

Preparation and Characterization of Magnesium Oxide Nanoparticles and Their Antibacterial Activity

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ABSTRACT

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Prepared Solutions Magnesium oxide nanoparticles using technology Excision for Pulsed laser In liquid to solid target using laser Nd-YAG wavelength nm 1064 with a fixed number of pulses (200 pulses) and different laser energies (840, 880, 800)mJ. These solutions were deposited by thermal chemical spraying on glass substrates to study the structural and optical properties of the particles and the extent of the effect of changing the laser energy on them. The results of the structural examinations showed (FE-SEM, AFM, XRD) The predominant crystal phase is (111) with an increase in the crystal size, while the optical properties showed strong absorption at the wavelength (nm 350) And the change in the energy gap ranges (4.57-5.32)eV. The results of biological tests conducted using solutions showed the effectiveness of particles MgO Nanoparticles inhibit the growth of Gram-positive and Gram-negative bacteria, with inhibition diameters ranging from (23-14) nm .

Keywords: particles Nano, Nd:YAG, Magnesium Oxide, Technology LA.

1. Introduction

Nanoscience is the study of materials and technologies at the nanoscale, ranging from 1 to 100 nanometers. This field focuses on the unique properties of materials at this scale, where their behavior changes dramatically compared to larger materials. Nanoscience is used in many fields, such as medicine, where it helps develop more effective drugs by delivering them specifically to cancer cells.[1]. In electronics, it contributes to the manufacture of smaller and faster components, such as microprocessors. It is also used to improve energy efficiency, such as in solar panels and energy storage devices, in addition to its role in pollution treatment and water purification. These applications open new horizons for improving quality in various fields.[2]

Magnesium oxide (Magnesium oxide (MgO) is a chemical compound composed of magnesium and oxygen, and is considered a material of great importance in many industrial and medical fields. Magnesium oxide has unique physical and chemical properties that make it suitable for a variety of uses [4,3].

Magnesium oxide (Magnesium oxide (MgO) is used in many fields, including medicine and nutrition. Magnesium oxide is effective in indirectly inhibiting some types of bacteria [5,6]. One of its effects is through its ability to adjust the acidity level (pH) of the surrounding environment. Some types of bacteria thrive in certain acidic conditions, and therefore, changing the pH level may hinder their growth [7].

Moreover, MgO can react with acids in bacterial cell walls, negatively affecting their structure and vital functions. This reaction inhibits bacterial growth and helps reduce their numbers in target environments.[8]

Bacterial inhibition is the process of preventing the growth or reproduction of microorganisms of a bacterial type. This is important in the fields of health, food, and the environment. This is achieved through a variety of methods and materials.[9].

Laser preparation techniques are among the most prominent methods used in the production of nanoparticles, as they have several advantages that make them a preferred choice in many scientific and industrial applications.[10].

This technology relies on the use of high-intensity laser beams to generate intense heat in the target materials, which leads to the evaporation and fall of nanoparticles in a precise and uniform manner[11].

One of the most significant benefits of this technology is the ability to precisely control the size, shape, and chemical composition of the resulting nanoparticles. By adjusting laser process parameters such as the power used, exposure time, and the type of source material, nanoparticles with specific properties can be produced that contribute to achieving research and application goals.[12,11].

2.The practical side

Magnesium oxide nanoparticles were prepared using a solid target of magnesium oxide in deionized water using a pulsed laser. The magnesium oxide target (99.9% purity) was fixed at the bottom of a glass container containing

(mL5 (of deionized water and the liquid level reaches the target surface)mm5) The removal was done using a laser.

Nd-yaG Pulse operates at a repetition rate of (HZ6) and wavelength (nm1064) and a fixed number of pulses of 200 pulses and different laser energymj(880, 840, 800),Then a portion of the resulting solutions was deposited as particles. MgoThe nanoparticles were placed on glass slides by thermal spraying to study the structural and optical properties, while the remaining part of the solutions was used to study the biological activity of these particles.

