Indian J. Applied & Pure Bio. Vol. 36(2), 273-279 (2021). **ISSN: 0970-2091**
A web of Science Journal

Biogenic synthesis of Nanoparticles using Honey

Madhavi Rane*[1], Nibha Shrivastav[1], Kashmira Yadav[1] and Snehal Kulkarni[1]

[1]Department of Microbiology, Abeda Inamdar Senior College,
Camp, Pune 411001 (India)
*Author for Correspondence : Dr. Madhavi D. Rane
drmadhavidrane@gmail.com

Abstract

With the approach of nanotechnology many related industries rapidly developed over the recent past. Generally, top-down and bottom-up are the two approaches used to synthesize nanoparticles; most of these require vacuum conditions, high temperatures, and toxic chemicals. As a consequence, harmful effects impacted organisms including humans. Some synthesis methods are more expensive and time-consuming. As a consequence, the concept of "green nanotechnology" emerged with the green synthesis of nanoparticles commencing a new stage in nanotechnology. This includes the synthesis of nanomaterials from microorganisms, and other biological materials.

Honey is described as the world's oldest food source with peculiar medical, pharmaceutical, physical, and chemical values. Honey mediated biogenic synthesis is a concept used during the past few years to synthesize gold, silver, carbon, platinum, and palladium nanoparticles. Honey acts as both a reducing agent and stabilizing agents in nanoparticle synthesis. This method usually requires room temperature and does not produce harmful byproduct. In this present work we have focus on biogenic synthesis of nanoparticles using honey .In conclusion, honey mediated green synthesis of nanoparticles provides a simple, cost effective, reproducible, biocompatible, rapid, and safe method. The special activity of honey functionalized nanoparticles may provide valuable end products with many applications in various fields.

Honey a divine medicine in Indian Ayurveda. The ancient Vedic culture considered honey one of nature's most great gifts to mankind. Honey is considered a healthy drink; the holy Qur'an vividly illustrates the potential therapeutic value of honey in Islamic medical system. Almost 1000 years ago as recommended by Avicenna the great Iranian scientist and physician honey as one of the best remedies in the treatment of tuberculosis and anticancer. Honey is a sweet, sticky editable substance produce by bees and some insects. Bees store honey in wax hexagonal arrangement called honeycombs. Honey gets its sweetness from the monosaccharide's (glucose and fructose) and disaccharides (sucrose). Honey use and its production have a long and classical activity[19].

The concept of nanotechnology was first discovered in 1959 by physicist Richard Feynman. Nanotechnology is the ability to understand, manipulate matter and control at the level of specific atoms and molecules.[19] These nanoparticles exhibit a variety of unique physical, chemical and electronic properties.[10] However the chemical and physical methods have certain disadvantage like more expensive chemicals, toxic solvents and very high temperatures and it's also effect on the environment. Therefore a nontoxic ecofriendly and economical method introduced called as 'green synthesis'. This method involves synthesis via biological processes. The main purpose of green synthesis is to reduce the use of toxic chemicals to prevent the environment from pollution.[2] Biogenic synthesis is multi-disciplinary integration of biotechnology, nanotechnology, chemical processing, physical methodology, drug delivery in medicinal and systems engineering into bio-chips and Nano biomaterials[14].

Biosynthesis of nanoparticles using honey:

Nanoparticles synthesis can be done by various methods such as physical and chemical method. But use of such methods is very harmful to the environment. This is a very harsh/toxic method for the synthesis of nanoparticles hence, new biogenic synthesis technology emerged. Biogenic synthesis is an ecofriendly technology of biosynthesis of nanoparticles. In the production of metallic nanoparticles (platinum, palladium, gold, silver, iron, and cadmium) and metal oxides (titanium oxide and zinc oxide), both the prokaryotic and eukaryotic microorganisms are used. These microorganisms are algae, fungi, bacteria and actinomycetes. According to the location of nanoparticles, synthesis of nanoparticles may be intracellular or extracellular.

