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Application and study of silver nanoparticles as antidiabetic agent and the role of LED (light emitting diode) or laser at the range (395 - 450) nm on the activity of the drugs

Ayad Khalaf Alhashimy[1], Abbas Abbd Latif[2,*], Abeer Qays Abdulwahab[1], Nihad Al-Hashimi[3]

[1]*Department of Pharmaceutical Chemistry, College of Pharmacy, University of Mustansiriyah, Baghdad, Iraq.*
[2]*Department of Clinical Laboratory Sciences, College of Pharmacy, University of Mustansiriyah, Baghdad, Iraq.*
[3]*School of Life Sciences, Pharmacy and Chemistry, Kingstone university, London, UK.*

[*]**Corresponding author:** alabbas16@uomustansiriyah.edu.i

Original Research

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Abstract:

Considerable research has been carried out on diabetes mellitus (DM) and many materials have been used to treat the disease. Silver nanoparticles (AgNPs) have been used in many fields in medicine, and have been utilised in the treatment of DM in vivo successfully. In this paper, AgNPs were synthesized using a green method and used with male albino mice (20 - 40) g. Light emitting diodes (LEDs) and lasers in the range (395 - 450) nm. AgNPs and LEDs or lasers were used in this work to evaluate their effect on diabetes mellitus. It was found that AgNPs at the concentrations 6, 15, and 30 mg/kg reduced blood glucose level (BGL) to normal values. The best concentration that was found to treat DM is 15 mg/kg. However, at concentrations of 15 and 30 mg/kg, several deaths occured, but when laser or LED were used by radiating AgNPs, the deaths decreased to a ratio of fifty percent. The laser and LED in the range of (395 - 450) nm made the drug active and reduced the deaths of animals to a ratio of 50%.

Keywords: Alloxan; Diabetes; Mice; Organic compounds; Silver nanoparticles; Silver nitrate; Laser; LED

1. Introduction

Diabetes Miletus (DM) is a disease that occurs in almost tenth of people in the world. It is produced because of a disorder happening to the pancreas [1]. There are two types of DM. Type (1): β-cells, which are in the pancreas, do not eject enough insulin hormone to the blood. Type (2): cells of the body resist insulin to enter inside them, and the matter develops until the glucose level in the blood raises [2]. Ninety percent of diabetic patients all over the world have type 2 DM. [3]. The main reason for diabetes disease is reactive oxygen species (ROS) which cause β-cells disorder and insulin resistance. Increasing food and decreasing activity of body physics make overload in glucose and fatty acids, which leads to formation of reactive oxygen species [4]. Pancreatic β-cells are sensitive to the stressors of physiological and pathological operations in the body, leading to a loss in insulin and β-cells death [5].

Diet, changing lifestyle, and oral administration of antidiabetic agents make key agents to down-regulate the formation of reactive oxygen species leading to treat diabetes [4, 6]. The objective of papers, research, and drugs is to control the blood sugar level in the normal range (70 - 140 mg/dl) [6]. Several types of drugs and antidiabetic agents were introduced to the medical field to maintain persistent control of glycemia. But these drugs induced adverse side effects like hypoglycemia, gastrointestinal discomfort, pancreatic degeneration, and other symptoms [7]. Then, finding new drugs decreasing blood sugar levels having fewer side effects and undesirable symptoms is the aim of the researchers

that have been performing for decades of years [8]. Different research have been published studying the antidiabetic effect of several materials and herbs on mice and rats (albino mice or albino rat) as diabetic models because they resemble human being in diabetes Miletus [9–11].

Nanotechnology emerged in 1966 from a Japanese man who established this science field. Nano word in Latin means the smallest thing. It is in the range of one to one hundred nanometer, which means one billionth unit [12–14]. Nanotechnology science was established that when the material converts to smaller particles; its chemical and physical properties will change [15]. Nanoparticles proved their high efficacy in medicine (treatment, diagnosis, and drug delivery). Especially, silver nanoparticles (AgNPs) became more desirable than any other nanoparticles since their amazing properties like biocompatibility, colloidal stability, low toxicity, bioavailability, and capacity for surface modification [16–18]. Silver was known to be a good antibiotic agent against different bacteria and a good medicine for many diseases since the Greek age. It was found that AgNPs are more effective in treating body infections than silver ions. Silver nanoparticles were used to treat burn infections, bacteria aggregation on dental filling, and microorganisms in textile fabrics and in water processes [19–21]. Since silver nanoparticles are a good antimicrobial agent, it was used in water filters, antibacterial detergents and sprays, cosmetics, making clothes, laptop key boards, and children toy‘s [22, 23]. Research also proved that it is a good antidiabetic agent [24, 25].

