Sudan University of Science and Technology
College of Graduate Studies

Effectiveness of Nd: YAG Laser in Wool Removal from Sheep Leather

فعالية ليزر النيوديميوم - ياغ في إزالةِ الصوفِ مِنْ جلدِ الخِرافِ

A dissertation Submitted as Partial Fulfillment of the Requirements for the Degree of Master of Science in Physics.

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الآية

قَالَ تَعَالَىٰ: ﴿ قَالَ يَٰقَوۡمِ أَرَءَيۡتُمۡ إِن كُنتُ عَلَىٰ بَيِّنَةٖ مِّن رَّبِّي وَرَزَقَنِي مِنۡهُ رِزۡقًا حَسَنٗاۚ وَمَآ أُرِيدُ أَنۡ أُخَالِفَكُمۡ إِلَىٰ مَآ أَنۡهَىٰكُمۡ عَنۡهُۚ إِنۡ أُرِيدُ إِلَّا ٱلۡإِصۡلَٰحَ مَا ٱسۡتَطَعۡتُۚ وَمَا تَوۡفِيقِيٓ إِلَّا بِٱللَّهِۚ عَلَيۡهِ تَوَكَّلۡتُ وَإِلَيۡهِ أُنِيبُ ٨٨ ﴾

صدق الله العظيم

سورة هود

Dedication

I dedicate my dissertation work to my mother and my father for their patience and endless love.

My deepest thank goes to all my family and friends for helping me.

Acknowledgments

First of all, I would like to thanks Allah for giving me the strength to finish this study. And thanks of my University.

Special thanks Dr. Ali Abdel-Rahman Saeed Marouf, supervisor of my dissertation for his guidance and assistance throughout the progress of this thesis. I would like to express my gratitude to Ali Hammad and my thanks extend to the lab assistant in the Medical Center of Institute of Laser-Sudan University of Science and Technology.

Abstract

Interaction of lasers with biomaterials such as tissues is an important area of research. This work aims to investigate removing of wool form sheep leather using Nd: YAG laser, which is one of three steps of tanning process with killing bacteria and fat removal. Crude leather of lamb was irradiated by Nd: YAG laser with 1064 nm and 60 Watts continuous mode point per point in order to remove wool. The results showed that laser successfully removed the wool from lamb leather without obtaining burning or damaging leather or changing its original color.

This result shows that wool could be removed from the butchered sheep leather by laser, safely without chemicals risks.

المستخلص

يعتبر تفاعل الليزر مع المواد الحيوية مثل الأنسجة أحد مجالات البحث المهمة. يهدف هذا البحث لتقصي إزالة الصوف من جلد الضأن باستخدام ليزر النيوديميوم – ياغ ، التي تعتبر أحد الخطوات الثلاث لدباغة الجلود مع قتل البكتريا وإزالة الدهون. شعع الجلد الخام بليزر النيوديميوم– ياغ ذو الطول الموجي 1064 نانومتر وقدرة خرج 60 واط بنمط مستمر نقطة بنقطة لإزالة الصوف. أظهرت النتائج نجاح الليزر في إزالة الصوف من جلد الحمل دون أن ينتج حرق أو ضرر الجلد ولا تغيير لونه الأصلي.

بينت هذه النتائج أنه يمكن إزالة الصوف من جلد الضأن المذبوح بالليزر بأمان دون مخاطر كيميائية.

Table of Content

Table of Figures

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND

All of us knew that a world have got this developing at all life's sides when laser appeared, and it used in many fields and gave excellent results and now all engineer fields and medicine fields depends on laser especially cosmetic medicine to remove hair, fats and destroy bacteria by using laser.

The leathers have a big importance to push countries economic especially for countries which have a large animal wealth like Sudan, but Sudan doesn't benefit of this unique value, because Sudan doesn't lay out and doesn't make a creativity in life, leather industry in Sudan even near time was so primitive, and take hard way to complete leather tanning process, but today after world development; some chemicals materials used to accelerate this process and give leather some good characteristics, but unfortunately these chemicals materials are costing so much and it is also so dangerous.

According to our faith that the scientific research is the best way to make a development and renaissance, and are sufficient and deep faith that this country will not rise without scientific research’s, so we are going on way to search about

another way of tanning with same characteristics when we used chemicals materials or at least near to it and haven't to be cost or even may have same cost and more, but must not be dangerous, so we are going to use a peaceful way and modern and also quick, this way is laser.

1.2. RESEARCH PROBLEM

Based on above introduction, the tanning process depends on dangerous chemical materials like sodium sulfide (Na_2S) which it is decomposes on burning, on contact with acids, water producing toxic and corrosive gases, which increases fire hazard. The solution in water is a strong base; it reacts violently with acid and is corrosive. Reacts violently with oxidants, also tanning process use Sulfuric acid (H_2SO_4) and it is a chemical compound very dangerous because can cause severe chemical burns and even secondary thermal burns, especially it is very dangerous even at moderate concentrations, between these chemical compounds that used in tanning hexavalent chromium (chromium 6) and this chemical compound increase risk of developing lung cancer, asthma, or damage to the nasal epithelia and skin especially when it burned. Furthermore, these chemical compounds cost much of money and time to get it and cost hard currencies then affect directly to economic, and decrease sales and profits companies because of expensive product.

