International Journal of Pharmacy and Biological Sciences-IJPBS™ (2021) 11 (3): 58-63
Online ISSN: 2230-7605, Print ISSN: 2321-3272
Review Article | Biological Sciences | OA Journal | MCI Approved | Index Copernicus

Biosynthesis of Titanium Dioxide Nanoparticles Using Eco-Friendly Approach: A Review

Aanchal Sharma
Department Of Biotechnology, UIET, KUK, Haryana

Received: 16 Mar 2021 / Accepted: 12 Apr 2021 / Published online: 1 Jul 2021
***Corresponding Author Email:** aanchal1636@gmail.com

Abstract
A significant subject of experimentation in nanoscience goes to the biosynthesis of nano particles of distinct chemical composition and size. Nanoscience is showing up as a continuosly creating circle with its various application in science and designing for the thought process of delivering new materials at the nano scale level. Nanoscience has gained various applications in the branch of pharmacology and science. Titanium dioxide (TiO_2) is climate neighborly attributable to its tremendous substance quality and is nontoxic. Titanium dioxide nanoparticles are of most extreme significance for use in beautifying agents, drugs, likewise shields skin from bright (UV) beams and their helpfulness in the arrangement of paper inks, food colorants and toothpaste. Different writing reports claims that the arrangement of metal nanoclusters with the help of plant extract is eco conscious and inexpensive. This article accentuation more on the biosynthesis of titanium dioxide nanoparticles with the aid of botanical extract and their antimicrobial movement.

Keywords
applications, green synthesis, nanoparticles, plant extract, TiO2

*****

INTRODUCTION
"Nano" is utilized as a prefix for one billionth part, for example 10^9.The extent of metal nanoparticles range from 1 to 100 nm (Nadeem *et al*., 2018). Nanotechnology is applied science that manages enormously little things, particularly singular particles, and atoms. The division of nanotechnology is the most ambitious locale of exploration in material sciences and the arrangement of nano particles (NPs) is getting fundamentally all through the world (Rafique *et a*l., 2017). Nanotechnology is getting a higher response due to its expected applications for example, clinical applications, dental applications, ecological applications, applications in close to home consideration items and customer products and so forth (Rafique *et al*., 2017). Metallic nano particles are generally utilized on account of their unambiguous substance reactivity, properties, and possible applications in different examination territories, for example, antibacterial, antiviral, diagnostics, anticancer and focused on drug conveyance (Kumar *et al*., 2014). In addition, metal nano particles can be synthesising by means of eco cordial or eco conscious strategies (organic techniques) and can likewise fabricate through eco-threatening or eco neutral strategies which are synthetic based strategies. Besides, the artificially incorporated nanoparticles were portrayed to show case not so much solidness and were more aggregated. On the other hand, these organic strategies, supposed green union techniques, are amiable and climate neighbourly as well as cost practical, fast, less relentless, non-harmful, effectively versatile to huge scope and more proficient than customary techniques (Kumar *et al*., 2014). Biosynthesis of nanoparticles can pursue via different natural techniques like by utilizing microbes, organisms, plant and their concentrate, yeast, chemicals and so on however this article emphasis more on the formation of nano particles

with the assistance of plants. Herbal extract serves as both reducing agent and balancing out specialists in the development of nano particles. The three-environment friendly and green science perspective for the combination of nano particles are the choice of the dissolvable medium, reducing specialist and non-harmful material for the maintenance of nano particles. The utilization of plant extract offers different benefits since it is effectively accessible, safe to utilize and have a wide scope of metabolites. The key phytochemicals responsible for the biosynthesis of nanoparticles are amides, flavones, aldehydes, ketones, terpenoids (Patida *et al*., 2017). Among all variety of inorganic material, an analyst shows their concern predominantly on metal oxide nano particles, because of their exceptional properties and applications towards physical and compound properties of Tio_2 (Swathi N *et al*., 2019). Titanium dioxide (TiO_2) is an inert, eco-friendly, and unreactive material, whose high refractive list and exorbitant ability to ingest UV light gives it a fascinating white colour and non-poisonous impetus. The nano sized TiO_2 particles are widely used to give pearl appearance and mistiness to items, for example, sunscreen creams, paints, plastics, papers, inks, food colorants and toothpastes (Dobrucka *et al.*, 2017). The bio synthesis of titanium dioxide nano particles has more advantages because of less utilization of synthetic compounds during the process. The progression of green synthesis over physical and chemical techniques are climate well disposed, practical, and effortlessly scaled up for tremendous scope of NPs, while High - temperature, energy, pressure, and hurtful synthetic substances are not needed for green blend. Consequently, this audit dictates the green-enlivened combination of Tio_2-NPs that can give advantage over the physical and compound techniques (Rafique *et al.*, 2017).