LED radiation has a wide field in medicine and treatment. Robert A. Weiss et al. (2007) prevented radiation-induced dermatitis occurring in breast cancer by LED photomodulation. Blue (415 nm) and red (660 nm) lead is effective in the treatment of acne [26].

Laser has entered the medicine from the widest door. The laser was used in lipolysis, tumor ablation, cancer treatment, ablation, surgery, cardiology, skin rejuvenation, dermatology, lithotripsy, atrial fibrillation, epilepsy [27], eye treatment [28]. Laser has wide future directions in cutaneous applications [29].

Since laser and LED has a wide range in medicine, it was used in this work with AgNPs to investigate its effect on diabetes.

Animal feces was found that it is a treatment for several diseases ; so, chicken stool was used in this search to investigate its effect on diabetes.

In this work, AgNPs have been synthesized (in the green method) by reducing silver nitrate by rosemary herb as done by [23, 24]. AgNPs synthesized were applied on forty albino alloxan-induced diabetic mice to investigate their antidiabetic effect.

2. Materials and methods

Chemical compounds used in this work

The chemical compounds used in this work are alloxan and silver nitrate ($AgNO_3$). Table 1 describes the chemical compounds used.

Organic compounds used

The organic compounds used in this search are rose merry herb and feces of chicken.

Apparatus used

The machines used in this work are magnetic stirrer, uv-spectroscopy, balance, LED in the range 395 - 450 nm and laser (395- 450 nm, power 250 mw), and “On call plus” (blood glucose monitoring system).

3. Preparing and synthesis of AgNPs

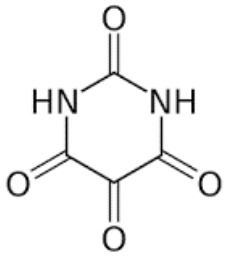
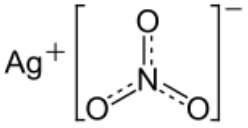
Preparing rose merry herb solution

Rose merry plant was dried and crushed and then immersed in alcohol until we can obtain a solution of it. The solution is filtered in a plate until it vaporizes; and then, the precipitate material is rubbed and dissolved in 10 mL of water. The resultant solution is filtered again.

Preparing silver nitrate solution

Put 1 mM of silver nitrate in 90 mL of distilled water, (mM means milli mole). The molar weight of silver nitrate is almost 170 grams; then milli mole of it is 0.170 gram or

Table 1. The chemical compounds used in this research.

The chemical compound name	The chemical molecule	Chemical structure
Alloxan	$C_4H_2N_2O_4$	
Silver nitrate	$AgNO_3$	

170 milligrams. Put the mixture on magnetic stirrer until it dissolves.

Pull 5 mL or 10 mL of the rose merry solution and inject it into the silver nitrate solution on the magnetic stirrer until the color of the solution converts from yellow pale to dark brown within 5 minutes. When the color converts from yellow pale to dark brown, it's a sign that silver nanoparticles have been generated. The images of that are in Fig. 1.

Characterization of the prepared AgNPs

The first test of generated silver nanoparticles is UV-spectroscopy of the suspension, which shows that there is an absorption at almost 430 nm, as shown in Fig. 2. The second one is FTIR, as shown in Fig. 3.

It is clear that FTIR of the AgNPs prepared is similar to the standard one that is in Fig. 4.

Preparing diabetic mouse

All procedures in this work were run according to the guidance of the Animal Ethics Committee of Mustansiriyah University/College of Pharmacy. Forty Adult albino mice aged from seven weeks to ten weeks and their weights from twenty to forty grams.

The mice were starved from food not water for 24 hours; and then, they were injected with alloxan by intraperitoneal (ip) method with ratio of 180 milligram per kilogram.

The origin of alloxan is from England or (sigma) from Germany exclusively. After alloxan is weighed with a ratio of 180 mg/kg, it is dissolved in 0.5 mL of distilled water. The operation is run in semi dark room because alloxan is oxidized and damaged if it is subjected to light. Alloxan is injected by ip method.