So this way of tanning is not suitable anyway not of security side, and nor economic sides. Therefore, this work try to perform a physical secured method in

removing wools using laser, in order to replace hazardous chemicals in removing wools in tanning process.

1.3. PREVIOUS STUDIES

A Lot of studies appeared to trying treat the danger of chemical compounds which use in tanning process some of these studies have got no result, because it confirmed that the process same completely depend on these chemical compounds, and no way to do without it, so it focused on recycling these chemical compounds lots times to decrease its danger, where other studies tried to use some classical materials especially in Sudan, but all these experiments failed in different proportions.

In 2004 at Sudan University of science & technology one of thesis had been offered, this thesis tried to solve the problem of a danger of these chemical compounds by using recycling it in lots of times, and researcher recommended to be applied in the tanneries gradually until it is well established because until the time of thesis it is not recognized as standard process, and the researcher arrived at that reduction in the cost of handling the effluent and reduction in pollution hazards, but he still use same compounds and in repeated way, as long as we use same compounds, that is not right way to deal this danger, so we need to replace these chemical compounds by another which must be benefit and secured thing, so

recycling method is not good to solve this problem (Tampal and Gasmelseed, 2013).

Another study was in 2012 and was also at Sudan University of science & technology, and researcher defined utilization of Moringa Oleifera (it is a desert plant) for a treat tanning wastewater where he concludes that the Moringa Oleifera has the potential to be used in the Tannery wastewater treatment in an efficient way. And that is a very good usage of Moringa in wastewater treatment in developing countries (Mohammed, 2012). He confirmed that his research lends support to earlier works recommending the use of Moringa for wastewater treatment. In this study Output of the wastewater .treatment does not comply with Environmental standards and regulations.

There have been numerous research studies the effect of laser matter irradiation; for example, laser milk pasteurization (Marouf and Sara, 2018; Amna and Marouf, 2018), solar cell surface modification (Marouf *et al*., 2014), bee honey irradiation (Al Humira and Marouf, 2017) and production of highly value materials from agricultural waste (Gawbah *et al*., 2017; Gawbah *et al*., 2018). There have been numerous research studies the interaction of low-level lasers with biological materials such as blood; for examples; studding of He-Ne laser effect on human whole blood (Haimid *et al*., 2019a), investigating the effect of He-Ne laser on human whole blood (Haimid *et al*., 2019b), and it also used to induce emission in

human teeth to distinguish between dental caries and sound teeth (Marouf and Khairallah, 2019). High power Nd: YAG laser irradiation of zirconium silicate obtained increasing in hardness of zirconium silicate (Awadala, *et al*., 2020).

Also, this study doesn't care just about finding a new way and replacing chemical compounds of a tanning process, but it also cares about wastes of tanning. So this current work considered the first one which tries to find a new way of tanning process by using the laser.

1.4. DISSERTATION OBJECTIVES

This study is targeting many important objectives which will facilitate different ways of removing wools from leather especially in that side which connected to safety, the objectives are to:

1- An initial scoping study into the suitability of laser technology to permanently remove wool from the leather of sheep.
2- Develop new safely and quickly method to remove wool from crude leather.
3- Compare between laser wool removal and laser hair removal.
4- Propose solution to the difficulties of this new method.

1.5. RESEARCH METHDOLOGY

To achieve this objectives a crude leather of sheep will be brought and cleaned by salt to protect it from harmful bacteria, after 60 hours the side which contain wool of this sample will be irradiated by Nd: YAG laser with 1064nm wavelength

in continuous mode to remove wool under 60 watts of power and then the sample will be compared to hair removed skin.

1.6. DISSERTATION LAYOUT

This dissertation is consist of four chapters, chapter one is an introduction and previous studies, then chapter two consist literature review and basic concepts of laser and leather, and laser-matter interaction**,** chapter three deals with the experimental part (the materials and devices and method), chapter four consist results, discussion, conclusion and recommendations; and finally references.

CHAPTER TWO

THEORETICAL BACKGROUND

2. 1 LASER

Laser is the acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation, where laser devices are devices which generate or amplify light (SCHAEFFER, 2007), so laser is light beam, but in specific characteristics and it creates by specific way that which use an amplification, and This special nature of laser light has made laser technology a vital tool in nearly every aspect of everyday life including communications, entertainment, manufacturing, and medicine.

Albert Einstein may inadvertently have taken the initial step in laser development by realizing that two types of emission are possible. In an article published in 1917, he was the first to suggest the existence of stimulated emission. For many years physicists thought that the spontaneous emission of light was the most likely and dominant form and that any stimulated emission would always be much weaker. It was not until after World War II that the search began for conditions that were necessary for stimulated emission to dominate, and to make one atom or molecule stimulate many others to produce the effect of amplifying emitted light. (Thomas J. Fellers, 2002). before a time, LASER had been named

MASER that is because the microwave was used to produce laser light where: **M**icrowave **A**mplification by **S**timulated **E**mission of **R**adiation.

2.1. 1 LASER PRODUCING

As long as laser stand on amplifying the light (photons) so we have to increase the number of photons to get amplified light, and that depends on Stimulated emission, so we will pass through these three conceptions absorption, spontaneous emission, and Stimulated Emission.