LITERATURE

Synthesis of TiO_2nanoparticles

To start with, Kumar *et al*., 2014 displayed the correlation among biosynthesized and synthetically combined titanium nanoparticles as described in Table 1. In case of green combined nanoparticles, Hibiscus flower extract was utilized considering its antimicrobial, anti-oxidative and antiproliferative action and thus be utilized to treat malignancy, particularly cellular breakdown in the lungs, cardiovascular illness, asthma and pulmonary function. Following the characterization of biosynthesized and synthetically synthesised nanoparticles were analysed through XRD, SEM, FTIR, and finally examined for antimicrobial action against bacterial strains, for example, *Vibrio cholerae, Pseudomonas aeruginosa, Staphylococcus aureus*. However, the inhibition zone created by synthetically combined TiO_2 nanoparticles is small than bio settled TiO_2 nanoparticles which were little in measurement and more dispersed. Concerning XRD, a sharp diffraction peak was seen in chemically combined TiO_2nano particles, while the strength of diffraction peak of green synthesized TiO_2 nanoparticles is less with slight widening. Consequently, indicating that the dimension of environment unfriendly nanoparticles is still enormous than the botanically synthesised TiO_2 nanoparticles. In this way, the analyser proposed that the phytochemicals existing in the concentrate of *Hibiscus* flower would have covered the outside of the TiO_2 nanoparticles, bringing about decreased intensity in XRD peak. This covering may increase the durability and the distribution of the nanoparticles, which thus may amplify their bioavailability, making them reasonable for natural applications. Unexpectedly, the chemically synthesised nanoparticles spotted with relatively high intense peaks, clearly showing that they are uncovered and uncapped. To sum up, the XRD profile uncovers that the green synthesis protocol that was created with the assistance of *Hibiscus* flower was very much grounded for the creation of bio-functionalized and bio-balanced out titania nano particles with possible biomedical highlights. In short, both nano particles were described for their size, and crystallinity utilizing XRD, covering phytochemicals by FTIR and morphology by SEM.

On the other side, Trouiller *et al*., 2009 noticed TiO_2 nanoparticles–stimulated inflammation, oxidative DNA damage, and genotoxicity in a mice model. Analyst introduced wild-type mice with TiO_2 nanoparticles in drinking water and revealed the degree of DNA damage. In addition, directed mRNA levels of proinflammatory cytokines and confirmed up regulation of these cytokines in the peripheral blood. Moreover, tio_2 nanoparticles improved the frequency of DNA deletion, DNA strand breaks, induced oxidative DNA damage. A section from these, a normal tail movement significantly expanded after tio_2 nanoparticles injection in the mice.

Biogenesis of TiO_2nanoparticles using plant extract

Pushing forward, Swathi N*et al*., 2019 witnessed that the synthesised Tio_2nano particles with the assistance of *Cassia fistula* plant extract exhibited antimicrobial movement against one gram negative and gram-positive microscopic organisms. Because of the way that *Cassia fistula* leaves contain B2, bioflavonoids, triflavinoids, rhein, rheinglucoside, sennoside A, sennoside B, chrysophanol, and

physcion. Besides, the plant is surveyed as therapeutic plant because of their wide scope of properties like a mellow purgative for kids and pregnant ladies, used to fix the unhealing problem, likewise have antipyretic, pain relieving, mitigating and hypoglycaemic activities. At last, the biosynthesized nano particles were portrayed by utilizing UV-Vis spectroscopy, X-beam Diffraction (XRD), Fourier changes intra-Red spectroscopy (FT-IR), nuclear power microscopy (AFM) , examining electron microscopy (SEM) , thermo gravimetric examination (TGA) as mention in table 1 . In this manner, the UV Vis results showed that the nano particles combined appropriately, XRD results predicted that the particles were translucent, the SEM and EDAX results showed that it has almost round fit as a fiddle and the essential structure of Tio_2 NPs in the sample, TGA-DTA and AFM indicated the heat liability of the nano particles and harshness of the nanoparticles separately. Moreover, Patidar *et al*., 2017 utilized *Moringa Olifera* herbal extract for the formation of nanoparticles. It is however, important to note that *Moringa* has antibacterial, antiseptic, antifungal and anti-inflammatory activities. The biosynthesis of titanium dioxide nanoparticles utilizing *Moringa oleifera* leaves extract was recorded by X- ray diffraction measurements and through UV-Vis spectroscopy. Moreover, the former was utilized to notice particle size and band gap of formed tio2 nanoparticles, and the latter showed the five diffraction peaks whereas crystalline size was 12nm which was calculated by Scherrer's formula. To summarize, the previous literature demonstrated that synthesis of TiO_2 nanoparticles utilizing *Moring oleifera* leaves extract is a novel strategy utilizing cheap precursors. This time saving, cost effective, simple, environment friendly method utilized in different applications.