Summary of the method

Mice are subjected to fasting from only food for 24 hours; then, the mice are injected with alloxan with the ratio mentioned above. After the mice have been injected, a sugar solution is put for them so that they drink it for 12 or 24 hours or more (the sugar solution consists of two food spoons of sugar dissolved in 400 mL of water). This solution of water is assumed to be a breakfast for the mice. Put food for them after one to two hours for them; and then, you can lift this water and put the usual water until measuring blood glucose level BGL. After seven or eight to ten days, blood glucose level (BGL) was measured for the mice since BGL reaches to the top value at this period. When BGL reaches or is more than 120, the mouse is assumed to be a diabetic mouse.

Experimental work

Forty-five mice were divided into nine groups. Each group contains five mice. According to the concentration of AgNPs that was mentioned by [30–33], the fatal concentration is between 10 – 20 mg/kg; so, the concentrations of AgNPs that were chosen in this work is around this range. The concentrations of AgNPs that were chosen in this research are 6, 15, 30, and 60 mg/kg. The concentrations of silver nanoparticles for every group of mice that is used in this research are listed in Table 2.

The measurements were taken after three days from injection by alloxan. The unit of blood glucose level is milligram per deciliter (mg/dl). Deciliter is 1×10^{-10} liter.

4. Results

Group (1) was treated with silver nanoparticles (AgNPs) with a concentration of 6 mg/kg that is mentioned in the Table 2. Table 3 explains the results of the group (1).

The results of the second group that is treated with AgNPs with concentration of 15 mg/kg are listed in the Table 4.

The results of the third group that they were treated with 15 mg/kg and radiated with laser or LED in the range of (395 - 450) nm are in the Table 5.

The results of the fourth group that is treated with AgNPs with concentration of 15 mg/kg in two doses (the period between the first dose and the second is three days) and radiated with laser or LED in the range 395 - 450 nm are in the Table 6. Both doses are radiated.

The results of the fifth group which is treated with AgNPs with a concentration of 30 mg/kg Table 7.

The sixth group which was treated by AgNPs with a concentration of 30 mg/kg and radiated with laser or LED at the range (395 - 450) nm whose results are in the Table 8.

The seventh group was treated with 60 mg/kg and its results are in the Table 9.

The diabetic control group is in the Table 10.

The control of the nondiabetic group is shown in Table 11,

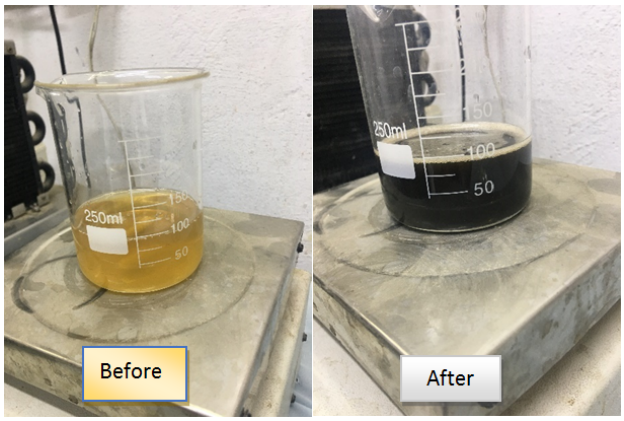


Figure 1. A figure explains how it converts from yellow shape to dark brown to be evidence that silver nanoparticles are generated.

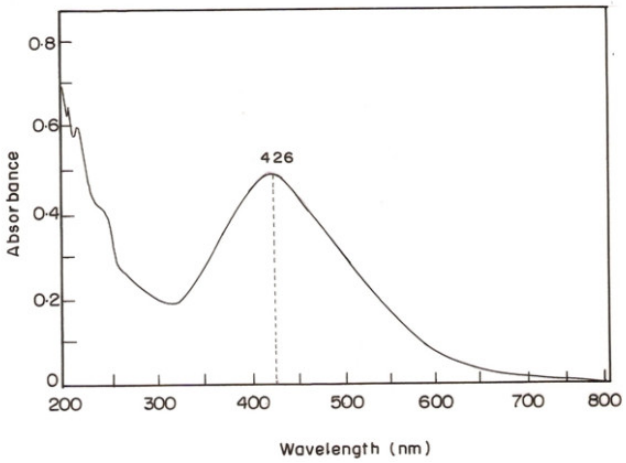


Figure 2. UV-spectroscopy of silver nanoparticles.