1. Absorption

If we have atom has the electron in lower energy level E_1 and there is a photon of light with wavelength λ collide this atom, during the collision the photon would be absorbed by an atom and electron will move up to an upper energy level E_2 (Figure 2.1).

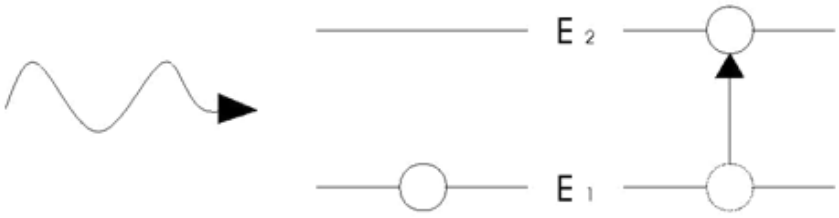

Figure 2.1: Absorption Process

To occurring absorption, the energy of photon must equal the difference of energy between two levels ($E \geq E_2-E_1$), where:

$$\boxed{R_{Lu}= e_v \times N_L \times A_{Lu}}$$

R_{Lu} ≡ Rate of movement from lower to upper level

e_v ≡ intensity of radiation by specific frequency

N_L ≡ intensity of atoms at the lower level

A_{Lu} ≡ probability of atoms at the lower level

2. Spontaneous Emission

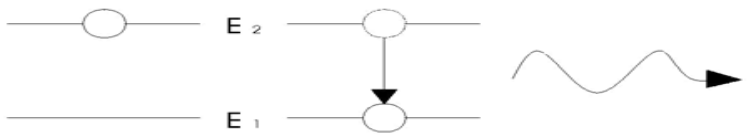

Figure 2.2: Spontaneous Emission

Spontaneous emission occurs when an electron be residing in upper energy level and jumping spontaneously to lower energy level when spent its lifetime and radiant a photon with random direction (Figure 2.2).

3. Stimulated emission

Stimulated emission occurs when an electron be in an upper energy level and there is photon of light with wavelength λ collide the atom, during collision the photon stimulates an electron to come down to lower energy level even its lifetime didn't finish yet, and radiate two photons in same properties in energy, phase, polarization, direction (Figure 2.3).

Note that one photon which collides excited electron in upper level lead to produce both electrons and that is an idea of amplification.

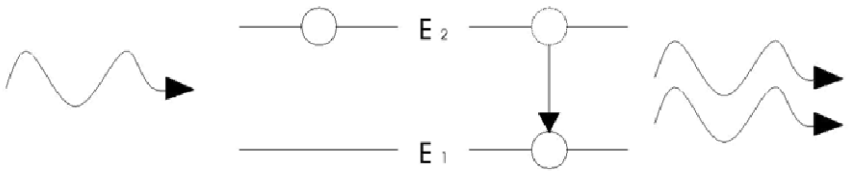

Figure 2.3: Stimulated Emission

2.1. 2 PROPERTIES OF LASER BEAM

Laser radiation is characterized by an extremely high degree of (I) monochromaticity, (II) coherence, (III) directionality, and (IV) brightness. To these properties, a fifth can be added, viz., (V) short time duration. This refers to the capability for producing very short light pulses, a property that, although perhaps less fundamental, is nevertheless very important (Svelto, 2010). We shall now consider these properties in some detail, figure (2.5).

I- Monochromaticity:

The laser emits all photons with the same energy, and thus the same wavelength, it is said to be monochromatic. The light from a laser typically comes from one atomic transition with a single precise wavelength. So the laser light has a single spectral color and is almost the purest monochromatic light available figure (2.5). (Siegman, 2018)

II- Directionality:

All photons move in one direction with collimated together and will continue in this situation event determined point called (Rayleigh distance) then will be scattered figure (2.4).

III- Coherence

Laser wave sources are perfectly coherent if they have a constant phase difference and the same frequency, and the same waveform, and there is two types of coherence:

A) Spatial coherence: where the waves keep on the distance between them where, a correlation between different places, but not along the path, and this refers to directionality.

B) Temporal coherence: will be the same phase and time at all points, where a correlation between the waves at one place and maybe different times, or along the path of a beam at a single instant, is effectively the same thing, and that refers to monochromaticity too figure (5).

IV- High density:

Laser beam features by high density, and concentrated on a narrow packet with one mm diameter where:

In pulsed source ($I = 10^{18}$ w/cm^2)

In continuous source ($I = 10^{12}$ w/cm^2)

