Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.14, No.13, 2023

A Review of Laser Ablation- Synthesis of Nanoparticles: Concepts and the Principles

Nadia Mohammed Jassim Alyaa Hussein Ali Nada Ismael Ibrahim
University of Diyala, College of Science, Department of Physics, Iraq
nadiajassim@uodiyala.edu.iq

Abstract
Laser tecnique is considered one to prepare different kinds of nano materials esspetially nano particles such as quantum dots, carbon nano tubes, nano wires, and core- shell nano particles. The current study review including nano particles which are prepared by pulsed -laser ablation . The growth procedure of nano particles by laser-ablation is focuced in this study . The important parameters to control of nano particle size and the aims to nano particle preparation by pulsed-laser ablation- technology are then discussed.
Keywords:pulsed - Laser ablation technique . parameters of laser . Laser focusing parameters . Mideum of ablation embient . Nano particle preparation
DOI: 10.7176/JNSR/14-13-04
Publication date: December 31st 2023

1. Introduction

Due to nanoparticles have a diversity of unique propertiest hat are not found in bulk materials (Buzee et al.., 2007). The important characteristic of nano particles is that the properties like electrical, optical, magnetic , and so on depend strongly on the size and size distribution of the particles (Kim et al.., 2014At room temperature the photolumenscence of silicon nano-particles are in visible region from electromagnetic wave (Kennmitsu, 1995; Yohida et al.., 1998); the particle size of nan-materials are more important to control the wave length of the light emission (Orri et al.., 2003) The titanum particles have many important in optoelectronic device(Organ and Gritzel, 1991) and photovoltaic application [1-8]. The photo-chemical properties of titanium nano particles have a strong dependence on the particle size and the crystal structure. there are several types of nano particles displaybehavior characteristics like ferro magnetism, para magnetism, pinnedemission, fluor-escence and spinquantum effect. at nano-scale (Zhang et al.., 2004; Kum et al., 2014). nanoparticle preparation methods have been advanced with the bottom-up behavior in the liquid state like sol-gel and chemical reduction and vapor phase like physical or chemical vapor deposi- tion [7,9-15]. The important Vapor phase processes at synthe-sizing with high purity nano particles by the continu ous flow reactor. In both of liquid and gas bottom-up methods , solid nano particles are generatedfrom the nu- cleation of super-saturated species. Pulsed- Laser ablation is a technique that uses laser beam as an energy pump for ablating solidtarget materials. this procedure, high energy laser is con- centrated at a specific- point on a solid surface target to evapo- rate lightabsorbing material. ‘ablation’ means removal the atoms from the surface target and it doesont involve a sin- gle photon process the chemical bonds breaking but also multi-photon excitation thermal eva-poration [16-25]. In study review, pulsed- laser ablation-originate in nanoparticle formation procesdures and their mechanism process are dis cussed, then laser ablation techniques for synthe- sizing kinds of nano particles. Finally, developed laser ablation procedures for preparing nano- materials are intro- duced[26-30]

2.PreviousPulse Laser ablation (PLA) review work published

PLA was invented in the 1960s, before the pulsed ruby laser. Many subsequent studies have looked into pulsed-laser ablation in vacuum and dilute gases [31-35].

By adjusting the materials, back-ground gases, and the parameters of laser , many different kinds of thinfilms can be created for ulitilze in diverse fields, such as eleetrodes, wearresistant attachements (Mehssina 2011). Metals oxides, semi-conductors, hightemperature super-conductors are examples of targets that can be used[36-41].

In 2011, authors (Ali and Raouf) created silver nanoparticles in distilled and deionized water using a pulse laser (Nd: YAG) with wavelength nm (1064), time ns (10) and energy 100-900 mJ. The nanoparticles were created The resultant silver has a spherical form and a size of (5-50nm)[42-48].