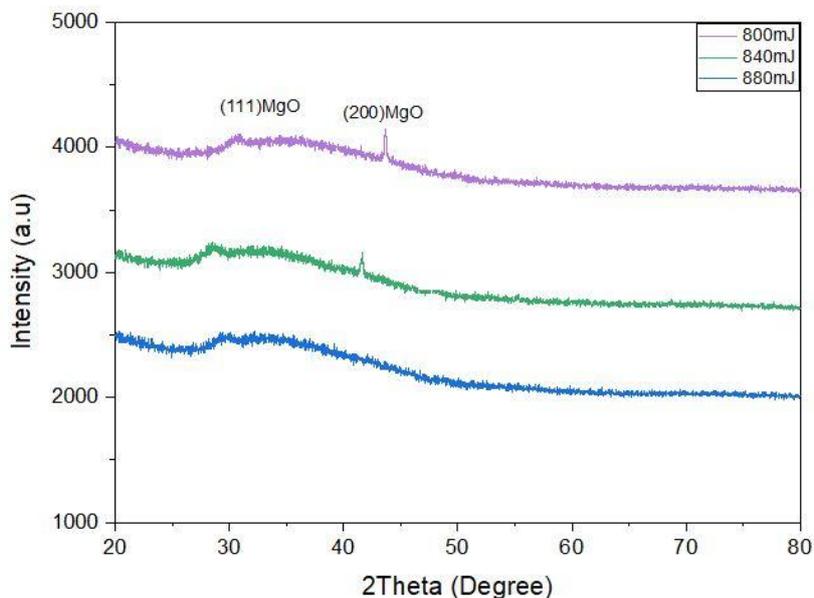
3.Results and discussion

1.3 X-ray diffraction results

The figure shows (1X-ray diffraction resultsXRD) of MgO filmsPrepared Different cardssoTbetweenThere is a clear effect of laser energy on the crystal structure and crystal size. The results also show that the dominant phase of the films is the (111) crystal phase, with a significant increase in crystal size with increasing laser energy, which can be explained by the increased amount of energy available for atomic arrangement during crystal growth. The dominant (111) phase indicates that the filmsshe hasFace-centered cubic structure (FCC) [13] with a preferred orientation in this phase.As in Table (1).

Table (1) X-ray diffraction results

Laser energies (m J)	2 Theta (deg)	FWHM (deg)	D (nm)	hkl
800	36.77	1.39	72.11291987	(111)
840	36.47	1.12	89.14968811	(111)
	42.9	0.97	113.0003916	(200)
880	36.84	0.932	107.6487456	(111)
	42.29	0.91	119.2776936	(200)