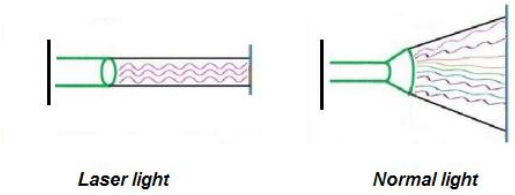

Figure 2.4: Directionality of laser beam

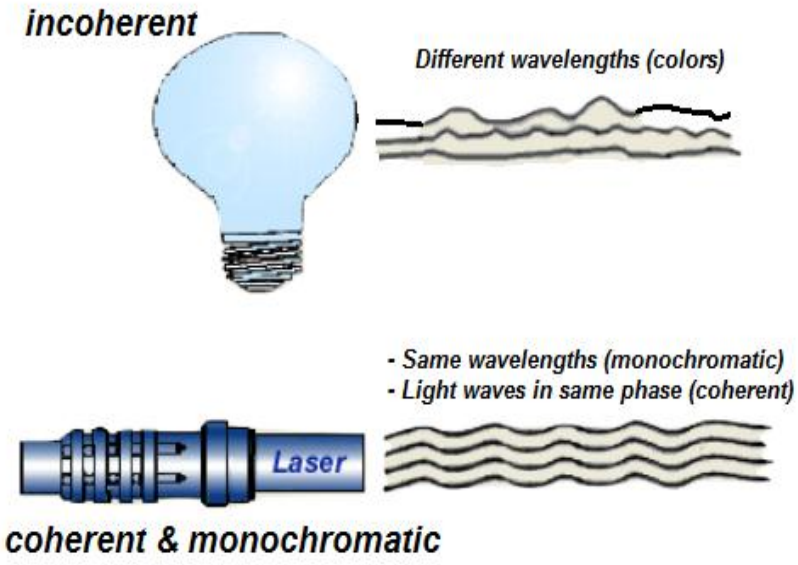

Figure 2.5: Monochromaticity and coherence

2.1. 3 COMPONENT OF LASER

Basic laser components which all the lasers comprise are three basic components, figure (2.6).

1) The active medium (gain medium):

The active medium consists of a collection of atoms, molecules or ions (in solid, liquid or gaseous form), which is capable of amplifying light waves. And the medium has to be kept in a state of population inversion (Larger number of

atoms in the upper state) and following is some types of gain mediums and example for each one:

► Atoms He ⟶ Ne

► Molecules ⟶ co_2 laser

► Liquid ⟶ melted organic dyes

► Solid ⟶ glass laser

► Gases ⟶ Krypton Kr-laser

► Semiconductors laser ⟶ gallium laser

2) Optical resonator (feedback - cavity):

It consists of two mirrors or lenses and it is medium with population inversion is capable of amplification; however, in order that it acts as an oscillator, a part of the output energy must be fed back into the system. Such feedback may be achieved by placing the active medium in a resonator like above-mentioned pair of mirrors facing each other.

On the other hand, one of the decaying atoms or molecules releases a photon parallel to the axis of the lasing material, it can trigger the emission of another photon and both will be reflected by the mirror on the end of the lasing rod or tube. The reflected photons then pass back through the material triggering further emissions along exactly the same path which is reflected by the mirrors on the ends of the lasing material. As this amplification process continues, a portion of the

radiation will always escape through the partially reflecting mirror. When the amount of amplification or gain through this process exceeds the losses in the cavity, laser oscillation is said to occur. In this way, a narrow concentrated beam of coherent light is formed (Administration, 2018).

3) Energy source (pumping source):

The pumping mechanism provides energy to laser system, when it is in a state of population inversion between a pair of energy levels of the atomic system and successively an input light beam can be amplified by stimulated emission, also Collision pumping depends on the transfer of energy to the lasing material by collision with the atoms (or molecules) of the lasing material. Again, energies which correspond to the allowed transitions must be provided. This is often done by electrical discharge in a pure gas or gas mixture in a tube (Administration, 2018). And pumping source may be:

- Electromagnetic energy.
- Thermal energy.
- Chemical energy (when an active medium is a liquid).

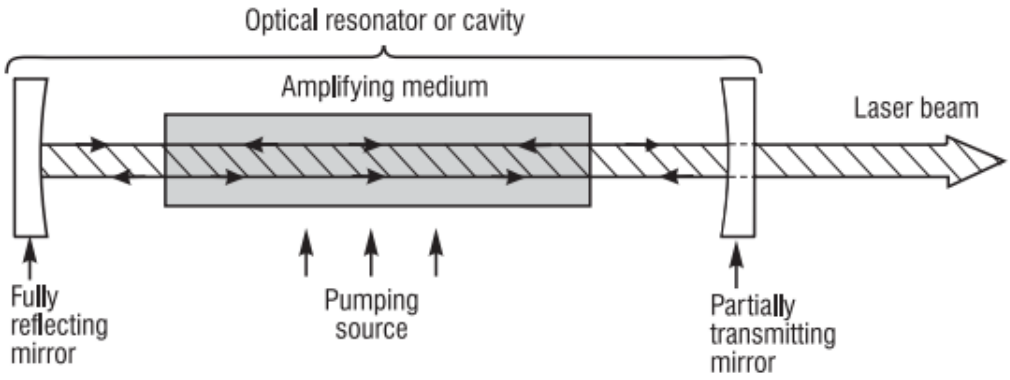

Figure 2.6: Components of laser

2.1. 4 A PRINCIPLE OF LASER ACTION

The number of atoms in any level at a given time is called the population of that level. Normally, when the material is not excited externally, the population of the lower level or ground state is greater than that of the upper level. When the population of the upper level exceeds that of the lower level, which is a reversal of the normal occupancy, the process is called as mentioned (population inversion). This situation is essential for laser action. For any stimulated emission, It is necessary that the upper energy level or met stable state should have a long lifetime, i.e., the atoms should pause at the met stable state for more time than at the lower level. Thus, for laser action, pumping mechanism (exciting with external source) should be from a such, as to maintain a higher population of atoms in the upper energy level relative to that in the lower level, and amplification will be continuous to produce laser beam ((DRDO), 2016).