Adawiya J. Haider et al. (2013) investigated TiO2 TiCl4 nanoparticles generated as precursors in an ambient atmosphere using a 1:10 ethanol solution and no additives. X-ray diffraction and electron microscopy (SEM) were used to analyze the nanoparticles' structure, shape, and size. A visible ultraviolet spectrophotometer was used to investigate optical characteristics. The results revealed that the anatase phase was only present in titanium dioxide powder up to a concentration of 500. The average size of TiO2 nanoparticles was found to be between (3- 30) nm. TiO2 particles produced at 10-5 and 10-3 concentrations shown improved antibacterial action against two kinds of bacteria, Escherichia coli (E-coli) and Staphylococcus aureus, respectively. TiO2

nanoparticles are more potent antibacterial agents against Staphylococcus aurous than E-coli[49-55].

(2014)created colloidal titanium dioxide nanoparticles by laser ablation of titanium metal submerged in anionic water (Khashan and et al.). They used the ultraviolet (UV-Vis) spectrum, the Fourier transform infrared (FTIR), and the transmission electron microscope (TEM) to investigate the characteristics of suspended nanoparticles. The researchers described the creation of titanium oxide particles using (FTIR) analysis, and the results of (TEM) photographs revealed granular ranged 3-30 nanomater. The nanoparticles were tested for antibacterial activity against (Staphylococcus aureus) and (Escherichia coli). Bacterial inhibition has been demonstrated using titanium dioxide nanoparticles [56].

Lakshmipathy and Nanda (2015) synthesized silver nanoparticles from gallic acid and investigated their biological applications. The UV-VIS spectra had a small peak with a maximum at 424nm. The FESEM micrograph shows a narrow size variation of AgNPs with sizes ranging from 30nm to practically spherical in form. AgNPs inhibited HEp-2 cell proliferation with an IC50 of 1mg/mL concentration, accompanied by morphological changes and membrane degradation. Its toxicity is due to its great affinity for intracellular proteins and thiol production, which may be extended for many biological uses as a broad spectrum therapeutica.gent [57].

Salman (2016) created nanoparticles of titanium oxide using pulsed- laser ablation by inserting with high-purity titanium 99.9% in (2) mililitter of di-ionizedwater and using a Nedyum- Yag laser at nm wave-lengths (1064,532) and a laser energy of mJ (500). The researcher investigated the properties of nano-particles using X rar diffraction;XRD, atomic force- microscopy; A-FM, and the absorbance measurments UV/Visble , and the average diameter of the resulting particles ranged between nm (84.78 95.96) at nm wavelengths (532,1064), respectively[58]. Caroline and her colleagues (2017) created silver nanoparticles using a pulse laser ablation method with a wavelength of 1064 nano-meter and a pulse width of 35 nm, as well as distinct impacts of silver target radiation in different conditions. They discovered that the nano-particles' visible UV-visible absorption spectra peak the absorption of the surface Plasmon resonance in the ultraviolet range. They measured the size and form of the nanoparticles using STEM and TEM micrographs. The results demonstrated that the diversity of the laser effect and the liquid medium had a considerable influence on the properties of the silver nanoparticles and their production rate. Various circumstances were used to create particles with diameters ranging from 2 to 80 nm. This work demonstrates promising studies[39]. Prahlad and his colleagues (2018) investigated the rise of plasmon bandwidth produced nanoparticles with increasing laser power on the silver target suggests a decrease in nanoparticle size [36]. In 2019, Billy and colleagues investigate the manufacture and characterisation of Au NPs by pulsed -laser ablation [38]. In 2020, Chen and colleagues will investigate ZnO colloids and ZnO nanoparticles generated by pulsed laser ablation of zinc granules in water in 2020. Structure and optical characterization of nano-particles indicated the production of ZnO NPs.

Rasha Hamed Ahmed researched the influence of laser on the Al particles in (2021)[16].Aluminum nanoparticles (AL NPs) were created in this study utilizing the ND/YAG - laser ablation method with the pumping wavelength 1064 nm, UV spectroscopy was used to investigate the optical properties for both the absorption and transmittance spectrums, as well as changes in laser power and wavelength.

Tahseen H. Mubarak and coworkers in 2022, investigated several physical properties of Al nanoparticles using the pulse laser ablation in liquid method (PLAl).[36].

In 2023, Alireza Ghasempour and etal highlight studying the properties of cadmum sulfide related to the bio-medical area such as bio-imaging , anti-bacteria and bio-sensores [37-39].