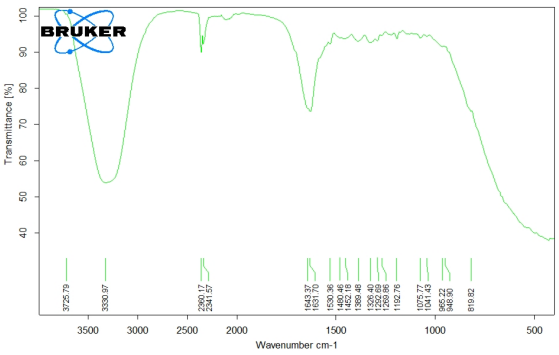


Figure 3. FTIR of prepared silver nanoparticles.

which shows the glucose levels for nondiabetic mice after and before three days. They are only given water and food. Tables 10 and 11 show statistical analysis of the comparison between before and after treatment of every group and between (after treatment) of every group and the control, respectively, the mean values, and the standard deviation of every group.

Fig. 5 shows a comparison in blood glucose levels for the groups before and after giving treatment.

Fig. 6 shows a comparison in BGL for the groups under study between the control diabetic and after giving treatment of every group.

Statistical software

The statistical analysis was run by statistical package for social sciences SPSS using Anova post hok test and Tukey HSD (version 23) USA and Exell Microsoft 2019. Each

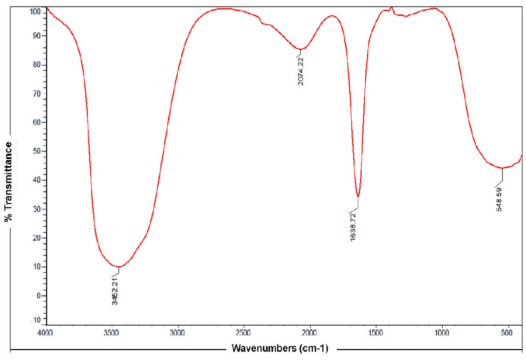


Figure 4. Standard FTIR of silver nanoparticles.

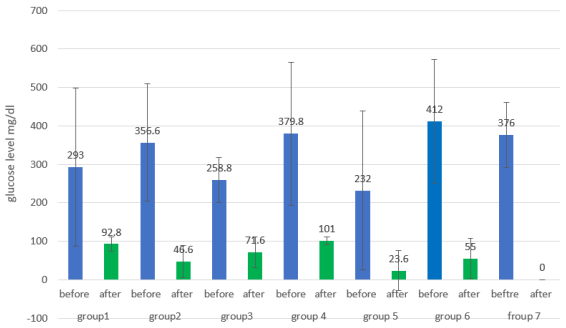


Figure 5. Compares in blood glucose levels (BGL) for the groups 1, 4, 5, and 6 before and after treatment. The blue bar represents blood glucose level (BGL) before treatment, and the green bar represents BGL after treatment. Each bar represents the mean value ± SD of five mice in each group.

bar in figures represents the mean value ± SD of five mice in each group. $p < 0.05$ was considered to be significant. ANOVA test was $p < 0.001$.

5. Discussion

As for comparison between the before-treatment and (after-treatment) of every group:

In group (1), it can be seen that the concentration of 6 mg/kg of AgNPs resulted in insignificant ($p > 0.05$) decrease in blood glucose level. This doesn't agree with [8, 23–25].

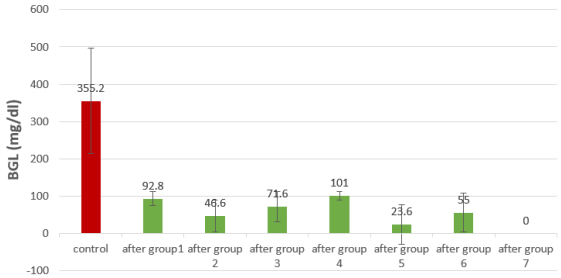


Figure 6. Compare between control and (after treatment) of the groups under study. Blue bar represents the mean value of the control and the red bar represent the mean value of each group (after treatment). ± Standard deviation (SD) of the five mice in each group.

Table 2. Concentration of silver nanoparticles used for the mice in this article.

