processes of ordinary gas kinetics when this state is valid finally.

2-The plasma approximation: Rather than just interacting with the closest particle (these collective effects are a distinguishing feature of plasma), the charged Particles should be close enough that each particle effects many nearby charged particles. When the number of carriers within the sphere of effect (called the Debye sphere whose radius is the Debye screening length) of a particular particle is higher than unity to provide collective behavior of the charged particles, the plasma approximation is valid. The average number of particles in the Debye sphere is given by the plasma parameter, [ambiguous] "Λ" (the Greek letter Lambda).

3-Bulk interactions: The Debye screening length is shorter if it's compared to the physical size of the plasma. In This standard we can see that interactions in the bulk of the plasma are more important than those at its edges, where boundary effects can take place. The plasma is quasi neutral when this criterion is satisfied (Bendy, 1990).

1.5. Common Forms of Plasma

1.5.1. Artificially produced:

a- This kind of plasma is found in displays like TV screens.

b- There is inside of fluorescent lamp kind of plasma (low energy lighting).

c- Exhaust of rocket as well as thrusters ion.

d- The area situated in front of spacecrafts heat shield during re-entry into the atmosphere.

e- Inside a corona discharge ozone generator.

f- Research of liquefaction energy.

g- The electric arc which happen in lamp arc or arc welder etc.

h- Plasma ball / plasma sphere or plasma global.

i- Tesla coils also produce arcs.

j- There is kind of plasma used in semiconductor device fabrication.

k- Laser produced plasma (LPP) reached when high power laser interact with materials.

l- ICP (Inductively coupled plasma) usually we can get it from argon gas.

m- MIP (Magnetically induced Plasma), produced by using microwaves as a resonant coupling method.

n- Static electric sparks or static electricity (electricity produced by friction)

1.5.2. Space and astrophysical:

a- We can find this in the sun and other stars which means plasmas heated by nuclear fusion

b- The solar wind (the steam of protons moving radially from the sun)

c- The space between planets

d- The interstellar medium (space between star systems).

e- The space between galaxies (intergalactic medium).

f- Accretion discs.

g- The Io-Jupiter flux tube.

h- Interstellar nebula (the space between stars).

1.5.3.Terrestrial plasma:

A - Upper- atmospheric lightning.

B - Sprites.

C - Polar aurorae.

D - Ionosphere.

E - Plasma sphere.

F - Some of the flames or blazes (Hastings et. al. 2000).

1.6. Plasma's Sterilization

The first report dealing with low-pressure plasma sterilization was published in 1968.The plasma sterilization is proceeding at low temperature without damaging polymeric materials. Furthermore, the low-pressure plasma can be generating is by radio frequency and microwave discharges, so plasma should be create in a non equilibrium state. Moreover, the front process of low-pressure plasma state is the electron bombardment. However, the plasma enthalpy and UV radiation are not intense resulting to the duration of a vacuum process treatment must be large for it to be proficient (typically tens of minutes, and sometimes it can be hours) (Menashi, 1968).

A new sterilization method which is low-temperature plasma sterilization is capable of killing microorganisms more quickly and also less damaging to the material (Chau et. al.1990).

2. HISTORICAL REVIEW

2.1 Historical of Nanotechnology

The growth of nanotechnology which is the latest defined as an allocated neoteric development in scientific research, was brought in 1981 and caused by the assemblage of experimental advance such as the invention of scanning tunneling microscope in 1981 and fullerenes discovery in 1985 with the exegesis and popularization of commercial work for the aim of nanotechnology beginning with 1986 publication of the book engines of creation. Nonetheless, nanotechnology did not develop into a field until 1980s, since the development of its central notion happened over a long period of time. In 1979, a scientist at the Massachusetts Institute of Technology named Eric Drexler expanded upon Feynman's vision of molecular manufacturing with contemporary developments in understanding protein function. Many believe that this is when the field of nanotechnology was created (Reineke, 2012).