Many case studies on the production of NPs via abaltion of laser approach have been described, however there is no -art review on parameters impacting NP production . The characteristics impacting the sproduction of Ps via laser aapproach are summarized in Fiq.1.

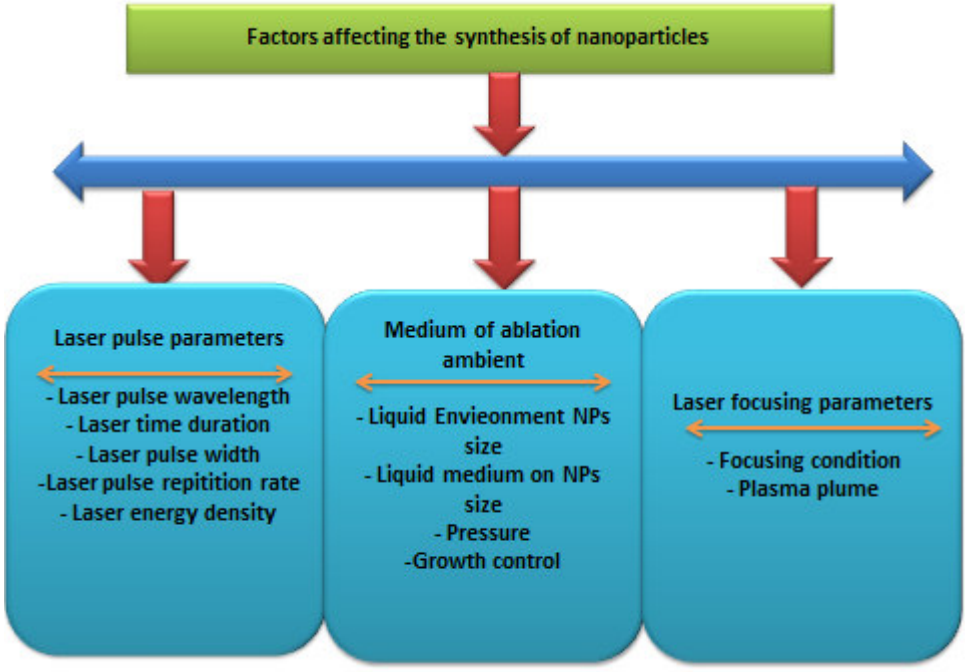

Fig. 1.the influencing parameters for particles producation via laser system

3. Basic concept of laser ablation

The process of synthesis can be used to create several types of nanoparticles shown in Fig2.

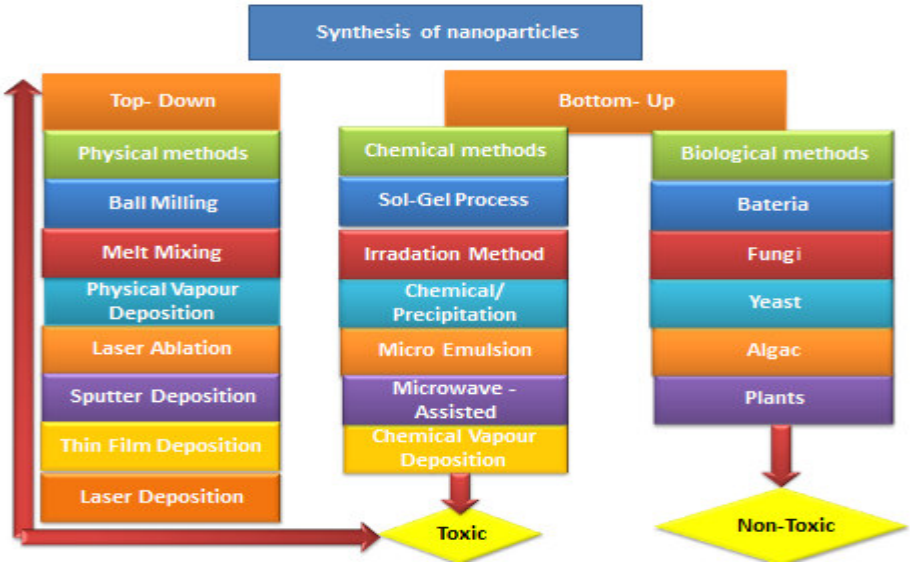

Fig.2. Different methods of synthesis nanoparticles

Using a (top-down) methodology, laser ablation technique has a more famous way to creating minerals. [40]. The ablation technique removes some materials off the surface as a result of the laser beam's interaction with the solid substance. Which is derived from the Latin term (Ablation) for elimination [41,42].