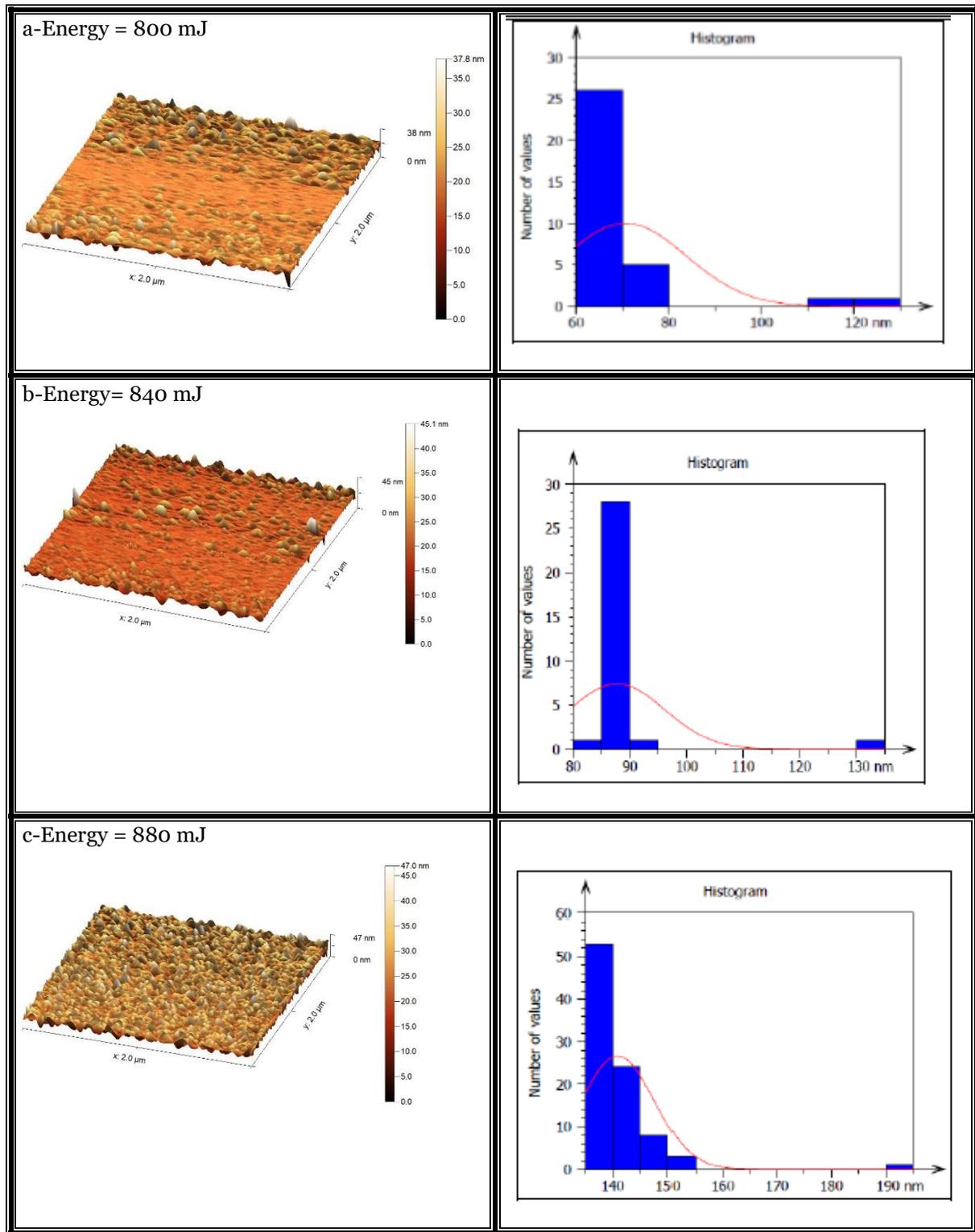
Mgo Figure (1) X-ray diffraction of the films

2.3 results Atomic force microscope (AFM).

Shape (2) Shows pictures atomic force microscope For prepared magnesium oxide thin films milliJ. FAt an energy of 800 mJ, the surface roughness was 1.7 nm, indicating that the films were thin and had flat surfaces. This low roughness indicates an efficient preparation process, making them suitable for applications requiring smooth surfaces, such as some sensors..andAt an energy of 840 mJ, the surface roughness decreased to 1.48 nm, a slight change reflecting the continuity of the smooth surface. This indicates that increasing the energy did not result in a significant increase in roughness, demonstrating the stability of the preparation process..ButAt an energy of 880 mJ, the surface roughness increased significantly to 4.59 nm. This increase suggests that the preparation process produced larger grains, resulting in a rougher surface. This higher roughness may enhance the effectiveness of the films in applications such as gas sensors, where they can facilitate interaction with gaseous molecules.[14].

Table (2) Atomic force microscope results for magnesium oxide films

Energy (mJ)	Grain size (nm)	Roughness	RMS
800	70 nm	1.7	2.5
840	87 nm	1.48	2.19
880	140 nm	4.59	5.76