2.1. 5 TYPES OF LASER

Types of laser classify during active medium or mode operation or pumping source:

• By active medium:

Depending on the nature of the active medium, lasers are classified into three main categories, namely, solid, liquid, and gas:

1) Solid state laser - crystal, or glass, doped with impurities ruby laser, Ti: sapphire laser, a semiconductor laser.

2) Gas laser - e.g. He-Ne laser, Ar^+ laser, CO_2 laser, N_2 laser, HCN laser.

3) Dye laser - active medium:

The dye laser was the first laser with a broad gain profile. The dye laser operates as a tunable CW laser or as picosecond laser (pulse duration 1 ps). The tuning range of a dye laser is about 5% relative to the laser frequency. By the use of different dyes, the whole visible spectral range can be covered with laser radiation.

• By mode of operation:

1) CW laser:

Continuous-wave (CW) operation of a laser means that the laser is continuously pumped and continuously emits light. The emission can occur in a single resonator mode (→ single-frequency operation) or on multiple modes.

2) Pulsed laser

Pulsed operation of lasers refers to any laser not classified as continuous wave so that the optical power appears in pulses of some duration at some repetition rate; this encompasses a wide range of technologies addressing a number of different motivations. Some lasers are pulsed simply because they cannot be run in continuous mode.

• By pumping and laser levels

- (3-level) laser

The three-level laser works only if the ground state is depopulated. As atoms or molecules emit light, they accumulate in the ground state, where they can absorb the stimulated emission and shut down laser action, so most three-level lasers can only generate pulses.

- (4-level) laser

An extra transition state is located between metastable and ground states. This allows many four-level lasers to emit a steady beam for days on end.

And we will present further types of lasers: dye laser; chemical laser; X-ray laser; organic laser, differentiate to their operational wavelengths, and their applications. And there are Thousands of kinds of laser, but most of them are used only for specialized research and determined used in a lot of applications (KarlF.Renk, 2012).

I. Solid State and Thin-Film Dye Laser

The active medium of a solid-state dye laser can consist of a solid matrix, for instance, polymethylmethacrylate (produced from the polymerization), containing dye molecules. Suitable as pump sources are semiconductor lasers or diodes. A thin-film dye laser consists of a thin film of dye molecules (embedded in a solid matrix) on a plane solid surface. A grating on the surface of the thin film can act as distributed feedback reflector.

II. Chemical Laser

The basis of a chemical laser is a chemical reaction. In an HF laser, a gas discharge drives the reactions

III. X-ray laser

The X-ray laser presented here is a mirror less laser: there is no feedback from radiation in a resonator. Laser radiation is generated by amplified spontaneous

emission (ASE). During propagating through the plasma, spontaneously generated radiation is amplified by stimulated emission of radiation

IV. Random Laser

A random laser can consist of an optical powder, for example, a powder of Nd_3C: YAG crystallites. Due to light scattering at the powder particles, the light emitted spontaneously is amplified by stimulated emission.

V. Fiber amplifiers

Fiber amplifiers consisting of glass doped with rare earth ions are suitable for amplification of radiation in the 1–3 m range; fiber amplifiers make use of the same rare-earth-doped glasses as fiber lasers. By the use of amplifiers, radiation at KW power levels can be generated.

The erbium-doped fiber amplifier – that is of great importance for long-distance optical communications

VI. Laser Tandem

A laser tandem is suitable for generation of laser radiation of high beam quality. A semiconductor laser, with high efficiency of conversion of electric power to laser radiation, pumps a solid state laser. The frequency doubled radiation of this laser pumps the third laser. A semiconductor laser has a low beam quality.

The combination of both types of lasers is most favorable: the use of a semiconductor laser as a pump laser of a solid state laser allows for efficient conversion of electric energy to high-quality laser radiation.

2.1. 6 LASER APPLICATIONS

As was showed previously a Laser light is different from ordinary light. It has various unique properties such as coherence, monochromaticity, directionality, and high intensity. Because of these unique properties, lasers are used in various applications. The most significant applications of lasers include:

a. Lasers in medicine

b. Lasers in communications

c. Lasers in industries

d. Lasers in science and technology

e. Lasers in military

• Lasers in Medicine:

Lasers are used for bloodless surgery, lasers are used to destroy kidney stones, and lasers are used in cancer diagnosis and therapy.

Lasers are used for eye lens curvature corrections.

Lasers are used in a fiber-optic endoscope to detect ulcers in the intestines.

- The liver and lung diseases could be treated by using lasers.
- Lasers are used to study the internal structure of microorganisms and cells.

Lasers are used to produce chemical reactions.

Lasers are used to create the plasma.

Lasers are used to remove tumors successfully.

Lasers are used to remove caries or decayed portion of the teeth.

Lasers are used in cosmetic treatments such as acne treatment, cellulite and hair removal.