The equilibrum plasma plum produced by pulselaser ablation to prepare the nanoparticles can reach temperatures in the hundreds of degrees Celsius. The sample surface reflects some of the energy released by a laser pulse. It is important to remember that reflectivity is affected by both the material and the laser wavelength. The sample absorbs energy, which is transformed from optical photons to electrons and subsequently distributed through the material by the lattice [46]. Pulses of high energy bursts can produce photochemical reactions that take atoms and molecules off the surface. As the heated surface approaches the critical temperature, the vaporization process accelerates. The vaporization process results in plasma, which is composed of ioni, vaporized electrons. some of the incident laser energy is absorbed by the plasma cloud, allowing just a fraction of the laser energy to get through. Because of the variation in the link of the laser to the material in different time

ranges, the processes of laser ablation differ in both nanosecond and picosecond laser pulses, and pulsed laser ablation is characterized by nanoseconds (79 ns) of both thermal and non-thermal mechanisms [47].

The production of particles at nano-scale via laserr-ablation shows in Figure3. When laser radiation is focused on the material surface in the ambient media gas and liquid, the temperature of the irradiated spot rapidly increases, vapor izing the target material. The colli- sions between the ev-aporated atom or clusters and the surrounding molecules result in excitation of the electron state coupled with light emission and production of electrons and ions, formang a laseriinduced plasma plume (Fig. 43). The target material, ambient media (liquid or gas), ambient pressure, and laser settings all influence plasma structures (plume size and emission spectrum).

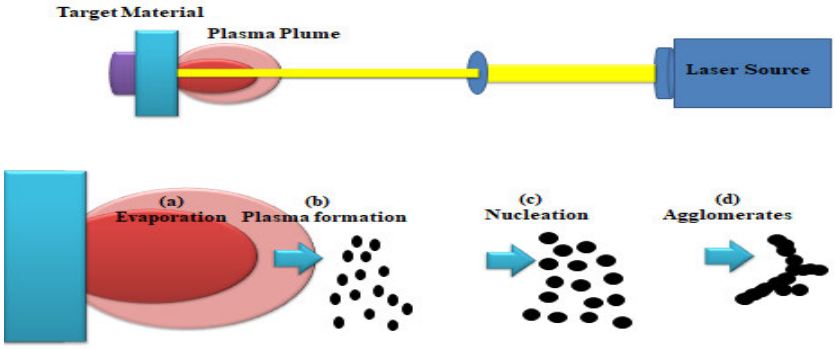

Fig. 3 Schematic of particle generation procedure in the laser ablation process.

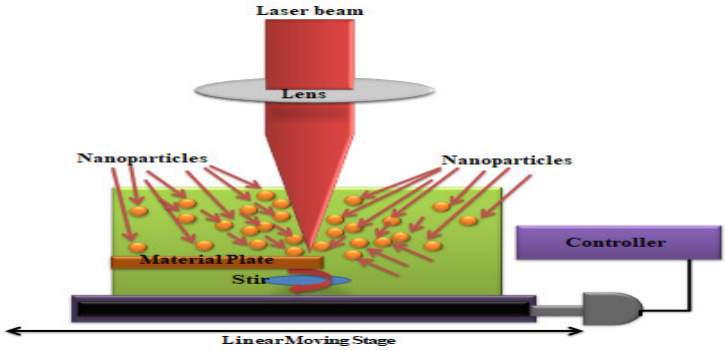

Fig. 4 Mechansim of Laser-induced plume of nanomaterials

4. Effect of laser pulse on nano-particles

4.1 The influence of laser pulse wavelength

The target material's different absorption at certain wavelengths leads in varied concentrations, which determine particlesizes. however, that the morph-ology of the resultant materials is unchanged (Chewshinda etal. 2013). Small- particle due to cause thermal fluectuations and form instability (Swirnkar e al. 2011).