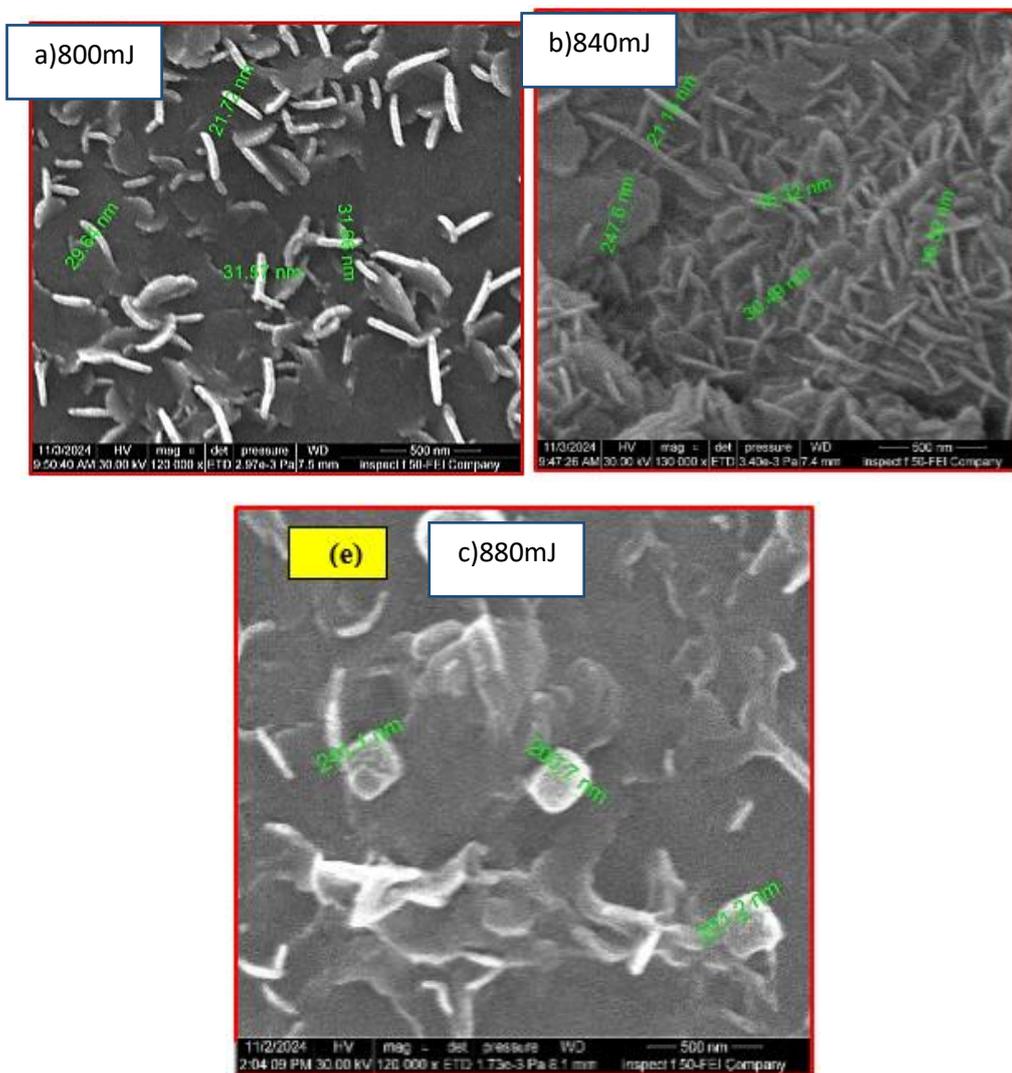


Shape (2) Atomic force microscope images of films MgO

3.3 Results a Scanning electron microscope The instigator of the field (FE-SEM)

The figure shows (3) Analysis result scanning electron microscope The instigator of the field (FE-SEM) for thin films Prepared FAt high energies the grain size increases significantly, as This increase leads to High resection rate and Formation of large particles. Increasing the energy of the particles colliding with the substrate leads to the growth of larger grains due to the effects of violent collisions and high thermal energy. Increasing the laser energy to