Table-1. Reducing and stabilizing agents and specific temperatures used in honey mediated biogenic synthesis of different nanoparticles

Nanoparticle type	Reducing agent	Stabilization agent	Specific temperature
Gold	(i) Vitamin C (ii) H_2O_2 and gluconic acid, produced when diluting honey with distilled water.	Proteins present in honey	RT
Silver	Honey	Proteins in honey	RT
Palladium	Honey	Proteins in honey	RT
Platinum	Honey	Proteins in honey	80^oC

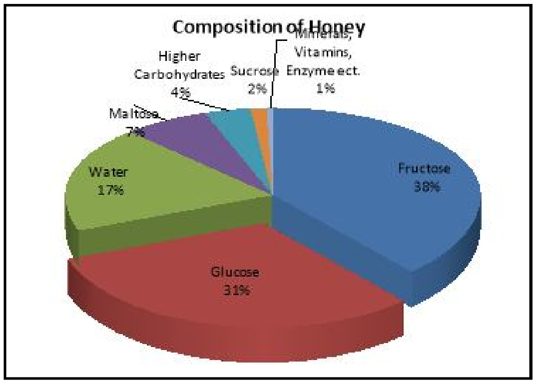

Figure1: Composition of honey in percentage.

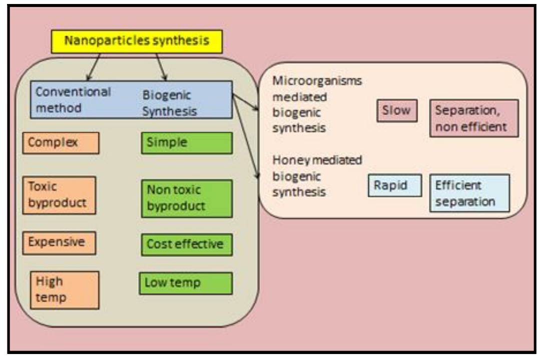

Figure 2: Comparison of conventional methods and biogenic synthesis methods of nanoparticle synthesis

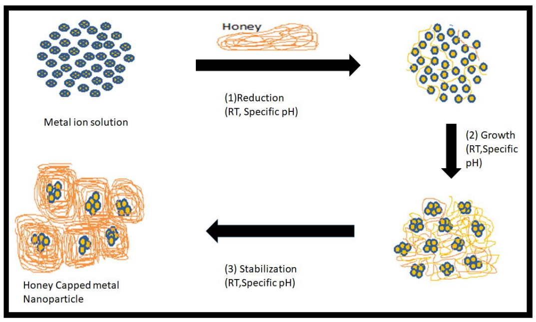

Figure 3: Generalized schematic diagram of honey mediated biogenic synthesis of nanoparticles.

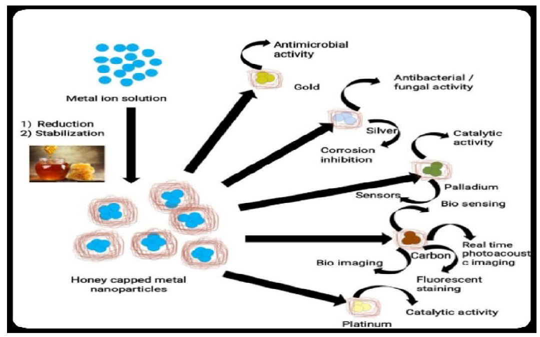

Figure 4: Schematic diagram of current applications of biogenic nanoparticles using honey.

Biogenic synthesis of gold nanoparticles using honey:

Philip synthesized honey mediated gold nanoparticles by reducing $HAuCl_4$ with different volumes of diluted honey. With the increasing volume of honey, the reduction speed of gold particles is increased. Olaitan and colleagues reported biogenic synthesis of gold nanoparticles at RT using honey as both a stabilizing and reducing agent.[19] The presence of high quantity of honey causes strong interaction between protective biomolecules and surfaces of nanoparticles preventing developing gold nanocrystals from sediment. With larger quantities of honey, the interaction is increase, leading to size reduction of spherical nanoparticles.

Biogenic synthesis of silver nanoparticles using honey:

Bar and colleagues synthesized silver nanoparticles using honey at RT, where honey acted as both are reducing and a stabilizing agent. Thus, it replaced toxic reducing agents such as hydrazine, dimethyl formamide and sodium borohydride used previously.