4.2 The influence of laser /pulse width variation on nano-particle

The pulse durition is an important element in the production of nanoparticles. When it is changed from nanaseconds (ns) to pcoseconds (ps) and femto-seconds (fs), the ablation mechanssm shifts from melting and thermal evaporation to phase expiosion. A shorter pulse duration leads to a more effective ablation process, with immediate eva-poration and a small heat-affected zone. Ablation was faster in picoseconds due to the metal's lower than ns threshold (Giorgetti et al. 2015a). It has also been noted that in the case of ultra-short laser pulses, the energy received by the target stays fairly low. As a result, using ultra-short laser pulse durations of ps/fs is advantageous since it may be used to many applications such as in biomedical , enviromental and sensores application and so on[56-58].

5. pulsed – laser system

5.1 ND-YAG laser system

Neodymum-doped ylttrium aluminum garnt is a lasing medium in solid-state lasers. A flash-lamp tube of laser diodes is used to optically pump the Nd:YAG laser. NDYAG lasers emit light at 1064 nm (infrared area)[43].

5.2 Laser excimer ablation

The active medium of an excimer laser is gas. The wavelength of the generated beam is between 193 and 351 nm.

In the late 1970s, the excimer laser was initially reported. Since then, many advances have been achieved in gas lifetimes, computer control electronics)[53,58].

6. Conclusion

This study includes information on laser puls parametres, laser fluence.

For creating NPs, the laser ablation technique is preferable and has few drawbacks. This technique can be used to create a wide variety of NPs. The shape, size, and dispersion of the for various targets are influenced by the liquid medium at room temperature, which also determines the NPs' composition.

The formation of thin films from practically any type of solid target material is thought to be possible using the gas medium of a solid target positioned in a vacuum chamber. The aim of the present review study is focusing on the developments in the synthesis of noble nanometals techniques and various their applications. like pulsed laser a technique . The current study addressed several importants sections: the firsit section dealt with the synthesis of gold and silver nanoparticles pulsed laser technique.The second section dealts with studying the properties of nano materials ,these properties include the structural, morphological and optical properties of pre-products nanomaterials.Finally, the current review study included the important applications of siver nanoparticles and gold nanoparticles, some of which are used as adsorption materials in the treatment of pollutantsin water as well as in anti bacterial and anti corrosion for some materials and so on.

REFRENCES

[1] G. Franci, A. Falanga, S. Galdiero, L. Palomb, M. Rai, G. Morelli, M. Galdiero , " Silver nanoparticles as potential antibacterial agents " , Molecules , vol. 20 , pp. 8856-8874 , 2015 .

[2] S. Tsuruga, T. Abe, "Preparation of electro conductive inkjet inks through silver halide photographic emulsion " , Proceedings of the pan pacific Imaging conference, pp. 56-59 , 2008 .

[3] Zhang, D., Liu, T., Cheng , J., Liang , S., Chai , J., Yang, X., " Controllable synthesis and characterization of tungsten disulfide nanosheets as promising nanomaterials foe electronic devices. Ceramics Int vol.45, pp. 12443-12448.2019 .

[4] Azharuddin , M., Zhu, G. H., Das, Ozgur , E., Uzun, L., Turner , A. P., " Arepertoire of biomedical applications of noble metal nanoparticles . Chem. Commum . vol. 55, pp. 6964-6996, 2019 .

[5] Sharma , V. K., Sayes , C. M., Guo, B., Pillai, S., Parsons, J. G., Wang , C., " Interactions between silver nanoparticles and other metal nanoparticles under environmentally relevant conditions ", AReview . Sci. Total Environ , vol. 653, pp. 1042-1051, 2019.

[6] Yaqoob, A. A., Parveen , T., Umar , K., Ibrahim , M., and Nasir , M. " Role of nanoparticles in the treatment of wastewater : Areview . Water , vol.12, PP.495 , 2020 .

[7] Chitra, M. A. " Rapid detection of staphylococcus aureus genomic dna using peptide nucleic acid and gold nanoparticles . Proc, Natl . Acad . Sci. U.S.A. vol. 88 , pp. 803-811, 2018 .