• Lasers in Communications:

Laser light is used in optical fiber communications to send information over large distances with low loss.

- Laser light is used in underwater communication networks.
- Lasers are used in space communication, radars, and satellites.
- Lasers in Industries
- Lasers are used to cut glass and quartz.

- Lasers are used in electronic industries for trimming the components of Integrated Circuits (ICs).

- Lasers are used for heat treatment in the automotive industry.

- Laser light is used to collect information about the prefixed prices of various products in shops and business establishments from the bar code printed on the product.

- Ultraviolet lasers are used in the semiconductor industries for photolithography. Photolithography is the method used for manufacturing printed circuit board (PCB) and microprocessor by using ultraviolet light.

- Lasers are used to drill aerosol nozzles and control orifices within the required precision.

• Lasers in Science and Technology:

- A laser helps in studying the Brownian motion of particles.

- With the help of a helium-neon laser, it was proved that the velocity of light is the same in all directions.

- With the help of a laser, it is possible to count the number of atoms in a substance.

- Lasers are used in computers to retrieve stored information from a Compact Disc (CD).
- Lasers are used to store a large amount of information or data in CD-ROM.
- Lasers are used to measure the pollutant gases and other contaminants of the atmosphere.
- Lasers help in determining the rate of rotation of the earth accurately.
- Lasers are used in computer printers.
- Lasers are used for producing three-dimensional pictures in space without the use of a lens.
- Lasers are used for detecting earthquakes and underwater nuclear blasts.
- A gallium arsenide diode laser can be used to set up an invisible fence to protect an area.

• Lasers in Military

- Laser range finders are used to determine the distance to an object.
- The ring laser gyroscope is used for sensing and measuring a very small angle of rotation of the moving objects.

- Lasers can be used as a secretive illuminator for reconnaissance during a night with high precision.
- Lasers are used to dispose of the energy of a warhead by damaging the missile.
- Laser light is used in LIDAR's to accurately measure the distance to an object.

2. 2 LEATHER

The leather is a durable and flexible material created by tanning animal rawhides natural protein polymer treated with tanning agents to make it resistant to enzymatic attack and putrefaction and improve its several physics properties, It can be produced at manufacturing scales ranging from cottage industry to heavy industry.

The process of converting hides and skins into leather is termed as tanning process In the tanning process the animal hides and skins, so treated, becomes more permanently resistant to decomposition when they are wet, and supple when dry The process of tanning requires consumption of vast quantities of water and chemicals, which in turn constitute pollutants to the surrounding environment if not treated to a certain degree.

Description of tanning processes:

The production processes in a tannery can be split into three main categories.

I. Pre-tanning(hide and skin storage and beamhouse operations)

II. Tanning (tanyard operation)

III. Post-tanning operations. (AHMED, 2015).

2.2.1. Pre-tanning (Beamhouse Operations)

Cleaning and conditioning hides and skins produce the biggest part of the effluent load. Beamhouse operation includes Soaking, Fleshing and Trimming, De-liming and Bating, Pickling, and Degreasing.

In soaking the preserved raw hides regain their normal water contents. Dirt, manure, blood, preservatives (sodium chloride, bactericides), etc. are removed. Soaking is usually carried out in processing vessels (e. g. Mixers, drums, pits, or raceways) in two steps, namely a dirt soak for salt and dirt removal, and the main soak. The soaking bath is often changed every 8 hours to prevent bacterial growth. Soaking additives include surfactants, enzyme preparations, bactericides, and alkali products, figure (2.7).

Figure 2.7: Soaking

In fleshing and trimming extraneous tissue is removed. Unhairing is done by chemical dissolution of the hair and epidermis with an alkaline medium of sulfide and lime. When after skinning at the slaughterhouse the hide appears to contain excessive meat. The fleshing machine is used to remove any fleshy matter from the leather where this machine consists of rollers and rotating spiral blades that the pelts, fleshing of green hides after soaking is called ‘green fleshing’. Fleshing performed after the liming and unhairing is known as ‘lime- fleshing’, where is the important thing where all animal leftovers obtained through fleshing and all animal fat were destroyed through burning and this caused a release of harmful substances (dioxins and nitrogen oxides) in the atmosphere.

Figure 2.8: Fleshing machine

In de-liming and bating the unhaired, fleshed and alkaline hide is neutralized with acid ammonium salts and treated with enzymes, similar to those found in the digestive system, to remove hair remnants and to degrade proteins. During this process hair roots and pigments are removed. This results in the major parts of the ammonium load in the effluents.

Pickling increases the acidity of the hide to a pH value of 3 by addition of acid liquor and salts, enabling chromium tannins to enter the hide. Salts are added to prevent the hide from swelling. For preservation purposes, 0.03 - 2% by weight of fungicides and bactericides are usually applied.

In decreasing normally performed together with soaking, pickling or after tanning, degreasing is performed by organic solvents or surfactants, where tough

part of the fat and natural greases is removed through this period "degreasing" where skins contain a lot of fats, and a process may be carried out either after deliming or after pickling.