Biogenic synthesis of palladium nanoparticles using honey:

Palladium nanoparticles synthesized using honey as both reducing and stabilizing agents. This nanocatalyst showed higher sustinable; Palladium nanoparticles were used as a catalyst for Suzuki cross coupling. Thus, honey coated Palladium nanoparticles possess possible applications in different fields including nanobiotechnology, sensors and organic catalytic transformation.

Table-2. Different methods of biogenic synthesis of nanoparticles with organisms, and characteristics of synthesized nanoparticles

Biological resource	Different types of nanoparticle synthesized	Organism's	Size and features
Microbial systems	Au	*Rhodococcus* sp. *Bacillus subtilis*	5–15 nm 5–60 nm
Bacteria	Ag	*Pseudomonas stutzeri* AG259	Up to 200 nm
Fungi	Ag	*Aspergillus niger*	1–20 nm
Plant systems	Au Ag, Au	*Cassia auriculata* *Rosa rugosa*	15–25 nm 12 nm and 11 nm
Leaf extracts	Ag Pd	*Argemone mexicana* *Cinnamomum camphora*	30 nm 3.2–6 nm
Root extracts	Ag	*Zingiber officinale*	10–20 nm
Biological material Ascorbic acid and starch	Ag Au Ag	- - -	17–30 nm ~15 nm 18.98–26.05 nm
Honey	Pd Pt C	- - -	5–40 nm 2.2 nm ~7 nm
Starch	Ag	-	10–34 nm

Biogenic synthesis of platinum nanoparticles using honey:

Venu and colleagues reported a honey mediated novel, ecofriendly practical method to synthesis biogenic platinum nanoparticles. They synthesized platinum nanoparticles at 100°C in aqueous honey solution. Furthermore, platinum nanowires formed with longer thermal treatment by self-assembly.

Applications of biogenic synthesis of nanoparticles :

The major purpose of biological synthesis of nanoparticles is to develop eco-friendly and synthetic protocols with lowest cost of production and applications. The properties of these nanoparticles are different from the nanoparticles synthesized via other conventional and chemical methods since, no capping agents or surfactants are involved. Honey functionalized nanoparticles express special activities such as catalytic properties, antimicrobial activity, and biosensing and bioimaging ability. The applications of biogenic synthesized nanoparticles range from biomedical photocatalytic and sensors. Large number of researchers diverted their recognition towards the use of biological systems for the synthesis of biocompatible metal nanostructures. Large scale research is going on and vast literature is available on the antimicrobial activity of nanoparticles. Silver nanoparticles have attracted much attention as an effective antimicrobial and biocompatible agent. These can effectively bind with the cell wall which is required for antimicrobial activity[1]. Honey mediated PtNPs compounds such as cis-platin, carboplatin and oxaliplatin are normally used in chemotherapy especially in the treatment of ovarian and testicular tumours. Silver nanoparticles were highly active against the different silver-resistant bacterial isolates obtained from wounds sepsis and burns. Therefore, they could be used as an effective treatment in resistant wound sepsis and burn infections. Silver nanoparticles are used as antimicrobial agents in textile industries for water treatments. Silver nanoparticles possess higher antibacterial activity against *E. coli* than *S. aureus* due to the structural difference of the cell wall[1]. Being super paramagnetic in nature, iron and iron oxide nanoparticles find great usage in biomedical applications such as cell labelling, tissue repair, magnetic resonance imaging (MRI), and drug delivery[1]. Gold nanoparticles have proved to be very important apparatus in many potential biomedical applications including an emerging alternative for life-threatening diseases and also have been used in DNA modelling.[1]

The use of different types of honey sample in the synthesis of nanoparticles has encouraged the designing of simple, green, cost and time effective approaches thereby, minimizing the use of chemicals and solvents. The method of biogenic synthesis is very simple, requiring less time and predictable mechanisms. This opens up an opportunity for the use of biodegradable materials especially in the synthesis of metal oxide nanoparticles.