[8] Ho, J. A. A., Chang, H. C., Shih , N. Y., Wu, L, C., Chang , Y.F., " Diagnostic detection of human lung cancer associated antigen using a gold nanoparticles based electrochemical immunosensor. Anal . Chem . vol. 82, pp. 5944-5950 , 2010 .

[9] Yaqoob, A. A., Umar, K., and Ibrahim , M. N. M. " Nanoparticles : various methods of synthesis , size affecting factors and their potential applications , Areview . APPL. Nanosci . vol.10, pp. 1369-1378, 2020 .

[10] R. S. Patil, M. R. Kokate, C. Jambhale, S. M. Pawar, S. H. Han, S. S. Kolekar , " One pot synthesis of PVA capped silver nanoparticles their characterization and biomedical application " , Adv . Nat . Sci. Nanosci. Nanotechnol . vol.3, pp. o15013-7-1, 2012 .

[11] M. J. Ahmed , G. Murtaza, A. Method, and T. M. Bhatti, " Green synthesis of silver nanoparticles using leaves extract of skimmia laureola : characterization and antibacterial activity : Mater . Lett., vol. 153, pp. 10-13, 2015 .

[12] R. Banasiuk ," Carnivorous plants used for green synthesis of silver nanoparticles with broad spectrum antimicrobial activity , Arab . J. Chem ., vol. 13 , pp. 1415-1428, 2020 .

[13] Faysal , Abd al Qadir , Musa, Ahmad .A. Jamil. Z. N, " Preparation of silver and gold nanoparticles by using ND-YAG pulse laser ablation " , Engineering and Technology Journal , vol. 32, pp. 138-144, 2014.

[14] Yasir A. , Ihsan .U, Mazhar. UL. Islam , " Adopting a green method for the synthesis of gold nanoparticles on cotton cloth for antimicrobial and environmental applications " , Arabian Journal of Chemistry , vol.14, 2021.

[15] Margarita I. Skiba , Victoria I. Vorobyova , " Preparation of silver nanoparticles in plasma liquid system in the presence of PVA : Antimicrobial , catalytic, and sensing properties ," Journal of Chemistry , vol.3, 2020

[16]Wenguang Chen , Chujun Yao , Jie Gan , Kai Jiang , Zhigao Hu , Jiamin Lin , Ning Xu , Jian Sun , Jiada Wu , ZnO colloids and ZnO nanoparticles synthesized by pulsed laser ablation of zinc powders in water. Material Science in Semiconductor Processing, 2020,104918,109.

[17] Kelly. K.L., et al., *The optical properties of metal nanoparticles: The influence of size, shape, and dielectric*