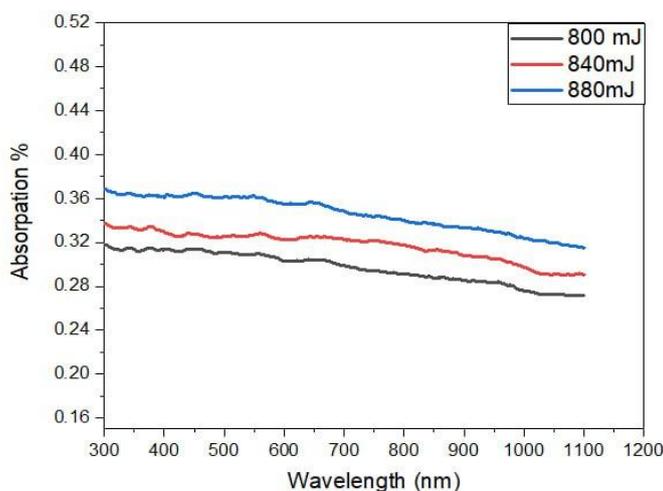
(mJ 880), the material ablation rate increases, resulting in the deposition of larger particles on the substrate. This change is associated with the increased thermal energy generated by the laser, which leads to the formation of larger particles during growth. At this stage, the surface structure of the films begins to show a gradual increase in grain size. The results of microscope analysis showed that the shape of the particles is not specific, tends to be spherical, and is mostly elongated in shape. [15].



Shape (3) Microscope images (FE-SEM) No films MgO

3.4 results Optical absorbance

Shape (4) Shows the absorption spectra of nanoparticles. No films prepared magnesium oxide and if Spectra were recorded in the wavelength range 300-1100 nm. Generally, the absorption spectra can be divided into two regions: (A) Strong absorption, where $\lambda \leq 350$ nm. Here the electron absorbs energy from the incoming photons and moves to the conduction band, leaving behind a hole in the valence band, thus forming an exciton; (B) Weak absorption area, $\lambda > 350$ nm [16]. Absorption occurs when electrons absorb incoming energy and are excited to a higher energy state. Nanoparticles appear to be MgO has strong absorption in the UV region at about 350 nm for all models counting semi-crystalline nature, the highest absorption value is obtained at laser energy (880 mJ).



Shape (4) Absorption spectrum films Mgo

3.5 Optical power gap

The figure shows (5) The optical energy gap, as a decrease in the energy gap was observed and it was ranging between (4.57-5.32) eV. This is due to the laser energy leading to the excitation of electrons in the material. As the laser energy increased, it was observed that the energy gap, the amount of energy required to move an electron from the valence state to the conduction state, began to decrease. This change can be explained by several factors. The energy generated by the laser excites the electrons, facilitating their transition to the conduction state, thus reducing the energy gap. The nanoscale size of magnesium oxide particles may affect their crystal structure. Radiating laser energy leads to distortions in this crystal structure, affecting the electronic properties. Radiating high energy also leads to the formation of defects in the crystal lattice, which also further reduces the energy gap [17].