Group	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Eighth
Concentration per mil liter of water	1.8 mg/mL	1.8 mg/mL	1.8 mg/mL	1.8 mg/mL	1.8 mg/mL	1.8 mg/mL	3.7 mg/mL	Control diabetic	Control nondiabetic
Concentration per every mouse	0.18 mg	045 mg	0.45 mg	0.45 mg	0.9 mg	0.9 mg	1.8 mg		
Concentration for weight	6 mg/kg	15 mg/kg	15 mg/kg	15 mg/kg	30 mg/kg	30 mg/kg	60 mg/kg		

Table 3. Results of the group (1). HI: blood glucose level $\geq$ 600 mg/dl.

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
184	70
HI	110
136	78
136	113
412	93

Table 4. The results of group (2).

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
222	Died
252	Died
301	74
408	81
HI	78

Table 5. The results of the third group.

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
313	89
288	87
239	96
165	86
289	Died

Table 6. The results of the fourth group.

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
209	86
210	96
600	112
328	113
552	98

Table 7. The results of the fifth group.

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
174	Died
150	Died
130	Died
108	Died
HI	118

Table 8. The results of the sixth group.

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
350	77
210	85
600	114
348	Died
552	Died

Table 9. The results of the seventh group which was treated with 60 mg/kg AgNPs.

Blood glucose level (BGL) (mg/dl) before treatment	Blood glucose level BGL (mg/dl) after treatment
387	Died
286	Died
487	Died
297	Died
424	Died

In group (2), this group was treated with AgNPs with a concentration of 15 mg/kg; it could be seen that this concentration produced a significant decrease in glucose level $p < 0.008$ but killed 40 percent of mice 40% (two mice from five).
Group (3), this group was treated with 15 mg/kg of AgNPs and radiated with LED or laser at the range 395 - 450 nm for 20 seconds. This concentration led to insignificant decrease $p > 0.05$ in glucose blood level and killed one mouse.
Note that the environmental conditions to the animals in group 2 and group 3 are the same from nutrition, light exposure (12 hours day and 12 night), humidity, temperature which was 24 Celsius (room temperature), water (ordinary water).
In group (4), this group was treated with 15 mg/kg (two doses) of AgNPs radiated (twice) by laser or LED at the range (395 - 450) nm. This treatment resulted in a significant ($p < 0.05$) decrease in blood glucose levels and treated all the animals. That means that AgNPs with 15 mg/kg (two doses) and radiated twice is assumed to be a treatment for diabetes mellitus. It could be seen here that laser or LED made the drug (AgNPs) reduced the glucose levels to the normal values and caused no deaths.
Group (5), this group was treated with AgNPs with a concentration of 30. This concentration made four of five mice died. It could be seen that this treatment reduced Blood glucose level insignificant $p > 0.05$.
As regards group (6), this group was treated with 30 mg/kg and radiated with laser or LED. This treatment resulted in significant $p < 0.05$ differences and died two animals.
The seventh group was injected with 60 mg/kg of AgNPs. This treatment made the animals all died.
In group (2) where no using LED or laser, that leads to occurring two deaths in spite of the others were treated from DM, but when radiation is used in the group (3), the deaths reduced to one, and the BGL returned to its normal values, but the difference is insignificant $p > 0.05$.
In group (4),where the treatment was given in two doses with the radiation twice, there were no deaths, and the drug (AgNPs) improved. Hence the difference became signifi-

Table 10. The diabetic control group.

Blood glucose level (mg/dl)
285
254
293
344
600

Table 11. The nondiabetic group (seventh group). Before and after three days (the period of treatment of the other groups).

Before	After
64	58
70	86
83	77
87	80
88	92

Table 12. Measurements of the glucose blood level (BGL) of the groups with regards to compare between after and before each group. Each value given in this table represents the mean ± SD of five mice in each group. Statistical analysis: groups 1, 3, and 5 are insignificant $p > 0.05$; groups 2, 4, 6, and 7 are significant $p < 0.05$.

Groups	BGL (mg/dl)	
	Before treatment	After treatment
Group 1	293 ± 205.9	293 ± 205.9
Group 2	356.6 ± 153	46.6±
Group 3	258 ± 59	71.6 ± 40
Group 4	379.8 ± 186	101 ± 11
Group 5	232 ± 206.9	23.6 ± 52.7
Group 6	412 ± 161	55 ± 52
Group 7	376 ± 85	0000
Control	355 ± 140.6	

Table 13. Measurements of BGL for the groups under study with regard to comparison between the control and (after treatment) of every group. Each value in this table represents the mean value ± SD of five mice in each group. Statistical icons: # = p = 0.53 (few greater than 0.05), @ = p = 0.009 < 0.05, $ = p < 0.05, & = p > 0.05, * = p < 0.05, % = p < 0.05, ∧ p = 0.001 < 0.05.