2.2.2. Tan yard operation

Tanning allows stabilization of the collagen fiber through a cross-linking action. The tanned hides and skins are tradable intermediate products (wet- blue). Tanning agents can be categorized into three main groups namely mineral (chrome) tanning agent; vegetable tanning agents; and alternative tanning agents (e. g. Syntans, aldehydes, and oil tanning agents)

Chrome tanning (CT) is the most common type of tanning in the world. After pickling, when the pH value is low, chromium (III) salts are added. To fixate the chromium, the pH is slowly increased through the addition of a base. The process of chromium tanning is based on the cross-linkage of chromium ions with free carboxyl groups in the collagen. It makes the hide resistant to bacteria and high temperature. Chrome tanned leather is characterized by top handling quality, high hydrothermal stability, user-specific properties and versatile applicability.

Waste chrome from leather manufacturing, however, poses a significant disposal problem.

Vegetable tanning (VT) produces relatively dense, pale brown leather that tends to darken on exposure to natural light. Vegetable tanning is frequently used to produce sole leather, belts, and other leather goods. Unless specifically treated, however, vegetable tanned leathers have low hydrothermal stability, limited water resistance, and are hydrophilic.

Vegetable tannins are polyphenolic compounds of two types;

- Hydrolyzable tannins (i.e. chestnut and myrobalan) which are derivatives of pyrogallols, and- Condensed tannins (i.e. hemlock and wattle) which are derivatives from catechol.

Alternative tanning with organic tanning agents, using polymers or condensed plant polyphenols with aldehydic crosslinkers, can produce mineral free leather with high hydrothermal stability similar to chrome- tanned leather. However, organic- tanned leather usually is more filled (e. g. leather with interstices filled with a filler material) and hydrophilic than chrome-free leather, with equally high hydrothermal stability. This tanning process is carried out with a combination of metal salts, preferably but not exclusively aluminum (III), and a plant polyphenol containing pyrogallol groups, often in the form of hydrolyzable tannins.

In draining, samming, and setting leather after tanning is drained, rinsed, and either hung up to age or unloaded into boxes and subsequently sammed (e. g.

brought to a uniformly semidry state to reduce the moisture content before further mechanical action. Setting (working over the grain surface of wet leather to remove excess water, to eliminate wrinkles and granulations, to give the leather a good pattern and to work out stresses so that the leather lies flat) may be carried out to stretch out the leather.

In splitting is to cut through skins/ hides or leathers at a set thickness. If the hide/ skin are sufficiently thick, splitting can yield a grain split and a flesh split that may both be processed into finished leather. Although splitting can be performed before tanning, after tanning, or after drying, it is usually performed after tanning.

In shaving is undertaken to achieve an even thickness throughout tanned or crusted leather. Shaving is carried out when splitting is not possible or when minor adjustments to the thickness are required.

in the case of drum tanning method, the float employed is very minimal ranging from 20-40% whereas in the bit tanning it may go up to 300-400% on the pelt weigh, where the vegetable tanned leather is given a bleaching with oxalic acid and bleaching syntans to remove the iron stains and import uniform color.

2.2.3. Wet Finishing (Post- Tanning)

Post-tanning operations involve neutralization and bleaching, following by re-tanning, dyeing, and fat-liquoring. These processes are mostly undertaken in a single processing vessel.

Specialized operations may also be performed to add certain properties to the leather product (e. g. Water repellence or resistance, oleophobicity, gas permeability, flame retardancy, abrasion resistance, ad anti-electrostatic properties).

Neutralization is the process by which the tanned hides are brought to a Ph suitable for re-tanning, dyeing, and fat-liquoring. Neutralization is performed using weak alkalis (e. g. Sodium or ammonium bicarbonate, formiate, or acetate). After neutralization, leather may be dried, generating an intermediate tradable product called white crust.

Vegetable- tanned skins and leathers with wool or hair may need to be bleached to remove stains or to reduce the coloring before re-tanning and dying.

Making the leather color fade may be achieved using treatment with chemicals (e.g. bleaching agents) or exposure to the sun/ weather elements.

A re-tanning process is performed to improve the leather characteristics and the rewetting properties (e. g .the introduction of liquid, such as water, into hides, skins or dried leather) of the hides necessary to facilitate and optimize the subsequent dyeing process. A wide variety of chemicals may be used for the re-tanning of leather, including vegetable tanning extracts, syntans, aldehydes, resins, and mineral tanning agents.

Dyeing is performed to produce colors in hides/ skins. Typical dyestuffs include water-based acid dyes. Basic and reactive dyes are less commonly used.

A wide range of dyestuff is available with different characteristics and physicochemical resistance (e. g. to light, PVC migration, and sweat migration, among others).

Fat-liquoring is the process by which leathers are lubricated to achieve product-specific characteristics and to reestablish the fat content lost in the previous procedures. The oils used may be of animal or vegetable origin, or may be synthetic products based on mineral oils. Stuffing is an old technique used mainly for heavier vegetable- tanned leather. Sammed leather is treated in a drum with a mixture of molten fat. The re-tanned dyed and fat-liquored leathers are then acidified by formic acid for fixation and usually washed before being aged to allow the fat to migrate from the surface to the inside of the pelt.