environment. Journal of Physical Chemistry B, 2003. 107(3): p. 668-677.
[18] Alborz, I, Rebecca .J, " A plasma based gas phase method for synthesis of gold nanoparticles " , Plasma processes and polymers , vol.16, 2019.
[19] I. Dolgaev, A. V. Simakin , V. V. Voronov , G. A. Shafeev, F. B. Verdueaz, Nanoparticles produced by laser ablation of solids in liquid environments , Appl. Surf . Sci . vol. 186, pp.546-551, 2022.
[20] H. Huang , Y. Yang , " Preparation of silver nanoparticles in inorganic clay suspensions , " Compos . Sci. Technol. Vol.68, pp. 2948-2953, 2008 .
[21] Hu H., Wang K., and et al. Precise Determination of the Crystallographic Orientations in Single ZnS Nanowires by SecondHarmonic Generation Microscopy,Nano Lett. 15 (2015) 3351-3357.
[22] Yang G. Laser ablation in liquids : principles and applications in the preparation of nanomaterials . Boca Raton : CRC Press, 2012.
[23] He Y, Li X, Wang J, " Synthesis , characterization and evalution cytotoxic activity of silver nanoparticles synthesized by chinese herbal cornus officinalis via environment friendly approach . Environ toxicol pharmacol , vol.56 , pp. 56-60, 2017 .
[24]. Shamsee, Z. R., Al Saffar, A. Z., AlShanon, A. F. Mol Biol Rep , vol.46, pp.381 , 2019 .
[25]. Sakiyama K., Koga K., Seto T., Hirasawa M., Orii T., Formation of size selected Ni/ NiO core shell particles by pulsed laser ablation , J. Phys. Chem. B, vol.108 , pp.423-529, 2004 .
[26]. Yonzon, C. *et al.* A comparative analysis of localized and propagating surface plasmon resonance sensors: the binding of concanavalin a to a monosaccharide functionalized self-assembled monolayer. *Journal of the American Chemical Society* 126, 12669–76 (2004).
[27] Willets, K. A.; Van Duyne, R. P. Annu Rev Phys Chem 2007, 58, 267.
[28] Satoshi, K.; Motoichi, O.; Masahiro, I.; Springer: Verlag Berlin Heidelberg New York, 2002.
[29] NM Jassim, NA Kareem, NI Ibrahim, SBA Manan,Investigation on synthesis, structural and nonlinear optical responses of cadmium selenide coated with gold nanoparticles induced by femtosecond laser excitation, Eastern-European Journal of Enterprise Technologies 3 (5), 111
[30] AH Ali, TH Mubarak, NM Jassim, IM Jasim, Biosynthesis and study of some optical properties of silver nanoparticles in corporate plasmon resonance for antibacterial activities Plant Archives 19 (2), 1063-1066.
[31] TH Mubarak, NM Jassim, QA Guidan,Some physical properties of Al nanoparticle Via pulse laser ablation in liquid method (PLAl), Academic Science Journal 1 (2), 66-81
[32] M. C. Sportelli, M. Izzi, A. Vople, M.Clemente , R. A. Picca, A. Ancona , " The pros and cons of the use of laser ablation synthesis for the production of silver nano antibacterials , " Antibiotics , vol.7, p. 67 , 2018
[33]. Noor ,M. A, Fathi . M. J, " Study of optical and structural properties of prepared gold nanoparticles by pulse laser ablation method " , Journal of Education and Science , vol.30 , pp.69-82, 2021.
[34] J.Natsuki , T. Abe , "Synthesis of pure colloidal silver nanoparticles with high electronductivity for printed electronic circuits : The effect of amines on their formation in aqueous media " , J. Colloid . Interf . Sci . vol . 359, pp.19-23 , 2011 .
[35] Hammad R. Humud , Ahmed S.Wasfi , Aqieel M.Maki ," Preparation of silver nanoparticles by exploding wire in different liquids " Asian Journal of applied Science and Engineering , vol 3 , pp . 23-32 , 2014 .
[36] Tahseen H Mubarak, Nadia M Jassim, Quds A Guidan: 2022, Some physical properties of Al nanoparticle Via pulse laser ablation in liquid method (PLAl, Academic Science Journal 1 (2),
[37] Alireza Ghasempour ORCID,Hamideh Dehghan ,Mehrnaz Ataee ,Bozhi Chen ,Zeqiang Zhao ,Mahsa Sedighi ,Xindong Guo and Mohammad-Ali Shahbazi, , "Cadmium Sulfide Nanoparticles: Preparation, Characterization, and Biomedical Applications "Molecules 2023, 28(9), 3857; https://doi.org/10.3390/molecules28093857.
[38] Suman TY , Radhika Rajasree SR , Ramkumar R , Rjthilak C, Perumal P." The green synthesis of gold nanoparticles using an aqueous root extract of Morinda citrifolia L. spectrochim Acta A Mol Biomol Spectrosc . , vol 118 , p 11-16 , 2014 .
[39] J. Natsuki , T. Abe , " Synthesis of pure colloidal silver nanoparticles with high electroconductivity for printed electronic circuits : The effect of amines on their formation in aqueous media : , J.Colloid . Interf . Sci . vol . 359 , pp .19-23 , 2011 .
[40] J. Natsuki , T . Natsuki , " Low molecular weight compounds as effective dispersing agents in the formation of colloidal silver nanoparticles : , J . Nanopart . Res . vol . 15 , pp . 1483 -1-8 , 2013 .
[41] J. Natsuki , T. Natsuki , " One step synthesis of silver nanoparticles using low molecular weight compounds at room temperature " . Inter . J.Mater . Eng . Techno . vol , 13 ,pp . 109- 119 , 2015 .
[42] P.K Dash and Y. Balto , Research Journal of Nanoscience and Nanotechnology , vol . 1 , pp.25-33 , 2011 .
[43] Vicki H. Grassian , When size really matters : size de[pendant properties and surface chemistry of metal and metal oxide nanoparticles in gas and liquid phas environments , J,Phys . Chem. C , vol.112 . pp.18303-18313, 2008 .
[44] Asep Bayu Dani Nandiyanto , Kikuo Okuyama , Progress in developing spray drying methods for the