Groups	BGL (mg/dl)
Control	355.2 ± 140.6
After treatment of every group	
1	92.8 ± 18.99 #
2	46.6 ± 42.6 @
3	71.6 ± 40 $
4	101 ± 11 &
5	23.6 ± 52.7 *
6	55 ± 52 %
7	0000 ∧

cant $p < 0.05$.

In the group (5), the concentration of AgNPs was high, thus four mice were died. But, when radiation was used in group (6), the deaths reduced to two mice (50%).

Then the role of LED or laser is: laser or LED made the treatment active for treating the disease DM and reduced the deaths to 50% as it is clear in the groups 3, 4, and 6.

The explanation of that is: the laser or LED at the range (395 – 450) gives an energy to the bio cells to become treated and activates them to be live and do not die.

6. Conclusion

The laser or LED at the range (395 - 450) nm made the treatment (AgNPs) active and treated the animals from diabetes mellitus and reduced the deaths to 50%.

Suggestions

I hope from the researchers to apply this radiation (laser or LED at the range 395 - 450 nm) on other drugs of the other diseases to make the drugs active and treat the diseases and to reduce deaths in human being.

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Authors Contributions
Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials
Data presented in the manuscript are available via request.

Conflict of Interests
The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] D. Federation. "IDF Diabetes Atlas, 8th.ed.". *International Diabetes Federation*, , 2017.

[2] J. Hussein, M. F. Attia, M. El Bana, S. El-Daly, N. Mohamed, Z. El-Khayat, and M. E. El-Naggar. "Solid state synthesis of docosahexaenoic acid-loaded zinc oxide nanoparticles as a potential antidiabetic agent in rats.". *Int. J. Biol. Macromol.*, **140**:1305–1314, 2019.

[3] S. Dhas, V. G. Kumar, V. Karthick, and K. Vasanth. "Effect of biosynthesized gold nanoparticles by Sargassum swartzii in alloxan induced diabetic rats.". *Enzym. Microb. Technol.*, **95**:100–106, 2016.

[4] E. Wright, J. Scism-Bacon, and L. Glass. "Oxidative stress in type 2 diabetes: The role of fasting and postprandial glycaemia.". *Int. J.Clin. Pract.*, **60**:308–314, 2006.

[5] C. J. Rhodes. "Type 2 diabetes—A matter of—cell life and death? ". *Science*, **307**:380–384, 2005.

[6] O. Veiseh and B. Tang. "Managing diabetes with nanomedicine: Challenges and opportunities.". *Rev. Drug Discov.*, **14**:45–57, 2014.

[7] M. Campbell and J. Taylor. "New Developments in Diabetes Management. ". *Drug Top*, **154**:32–39, 2010.

[8] S. A. Kazmi, M. Qureshi, Z. Sadia, and S. Alhewairini. "Minocycline-derived silver nanoparticles for assessment of their antidiabetic potential against alloxan-induced diabetic mice.". *Pharmaceutics*, **13**:1678, 2021.

[9] Y. Yang. "Antidiabetic Activity of Mung Bean Extracts in Diabetic KK-A y Mice.". *Journal of Agricultural and Food Chemistry*, **56**:8869–73, 2008.

[10] N. Ahmad. "Medicinal plants used in indigenous therapy by people of Madyan Valley in District Swat, Pakistan.". *International Journal of Medicinal and Aromatic Plants*, **3**:2249–4340, 2013.

[11] S. A. Nabi. "Antidiabetic and antihyperlipidemic activity of Piper longum root aqueous extract in STZ induced diabetic rats.". *BMC Complementary Altern. Med.*, **13**:37, 2013.

[12] K. Bogunia-Kubik. "From molecular biology to nanotechnology and nanomedicine.". *AIP Conference Proceedings*, **65**:123–138, 2002.

[13] M. C. Daniel and D. Astruc. "Gold nanoparticles: assembly, supramolecular chemistry, quantum-size-related properties, and applications toward biology, catalysis, and nanotechnology.". *Chemical reviews*, **104**:293–346, 2004.