Accordingly, K. Eric Drexler (mathematical American scientist) put his book "engines of creation" in 1986 .He explained the basic notion of nanoscience. Also his book was succeeded in drawing attention to the technique: THE NEXT NANOTECHNOLOG AGE which was released 1986, NANOSCALE SYSTEM, MACHINARY, MANUFACTURING AND MOLECULAR COMPUTING, which was released in 1998. The eights was important for nanotechnology because it witness the birth of science of staphylococcus and the invention of tubular scanning microscope , these development have let the discovery of Alfoloren by scientist from the university Sussex and rice , named for Dr. Richard fuller's name shortly after the discovery of carbon. The discovery of a new physical phenomenon for the first time was in 1990 a nanotube in NECS electronics industry in Japan by the world sumio to Lijima, when he was studying ash from the electrical discharge between two electrodes of carbon using a high- efficiency electronic microscope process, and the result was that he had found the carbon particles take arrangement like the pipes inside each other (Drexler, 1981).

Nanotechnology though is the realization and leading of matter at dimensions of nearly 1 to 100 nanometers, where unique phenomena enable new applications. Includes Nanoscale science, engineering and technology, nanotechnology includes imaging, measuring, modeling, and manipulating matter at this length scale. At the Nanoscale, the physical, chemical, and biological properties of materials differ in fundamental and valuable ways from the properties of individual atoms and molecules or bulk matter. Nanotechnology is directed toward understanding and creating improved materials, devices, and systems that profiteering these new properties. Simultaneously, Working at the atomic, molecular and supra-molecular levels, in the length scale of roughly 1 – 100 nm range, through the control and treating of matter at the atomic and molecular level in order to lay out, create and use materials, devices and systems with fundamentally new properties and functions because of their small structure (Charles et. al. 2003).

3. LITERATURE REVIEW

3.1. The Discovery of Bacteria

Before the discovery of bacteria, its existence was considered very possible among many people. Therefore, the actual proof of bacteria's existence was the development and construction of a compound microscope that is suitable for the observation and study of forms of microbial life. In addition, this achievement must be appreciated from the Dutch pioneer microscopist Antonj Van Leeuwenhoek who was among the first to recognize cells in animals also he was the one who gave the first accurate descriptions of microbes and spermatozoa and blood corpuscles while he was marked perfection lenses of short focal of bacteria so that he was able to see the larger forms of bacteria. The observations of Leeuwenhoeks of microscope provided the foundation bacteriology and resumed the questions and concerns of the main cause of leavening and disease (Join, 2008).

3.2. The Reason of Infections

The infections are the invasion of the living body by pathogenic microorganisms causing inflammation, mostly an infectious disease which is transmitted. Due to the lack of knowledge and the ignorance of sterilization, it lead to and was major cause of morbidity and death-rate in hospitals because of infections. Nowadays, hospitals import very expensive sterilizing equipment and became their first concern. However, very little effort is made to train the people to use these machines properly. We must understand that the machine is as clever or as dumb as the person behind it. Unfortunately, in spite of so many advances in medical education, many countries do not have a single recognized training program to introduce the people in this field to use sterilization the right way. This is our attempt in that direction to come up with a formal training program to train technicians in this animated area of health care delivery system (Jay, 2011).

3.3. Definition of Sterilization and The Proper Way of Using it

Sterilization is defined as the process of making some object free of live bacteria of other microorganisms, usually achieved by using heat or chemical means. The proper and correct process of medical devices, surgical instruments, supplies and equipment sterilization which play and has a big impact on the patient's safety is very important in our modern health care. This is by definition the Association for the Advancement of Medical Instrumentation defines Sterility is measured by probability expressed as sterility assurance level. It is generally accepted that a sterility assurance level (SAL) of 10^{-6} is appropriate for items intended to come into contact with compromised tissue, which has lost the integrity of natural body barriers. This would include sterile body cavities, tissues and vascular system. A sterility assurance level (SAL) of $10^{-6}$by meaning that there is a possibility of even one in a million that a particular item is unsterile yet during a certain sterilization process. Sterilization is a complex process. Regardless of the place, the sterilization is a must, whether it is a care hospital, ambulatory surgical center, outpatient facility, dental or even a physician's office (Satt, 2006).

As mentioned earlier, the important thing among the aseptic is a sterilization package. So using the methods to keep free of path alogical micro organisms and prevent from microbial contamination is of a great deal for whom it may concern.