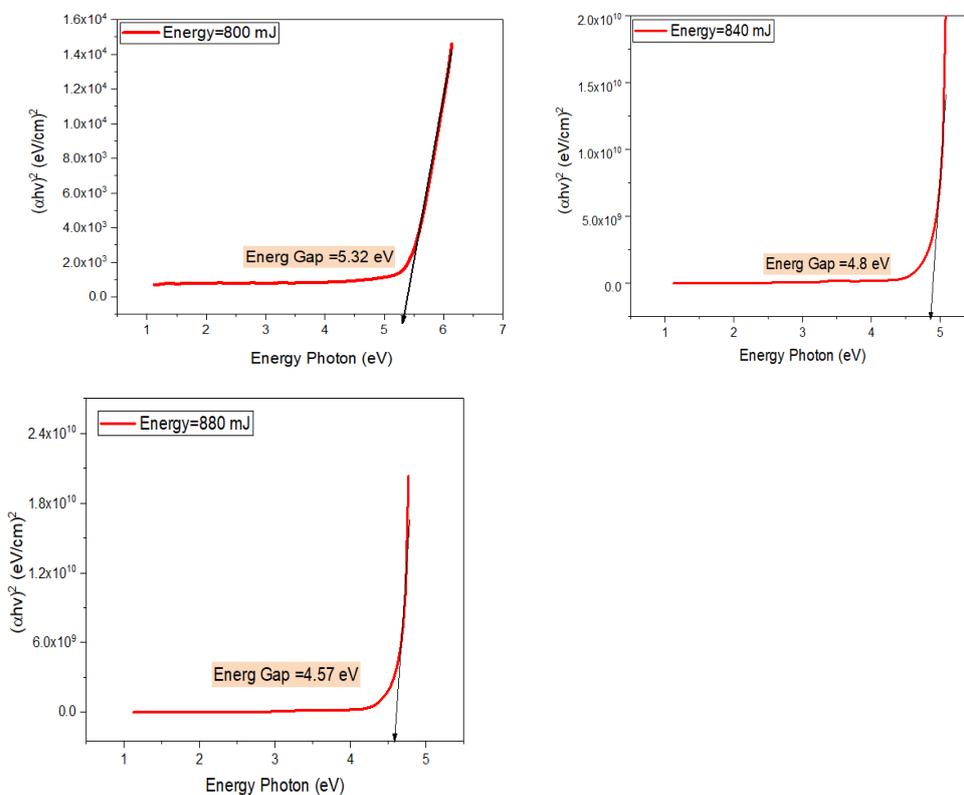


Figure (5) shows the energy gap of magnesium oxide films.

3-6 Biological tests

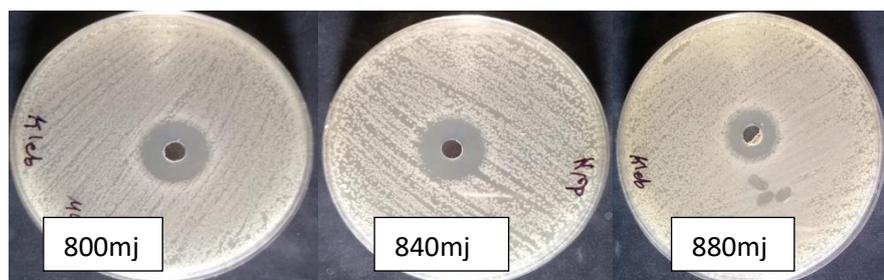
The figure shows (6,7,8,9,10) Effectiveness particles magnesium oxide nano in inhibiting the growth of some types of bacteria Prepared at different laser energies (800, 840, and 880 mJ). At 800 mJ, the inhibition zone was 20 mm in diameter, where positive bacteria such as Staphylococcus aureus and Staphylococcus epidermidis responded well, while the substance was less effective against gram-negative bacteria such as Escherichia coli and Klebsiella sp. As shown in the figure (10).

As for energy 840 mJ, the diameter of the inhibition zone remained the same, indicating that increasing the energy did not lead to improved performance, with the effectiveness of magnesium oxide against gram-negative bacteria continuing to decline. But At 880 mJ, the diameter of the inhibition zone decreased significantly to 14 mm, indicating a deterioration in efficacy, especially against Klebsiella sp. As for negative bacteria Escherichia coli The diameter was 22 mm, which means improved effectiveness of magnesium oxide particles on this type of bacteria, as shown in Table (3).

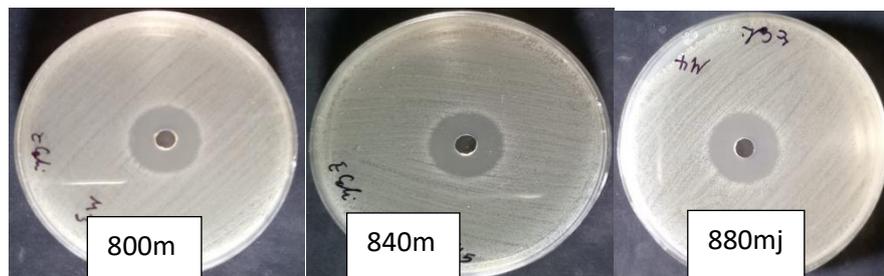
The results indicate that increasing energy from 800 to 880 mJ results in a significant decrease in efficiency particles magnesium oxide nano, with positive bacteria being more affected than negative bacteria. because Gram-negative bacteria may be able to develop resistance mechanisms, such as secreting enzymes that degrade antigens or modifying the cell wall to reduce permeability. [18] This decrease in the retardation diameter when the laser power is increased may be due to the change in the crystal size and the size of the nanoparticle, as indicated by the test results. (AFM) and (XRD) The larger the size, the greater the ablation energy.