Drying techniques include Samming, setting, centrifuging, hang drying, vacuum drying, toggle drying (leather dried while held under tension on the frame using toggles), paste drying (drying method used for upper leather with the corrected grain), and over drying. Samming and setting are used to reduce the moisture content mechanically before implementing another drying technique. After drying, the leather may be referred to as ‘crust', which is a tradable and storable intermediate product.

The objective of drying is to dry the leather while optimizing leather quality, The crust that results after re-tanning and drying is subjected to a number of finishing operations. The purpose of these operations is to make the hide softer and to mask small mistake. The hide is treated with an organic solvent on water-based dye and varnish. Environmental aspects are mainly related to the finishing chemicals which can also reach effluent water.

CHAPTER THREE

EXPERIMENTAL PART

3.1. INTRODUCTION

This chapter includes the materials and devices used in this research experiment and the following methods (sample preparation and setup) and the procedure.

3.2. MATERIALS AND DEVICES

In this research, a number of materials and devices depended on the practical part, including:

3.2.1. Skin

The sample of crude skin of sheep (lamb with 8-months-old) has been brought and cleaned completely by salt to protect it from harmful bacteria from internal side, where an external side (wool side) with light brown in color had been partially shaved see figure 3.1.

Figure 3.1: skin of the lamb after bit shaving

3.2.2. Install tool

Brace in shape of a rectangular (15 x 10 cm^2) made from wood to install skin during laser treatment, figure 3.2.

Figure 3.2: Install tool

3.2.3. Nd: YAG laser

The Dornier Medilas Fibertom 5100 is a 100 watt Nd: YAG (figure 3.3.) continuous wave laser with a 1064 nm wavelength. This versatile system is ideal for a variety of surgical applications including non-contact or interstitial

coagulation, bloodless vaporization, and precise tissue cutting. The Medilas Fibertom 5100 also includes unique safety features including the LPS, Light guide Protection System and Fibertom cutting mode.

Figure 3.3: Nd: YAG laser

3.3. Method

Sample of crude skin of sheep (8-month-old) has been brought and cleaned completely by salt to protect it from harmful bacteria from internal side, where an external side (wool side) with light brown color had been partially shaved to decrease the pressure on the laser machine, then this piece of skin had been installed on install tool and then began treating with Nd: YAG laser by power 10 watts and gave no result then power had been increased to 20 watts and give shameful result, then by increasing of power the wool had been removed with power 60 watts and area with 4 cm^2 had been irradiated in 30 second.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter summarizes results obtained during the work. Results include photographs, In addition discussion, conclusion, conclusion and recommendations.

4.2 RESULTS AND DISCUSSION

Nd: YAG laser with power 60 watts the laser-processed area of the leather was observed that perfectly and immediately the wool combusted and removed after it had been burned by laser beam, the irradiation processes was done point per point (see figure 4.1) because of the small waist of laser beam.

Figure 4.1: Nd: YAG laser effect on leather.

Application of laser treatment was well tolerated on sheep leather, because of the treatment was applying on a leather of butchered sheep; there was no behavioral signs of discomfort. The high power laser dosage combusted the light brown in color wool by transfer of heat down the wool fibre to destroy the follicle bulb immediately, as it depicted in figure 4.1.

Figure 4.2 shows the leather surface after wool combustion using laser. Wool absorption of the 1064 nm wavelength converted it into ash without combustion of leather, indicating that leather does not absorb this wavelength. Gases was observed with formation of wools ash which might be converted into fertilizer materials; as a recycling process.

Figure 4.2: Burned wool using Nd: YAG laser

After the leather surface cleaned with water to remove leather ash (as shown in figure 4.3); it was obtained clearly that the laser irradiation successes in removing wool from the sheep leather without burning or destroying leather nor changing its original color.

Figure 4.3: Treated leather after cleaning

Since the leather of butchered sheep; this is enable us to use high dosage of laser to generate heat in order to achieve the removing process within short time, conditionally using the right wavelengths of laser.

This result shows that wool could be removed from the butchered sheep leather by laser, safely without chemicals risks.

This method is corresponding to laser hair removal using Q-switched pulses produce a photomechanical impact on the tissue and also on hair shaft and hair follicle, causing reduction as well as delay in hair growth cycle. Since it is not color dependent, it can be suited for all skin types, even on tanned skins without fear of pigmentary changes.

Some difficulties in this method is the small laser beam waist which needs long time for treatment. This problem could be solved using moving machine such as laser CNC machine.

4.3 CONCLUSIONS

This work successfully performed laser wool removing on sheep leather using Nd: YAG laser with wavelength 1064 nm and output power 60 Watts and with continuous mode. Leather tolerated treatment well. With no pre-wetting of the wool surface laser wool removing on leather resulted in significant overall removal of wool without damages found on leather surface such as burning or destroying leather nor changing its original color. Where by using laser the wool could be removed in quick and simple way and this is enable us to stop using harmful chemicals compounds to remove leather's wool.

4.4 RECOMMENDATIONS

In this research, the researchers recommend the follow:

1. Further researches are recommended to investigate the properties of the laser wool removed skin.

2. Based on the obtained results, lasers are recommended to remove the wool from the skins instead of chemicals compounds in tanning processes.

3. Future studies could be done to use a laser in the other steps of tanning like killing bacteria and fat removal.

4. More future studies to replicate results on several leather types.

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