3.4. Methods of Sterilization

In health care field, many sterilization ways and methods are available to use, devices that are right to this process either by heat or chemical means, and this chart explains it all:

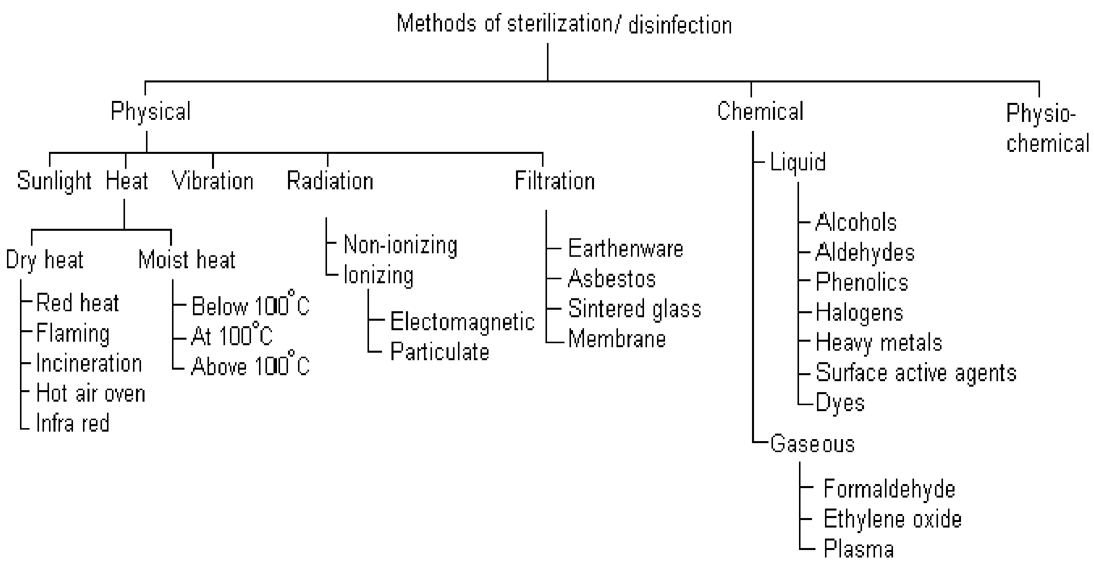


Fig.3.1. Explain the chemical & physical methods for sterilization

For now, in this thesis we will deal with the most common sterilization methods that are practiced widely.

3.4.1. Steam sterilization:

This methods is one of the oldest, safest, and cheapest also the most understood method sterilization available to health care facilities. It is basically a heating system, using a water vapor which is nontoxic and easy to use. To ensure that the steam sterilization is its right way, we need to keep an eye on three factors which are time, temperature and moisture**.** The steam sterilizer should contain no liquid water but vapor. Although, the principle of steam have not changed during the past century and remained the exact same (Marimargaret et.al.1997).

3.4.2. Per acetic acid liquid sterilization:

Acetic acid is an item widely used in manufacturing pharmaceuticals. The Per acetic acid sterilization consist of acetic acid, water and oxygen. The substance acetic acid is highly water soluble and a colorless pungent liquid. It is effective in low temperatures also in the presence of organic matter. Per acetic acid at relative low concentrations (less than 1%) is an effective germicidal agent and even more potent than hydrogen peroxide. It where it has the features to be sporicidal, bactericidal, virucidal, fungicidal, and tuberculocidal. In addition, as a weak acid, per acetic acid is more active at acidic pH but is also germicidal at high concentrations in the alkaline pH range.

In a low-temperature liquid chemical sterile processing system, several steps must be followed to an effective sterilization:

1. Observe if there is any leaking in ampoules to avoid damage.
2. The clean devices are necessary; because a lot of these devices have small connected lumens.
3. Thesterilant concentrate is provided in a sealed single- use cup and prescribe no pre-mixing or dilution.
4. Select the appropriate container because if the device has lumens it must have the suitable connector attached to it (Puals, 1993).

3.4.3. Ethylene oxide sterilization:

Ethylene Oxide (EO) is also a kind of sterilization which works in a low temperature, this method has been used for many years. (EO) is basically a flammable gaseous alkylation that is obtained from petroleum and natural gas and used in manufacturing many other chemicals, sometimes it can be used as an anesthetic. The EO penetrates the cells membrane and reacts with the nuclear material making it unable to metabolize and reproduce. The EO disadvantages are its long process for sterilization as well as the need for aeration for a specific duration of time. Moreover, the aeration after the sterilization process is needed to allow the residue to escape from the medical devices before they are used. To an effective sterilization, there are four primary conditions that are required which are gas concentration, humidity, temperature and time.