table:3 Inhibition diameter values for bacterial species

Energy (mJ)	Staphylococcus aureus	Staphylococcus epidermidis	Escherichia coli	Klebsiella sp
800	22	22	23	20
840	21	21	22	20
880	18	20	22	14



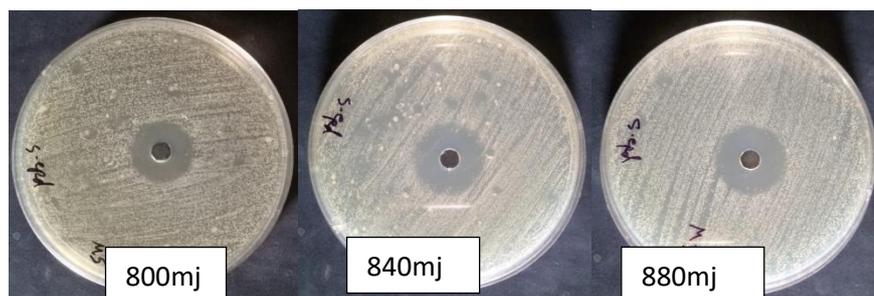
Shape (6) Antibacterial activity of particles MgO Nanoparticles against bacteria klebsiella.sp



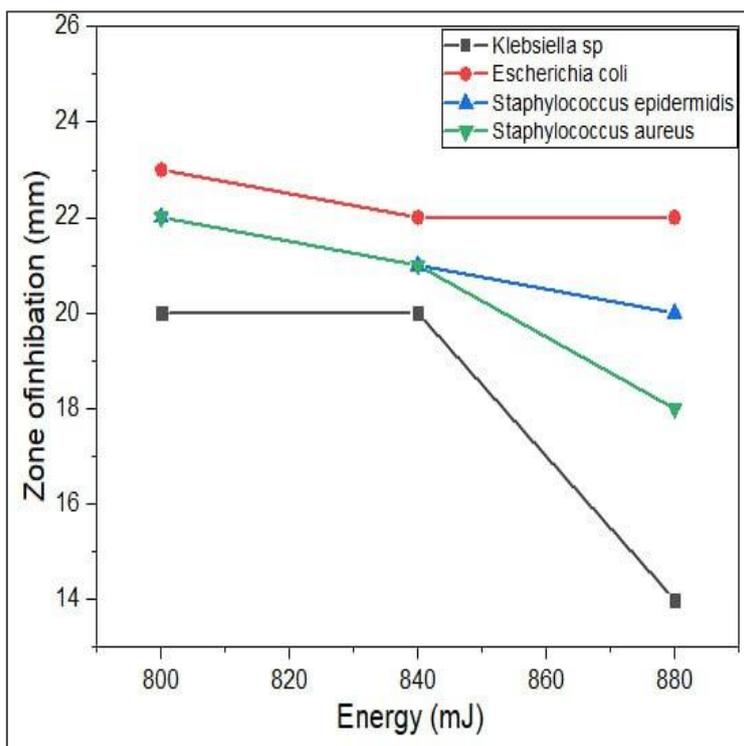
Shape (7) Antibacterial activity of particles MgO Nanoparticles against bacteria E.coli



Shape (8)Antibacterial activity of particles MgO Nanoparticles against bacteria S.auras)



The shape(9)Antibacterial activity of particles Mgo Nanoparticles against bacteria S.epd)



Shape (10) The effectiveness of Mgo nanoparticles in inhibiting the action of some types of bacteria.

Conclusions

From the results it can be concluded that technique Excision Laser is an effective method for preparing magnesium oxide nanoparticles. where nanoparticles are characterized by prepared by it with structural and optical properties improved as well. The particles showed a strong ability to inhibit the growth of multiple types of bacteria., so magnesium oxide may be considered a promising option in strategies to combat bacterial infections.

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