production of controlled morphology particles : From the nanometer to submicrometer size ranges , Advanced powder technology , vol.22 , pp.1-19 , 2011.

[45] Jun Natsuki , Toshiaki Natsuki , Yoshio Hashimoto ," A Review of silver nanoparticles : synthesis Methods , properties and Applications " , International Journal of Materials Science and Applications , vol .5 , pp.325-332 , 2015 .

[46] Praus et al, Precipitation of ZnS Nanoparticles and Their Deposition on Montmorillonite. Adv. Sci. Eng.Med. 3, 113–118, 2011.

[47] S. Y. Yeo, H. J. Lee , S. H. Jeong ," Preparation of nanocomposite fibers for permanent antibacterial effect " , J. Mater . Sci . vol 38 , pp. 2143-2147 , 2013.

[48] S. Tsuruga and T. Abe , " Preparation of electro conductive inkjet inks through silver halide photographic emulsion " , proceedings of the pan pacific Imaging conference , pp.56-59. 2008.

[50] N. T. K. Thanha , L. A. W. Green , " Functionalization of nanoparticles for biomedical applications " , Nano today , vol. 5 , pp.213-230 , 2010 .

[51] V. Ravichandran , S. Vasanthi , S. Shalin , S. A. A. Shah , M. Tripathy , and N. PALIWAL , "Green synthesis , characterization , antibacterial , antioxidant and photocatalytic activity of parkia speciosa leaves extract mediated silver nanoparticles , Results Phys ., vol. 15, pp.102565, 2019.

[52] S. F. Hashemi, N. Tasharrofi , and M. M. Saber , " Green synthesis of silver nanoparticles using Teucrium polium leaf extract and assessment of their antitumor effects against MNK45 human gastric cancer cell line ., J. Mol. Struct ., vol. 1208 , 2020 .

[53] S. Chinnappan , S. Kandasamy , S. Arumugam , K. K. Seralathan , S. Thangaswamy , and G. Muthusamy , " Biomimetic nanoparticles using flower extract of Bauhinia purpurea and its antibacterial activity against clinical pathogens ., Environ . Sci. Pollut . Res., vol.25 . pp. 963-969 , 2018 .

[54] Mohamed , M. M., Fouad , S. A., Elshoky , H. A., Mohammed , G. M., and Salaheldin , T. A. " Antibacterial effect of gold nanoparticles against Corynebacterium pseudotuberculosis . Int . J. Vet . Med . Sci,5 , pp.23-29, 2017 .

[55] Cai, H., Degliangeli , F., Palitzsch , B., Kunz, H., Schmitt, . Glycopeptide functionalized gold nanoparticles for antibody induction against the tumor associated Mucin -1 glycoprotein , Bioorg . vol 24 , pp. 1132-1135 , 2016 .

[56] Taylor , U., Brachanski , A., Garrels , W., Klein , S., Kues , W., Barcikowski , S., " Toxicity of gold nanoparticles on somatic and reproductive cells , Nano biotechnology for Biomedical and Diarnostic research . Singapore , Springer . vol.12 , 2012 .

[57] Chaloupka , K., Malam , Y., and Seifalian , A. M. " Nanosilver as a new generation of nanoproduct in biomedical applications " Trend Biotechnol , vol . 28 , pp. 580-588 , 2010 .

[58] Ngwa , W., Kumar , ., Sridhar , S., Korideck , H., Zygmanski , P., Cormack , R. A., " Trageted radiotherapy with gold nanoparticles : current status and future perspectives . Nanomedicine , vol . 9 , pp. 1063-1082 , 2014 .