The ethylene sterilization device depend on the capacity of the room that is surrounded by a water jacket. Emptying the room from air, humidity and conditioning of the load is done by passing a sub-atmospheric pressure steam, then the evacuation is done again and preheated vaporized ethylene oxide is passed. After treatment directly all gases are evacuated outside atmosphere or through a special exhaust system (Dr.Yashmin, 2002).

3.4.4. The sterilization of hydrogen peroxide:

Hydrogen peroxide, which is used in the aseptic filling industry, is an effective sterilant which achieves these conditions, and is also a strongly oxidizing kind and decomposes spontaneously into water and oxygen

$$2H_2O_2 \longrightarrow 2H_2O + O_2 \qquad (3.1)$$

Using mixture of 35% hydrogen peroxide and 65% of water with the temperature (60 - 140) C is the best ratio to use hydrogen peroxide in sterilization which depends on capacity of chamber and the model of device. This efficiency relies also on the hydrogen peroxide concentration increases. The hydrogen peroxide safe and reliability are always considerable by the experimenters due to the process producing oxygen and water as it seen in equation above. The produced compound is not toxic for food or even instrument. The use of vaporized hydrogen peroxide the consumption of hydrogen peroxide compared to using liquid of hydrogen peroxide is three times lower. The remaining values of hydrogen peroxide that are left in the package are very low. As an oxidizing agent, hydrogen peroxide has strong oxidizing potential and will oxidize many organic compounds, since it generates highly reactive hydroxyl radicals. This process will create a sterile environment since the organic compounds will destroy (Ansari et.al. 2003).

3.5. Low-Pressure DC-discharge Hydrogen Peroxide and Plasma and Their Benefits on Sterilization

The technology's transmission to the evolution of new cold sterilization is very significant because of many reasons such the need of a long aeration process (up to 24h), and the production of a risk which treats for individuals and environment. In addition, the use of gas-discharge plasma as a sterilizing agent considers as one of the most serious recent alternatives to gaseous sterilization. This related to its benefits as the form of plasma by excitation, dissociation, and ionization of any gaseous or vaporous material, including nontoxic substances and even rigid gases (Soloshenko et.al. 2000).

3.6.The use of Plasma and Hydrogen peroxide to Sterilize

Hydrogen peroxide is a liquid with strong oxidizing properties, used as a disinfectant. Furthermore, Hydrogen peroxide gas plasma (HPGP) sterilization is depended on the synergism between vapor of hydrogen peroxide and low temperature gas plasma. The aeration is not necessary because the toxic remains have not been reported (Slatter, 2003).

System by-products are oxygen and water vapor, and operators do not come in contact with dangerous materials. However, many questions are still asked about the efficacy and potential risks from the sterilized materials (Egitto et.al.1990).

HPGP is considered a strong oxidizer as an important agent in chemical phase. Process of sterilization supply an initial contact of the material to be sterilized with the hydrogen peroxide before the generation of plasma at a power level enough to satisfying sterilization (Baldry et.al.1983).

It was discovered that the use of an initial contact period with hydrogen peroxide safely decreases the total time and power required to do the purging with low temperature plasma. Peroxide allows sterilization to happen within many different types of packaging material (Paul, 1985).

Low temperature hydrogen gas plasma is comparatively a new technology, marketed under the trade name sterrad by ASP, its sterilization system uses a collection of low temperature gas plasma and hydrogen peroxide vapor that quickly sterilize medical instruments without leaving any toxic residues. The five phases of stages of the low temperature HGP sterilization process consist of vacuum, H2O2 injection, diffusion, plasma and vent. Low temperature hydrogen peroxide has some advantages and disadvantages:

Advantages:

1-Short sterilization cycle (1-4) hours.
2- Negligible environmental impact.
3- No toxic chemical excess.
4- No aeration is required.
5- Wide similarity with materials.
6- The control of sterilization in – house.