Future prospects :

The biosynthesis of nanoparticles using honey sample will help researchers not only to design safer nanomaterials but also to promote the understanding of health and safety considerations of nanoparticles. Useful materials can be synthesized easily even at feasible scale because the biomaterial based routes eliminate the need to use toxic chemicals. Considerable efforts are constant on different capping agents such as biomolecules. Which can act as both stabilizing and reducing agents for the biogenic synthesis of nanoparticles. Greener methods that have been used in nanoparticles synthesis are generally single-pot reactions, without the use of additional capping and stabilizing/reducing agents. Overall, the use of honey sample for green synthesis of nanoparticles is an emerging and exciting area of nanotechnology and may have significant impact on further advances in nanoscience. However, with the availability of computational techniques, area of biogenic synthesis and development of nanomaterials will be broadened that could be used in the field of medicine as 'nanodrugs' in the near future.

References :

1. Al-Zahrani, S.S. and S.M. Al-Garni (2019). *Journal of Biomaterials and Nanobiotechnology*, *10*(01): p.11.
2. Balasooriya, E.R., C.D. Jayasinghe, U.A. Jayawardena, R.W.D. Ruwanthika, Mendis de Silva, R. and P.V. Udagama (2017). *Journal of Nanomaterials*, 2017.
3. Bar, H., D.K. Bhui, G.P. Sahoo, P. Sarkar, S. Pyne and A. Misra (2009). *Physicochemical and Engineering Aspects* *348*(1-3): 212-216.
4. Choudhary, M. and O. Jangir (2016). *Int. J. Sci. Res. Publ*, *6*: 142-147.
5. Daizy, Philip (2009) *Spectrochimca Acta part A Molecular and Biomolecular Spectroscopy 73*(4): 650-653.
6. El-Desouky, T.A. and H.A. Ammar (2016). *Journal of Applied Pharmaceutical Science*, *6*(06), 083-090.
7. Gholami-Shabani, M., Z. Gholami-Shabani, M. Shams-Ghahfarokhi, A. Akbarzadeh, G. Riazi and M. Razzaghi-Abyaneh (2016) *International Journal of Nanoscience and Nanotechnology*, *12*(4): 199-206.
8. Gour, A. and N.K. Jain (2019). *Artificial cells, nanomedicine and biotechnology*, *47*(1): 844-851.
9. Gujarathi, D.B., K.T. Bharati, R.D. Kanawade and P.S. Gopale (2017). Bio-derived Synthesis of Silver Nanoparticles using aqueous Honey and Turmeric Solution (HTS) and their Antimicrobial Activity.
10. Haiza, H., A. Azizan, A.H. Mohidin and D.S.C. Halin (2013). In: *Nano Hybrids* (Vol. 4, pp. 87-98). Trans Tech Publications Ltd.
11. Hosny, A.M., M.T. Kashef, S.A. Rasmy, D.S. Aboul-Magd and Z.E. El-Bazza (2017). *Advances in Natural Sciences: Nanoscience and Nanotechnology*, *8*(4): 450-459.
12. Jeyapaul, U., M.J. Kala, A.J. Bosco, P. Piruthiviraj and M. Easuraja (2018). *Oriental Journal of Chemistry*, *34*(2): 783-790.
13. Kanchana, A., S. Devarajan and S. R.

Ayyappan (2010). *Nano-micro letters*, *2*(3): 169-176.

14. Karthik, R., R. Sasikumar, S.M. Chen, M., Govindasamy, J.V. Kumar and V. Muthuraj (2016). *Int. J. Electrochem. Sci*, *11*: 8245-8255.
15. Neupane, B.P., D. Chaudhary, S. Paudel, S. Timsina, B. Chapagain, N. Jamarkattel, and B.R. Tiwari (2019). *International journal of nanomedicine*, *14*: 3533.
16. Prabhu, N. and T. Gajendran (2017). *IOSR J. Biotechnol. Biochem*, *3*: 107-112.
17. Shaik, M.R., Z.J.Q. Ali, M. Khan, M. Kuniyil, M.E. Assal, H.Z. Alkhathlan, A. Al-Warthan, M.R.H. Siddiqui, M. Khan, and S.F. Adil (2017). *Molecules*, *22*(1): 165.
18. Sharma, D., S. Kanchi and K. Bisetty (2015). *Arabian journal of chemistry*. *12*(8): 1803.
19. Sur, U.K. (2014). *Advances in nano research*, *2:* 135-145.