[14] V. Zharov, J. Kim, and M. Everts. "Selfassembling nanoclusters in living systems: application for integrated photothermal nanodiagnostics and nanotherapy. ". *Nanomedicine*, **1**:1326–1345, 2005.

[15] A. Virgen-Ortiz and S. Limón-Miranda. "Biocompatible silver nanoparticles synthesized using rumex hymenosepalus extract decreases fasting glucose levels in diabetic rats. ". *Dig. J. Nanomater. Bio.*, **10**: 927–933, 2015.

[16] El. Burdusel. "Biomedical applications of silver nanoparticles: An up-to-date overview.". *Nanomaterials*, **8**:681, 2018.

[17] K. Park. "Bioavailability and toxicokinetics of citrate-coated silver nanoparticles in rats. ". *Arch. Pharmacal Res.*, **34**:153–158, 2011.

[18] K. Siddiqi and A. Husen. "Recent advances in plant-mediated engineered gold nanoparticles and their application in biological system.". *J. Trace Elements Med. Biol.*, **40**:10–23, 2017.

[19] L. Panacek, L. Kivtek, R. Prucek, K. Milan, R. Vecerova, and N. Pizurova. "Silver colloid nanoparticles: synthesis, characterization, and their antibacterial activity.". *J. Phys. Chem. B.*, **110**:16248, 2006.

[20] L. Bo, W. Yang, M. Chen, J. Gao, and Q. Xue. "A simple and green synthesis of polymer-based silver colloids and their antibacterial properties. ". *Chem. Biodivers.*, **6**:111, 2009.

[21] B. Tomsic, B. Simoncic, B. Orel, L. Cerne, P. Tavcer, M. Zorko, and A. Jerman. "Sol-gel coating of cellulose fibres with antimicrobial and repellent properties. ". *Sol–Gel Sci. Technol.*, **47**:44–57, 2008.

[22] R. Kaegi, B. Sinnet, S. Zuleeg, H. Hagendorfer, E. Mueller, R. Vonbank, M. Boller, and M. Burkhardt. "Release of silver nanoparticles from outdoor facades. ". *Environ. Pollut.*, **158**:2900, 2010.

[23] T. Jasim. "Synthesis of herb silver nanoparticle and study the effect against some bacterial infection.". *Journal of Pharmaceutical Sciences and Research*, **10**:1649–1651, 2018.

[24] T. M. Jasim. "The effect of silver nanoparticle induced diabetic on wound healing full thickness Pseudomonas aeruginosa contaminated mouse skin wound models.". *IJPQA.*, **10**:720723, 2019.

[25] S. Ullah, S. Ali shah, M. Qureshi, and M. Z. Hussain. "Antidiabetic and hypolipidemic potential of green AgNPs against diabetic mice.". *ACS Applied Bio Materials*, **4**:3433–3442, 2021.

[26] S. Lee. "Blue and red light combination LED phototherapy for acne vulgaris in patients with skin phototype IV.". *Lasers in Surgery and Medicine*, **39**:180–188, 2006.

[27] B. Azadgoli. "Laser applications in surgery. ". *Annals of Translational Medicine*, **4**:452, 2016.

[28] C. Migdal. "Long-term functional outcome after early surgery compared with laser and medicine in open-angle glaucoma. ". *Ophthalmology*, **101**:1651–1657, 1994.

[29] S. Fabi. "Future directions in cutaneous laser surgery.". *Dermatologic Clinics*, **32**:61–69, 2013.

[30] A. Sengottaiyan. "Synthesis and characterization of Solanum nigrum-mediated silver nanoparticles and its protective effect on alloxan-induced diabetic rats.". *Journal of Nanostructure in Chemistry*, **6**:41–48, 2016.

[31] M. UL Haq. "Green silver nanoparticles synthesized from taverniera couneifolia elicits effective antidiabetic effect in alloxan-induced diabetic wistar rats.". *Nanomaterials*, **12**:1035, 2022.

[32] A. Mohamed. "Some of biochemical parameters in diabetic rats induced by alloxan treated with olive leaf extract and silymarin extract for silver nanoparticles.". *Acta Biomed.*, **94**, 2023.

[33] F. Mahmoudi and M. Mostafa. "Biosynthesis of novel silver nanoparticles using eryngium thyrsoideum boiss extract and comparison of their antidiabetic activity with chemical synthesized silver nanoparticles in diabetic rats.". *Biological Trace Element Research*, , 2020.