Disadvantages:

1- Strong hydrogen peroxide absorbers like cellulosic's.
2- Inability to process liquids (Timm et. al. 2002).

For long and narrow lumens, the time it takes for the vapor to travel through the lumen can exceed the length of the diffusion cycle. To this degree some lumen restrictions also apply. Thus, to ensure adequate penetration and efficacy for the given cycle parameters, guidelines have been developed for lumen diameter and length. Besides, keeping an eye on the walls of the restricted area that it is not composed of materials that may absorb or decompose vapor and thus decrease the effectiveness of sterilization (Leslie et. al. 1997).

4. EXPERIMENTAL

4.1.Principle of Work

Low temperature hydrogen peroxide gas plasma sterilization process is dry rapid. This process has five phases beginning with a vacuum phase during with this phase the chamber is an evacuated reducing the internal pressure in preparation for the process to come.

Next the injection phase a measure the amount of liquid peroxide is injected into the chamber vaporizing the aqueous hydrogen peroxide solution in this percent into the chamber during the diffusion phase, the hydrogen peroxide vapor vaporize the chamber explosion all load contents to vapor cloud at the completion of this phase the chamber pressure is reduced and the radio frequencies plasma discharge is initiated during the plasma phase an electric magnetic field is created.

The hydrogen peroxide gas plasma cloud result consisting ultraviolet light and free radicals the combination of which inactivate all remaining bacteria rapidly sterilized in most instrument and materials with no toxic residues. The radio frequency is turn off and the activated components loss their high energy and recombine to form oxygen, water and other non-toxic bio-products. In the sterilization systems all phase are repeated.

4.2. Stages of Sterilization

Pressure = 10^{-3} Torr

Frequency = 50 KHz

Power = 500 w

Table.4.1.Stages of sterilization

No.	Medium	Time/min
1	Vacuum	13-16
2	Diffusion	6-10
3	Vacuum	6-8
4	Plasma	2
5	Diffusion	6-10
6	Vacuum	1

4.3. Experimental 1

Pressure = 10^{-3} Torr

Frequency = 50 KHz

Power = 500 w

Table.4.2. Results of first sterilization

No.	Medium	Time/min
1	Vacuum	13-16
2	Diffusion	6-10
3	Vacuum	6-8
4	Plasma	2
5	Diffusion	6-10
6	Vacuum	1

Note: failed

4.4. Experimental 2

Pressure = 10^{-3} Torr

Frequency = 50 KHz

Power = 100 w

Table.4.3. Results of second sterilization

No.	Medium	Time/min
1	Vacuum	13-16
2	Diffusion	6-10
3	Vacuum	6-8
4	Plasma	2
5	Diffusion	6-10
6	Vacuum	1

Note :Failed

4.5.Experimental 3

Pressure = 10^{-3} Torr

Frequency = 50 KHz

Power = 250 w

Table.4.4. Results of third sterilization

No.	Medium	Time/min
1	Vacuum	13-16
2	Diffusion	6-10
3	Vacuum	6-8
4	Plasma	2
5	Diffusion	6-10
6	Vacuum	1

Note : Failed

4.6.Experimental 4

Pressure = 10^{-3} Torr

Frequency = 50 KHz

Power = 150 w

Table.4.5 Results forth of sterilization

No.	Medium	Time/min
1	Vacuum	13-16
2	Diffusion	6-10
3	Vacuum	6-8
4	Plasma	2
5	Diffusion	6-10
6	Vacuum	1

Note :Failed

4.7. Experimental 5

Pressure= 10^{-3} Torr

Frequency=50 KHz

Power = 100 w

Vacuum, plasma &hydrogen peroxide ⟶ 40 minutes

Note: Failed

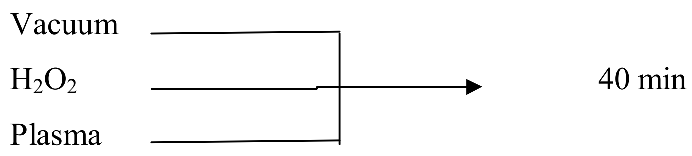
4.8.Experimental 6

Firin plasma:

Pressure =10^{-3} Torr

Frequency= 50 KHz

Power = 300w



Note :Failed

Fig.4.1.System for sterilization

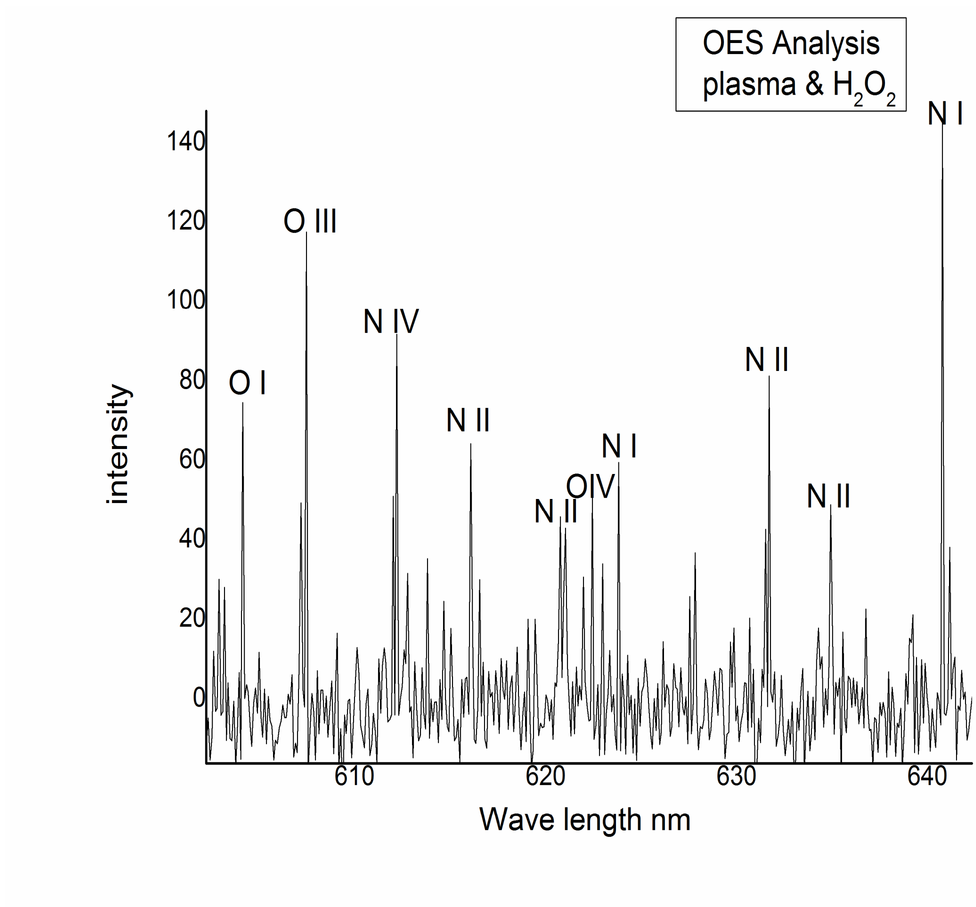


Fig.4.2.OES analysis of plasma & H_2O_2

5. CONCLUSION AND RESULTS

5.1. Conclusions

Sterilization by hydrogen peroxide and plasma is widely uses that are safe for patient, workers, instrument and environment. This kind of machine considers uncomplicated. It represents a new development way for sterilization. The features of this device are short time (45-60) min, without toxic remains (hydrogen peroxide will change to H_2O and O), low temperature (so that we can use it directly and make its suitable for all materials that is used in medical devices).There is other new techniques sterilization which is used oxidizing agents such as ozone, per acetic acid, and chlorine dioxide, which can kill bacteria and as well as affect genetic material. But this process of sterilization is not safety if it is compared with the system of low temperature plasma and hydrogen peroxide.

5.2. Results

Through analysis hydrogen peroxide and plasma by using the optical emission spectroscopy device we observe inside of the sterilization chamber which contain peak of O I, O II, O III, O IV and other compound N I, N II, N IV. Now I will show the details of (O).

OI or O Its mean ionized oxygen and one electron left to other level but in same atom.
OII or O^+ that's mean single ionized oxygen and one electron left to outside of atom.
OIII or O^{++} that's mean double ionized oxygen with and two electrons left to outside of atom.

O consider more stable than O+ also O+ more stable than O++.

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