Nadeem *et al*., 2018 illustrated a review of the green synthesis of TiO_2 NPs from various natural concentrates, for example, plants, microorganisms, and biological products as well as their likely applications. The experimenter depicted the antimicrobial, anti-parasitic, and photocatalytic capability of titanium nano particles. NPs have been utilized against a wide scope of irresistible microorganisms including different bacterial strains, endospores, fungi, algae, protozoa, viruses. TiO_2 NPs trigger the beginning of receptive oxygen species (ROS) when confronted with microbial cells. These ROS kills microorganisms by upsetting cell wall's integrity mainly by phospholipids oxidation, which brings about reduced adhesion and distorted ionic equilibrium. Inside the cytosol, it represses the respiratory cytosolic compounds and altering macromolecules structures, creating considerable consequences for cell integrity and gene expression. Both green blended and synthetically inferred TiO_2 NPs kills microorganisms in same fashion, but the naturally derived NPs show better antibacterial action because of the stabilizing agents in the plant extract. On the flip side, the researcher additionally featured that the plant mediated nanoparticles has magnificent photocatalytic activity. Sundrarajan *et al*., 2011 crystal cleared the formation of stable titanium dioxide nanoparticles utilizing theleaves of plant *Nyctanthes arbor-tristis*. Fundamental and morphological properties of biosynthesised nanoparticles were described. XRD examination exhibited that the TiO_2 samples are cubic with higher crystallinity and purity. The biosynthesised nanoparticles indicated round morphology and molecule size in the range of 100-150nm by SEM and PSA. The examination proved that the *Nyctanthes* home concentrate is another advantageous technique utilizing cheap precursors for the synthesis of titanium dioxide nanoparticles. Moreover, this simple, efficient, laboursaving, and eco-friendly strategy offers different applications. The climate friendly methodology by the utilization of these leaf extracts for the preparation of nanoparticles will improve their economic sustainability and management.

Characterization of biologically synthesized nanoparticles

Probing further, Dobrucka *et al*., 2017 utilized the plant named *Echinacea purpurea* for the biosynthesis of titanium dioxide nanoparticles. *Echinacea purpurea* develop in the local climate of northern pieces of Africa. *E. purpurea* is the individual from *Asteraceae* family. It is however important to note the advantages of *Echinacea purpurea* and are as following. E. purpurea is utilized to fix relentless contaminations of respiratory framework and furthermore treats the disease of bladder. Likewise, *Echinacea purpurea*has capacity to stimulate macrophage cytotoxicity actions in opposition to cancer cells and miniature living beings. The researcher showcased the presence of nano particles via different techniques for instance, UV-Vis spectra examination, scanning electron microscopy, Fourier Transform Infrared Spectroscopy, total reflection X-Ray fluorescence investigation as reported in table 1. To follow UV-Vis spectroscopy, two solutions were prepared and for the confirmation of nanoparticles in the subsequent solutions, the UV-Vis spectra were examined. The pH of one arrangement was 2 (acidic), and of the other – 8 (alkaline). The point of the examination was to screen the impact of the response of the arrangement on the development of

TiO_2 nanoparticles. The conducted study uncovers that the basic response of the arrangement (pH = 8) prompted the expansion in absorbance. The peak was seen at 280 nm. The expansion in absorbance may reflect the developing number of TiO_2 nanoparticles in the inspected solution. Besides, the size of the nanoparticles was estimated utilizing SEM-EDS. The normal size of the obtained nanoparticles was around 120 nm. In conclusion, the elemental composition of the green-synthesised arrangement was also investigated utilizing X-ray fluorescence spectrometer.

Antimicrobial and antioxidant potential of TiO_2nanoparticles

Santhosh Kumar *et al*., 2014 displayed the usefulness of antibacterial and antioxidant activities of aqueous natural concentrate of *Psidium guajava* mediated synthesis of titanium dioxide nanoparticles (TiO_2 NPs). Green synthesised TiO_2 NPs were inspected by agar diffusion test against human pathogenic microbes. The total antioxidant activity and phenolic content of prepared TiO_2 NPs and watery plant extract were analysed. The free radicals were calculated by DPPH strategy. The prepared TiO_2 NPs were evaluated by XRD, FTIR, FESEM and EDX. In addition, FTIR spectra of biosynthesized TiO_2 NPs showed noticeable peaks. The morphological characterization of integrated TiO_2 NPs was investigated by FESEM which displayed circular shape and clusters with a normal dimension of 32.58 nm. The greatest zone of inhibition was seen in the synthesised TiO_2 NPs against *Staphylococcus aureus* (25 mm) and *Escherichia coli* (23 mm). The synthesised TiO_2 NPs displayed more antibacterial potential than the standard anti-biotic disk, tetracycline which severely decreases the chance for the development of antibiotic resistance of bacterial species. On the other hand, the botanical extract and synthesised TiO_2 NPs were found to have more antioxidant potential when contrasted with ascorbic acid. Overall, biosynthesized TiO_2NPs gives a promising approach and can satisfy the large-scale production having the points of interest like economical, eco-friendly etc. Moving further, Ajmal *et al*., 2019 crystal cleared the eco-friendly synthesis of tio_2 nanoparticles utilizing a methanolic extract of fruits peel agrowaste. Researcher added that the size of TiO_2 blended from Plum, Kiwi and Peach were discovered to be 47.1 and 63.2, 54.1 and 85.1 and 200 nm, separately. All the TiO_2NPs displayed size- and dose dependent antibacterial and antioxidant activites. The antimicrobial action was assessed against some chose pathogenic bacterial strains, for example, *Escherichia coli* (NCIM 2079), *Staphylococcus aureus* (NCIM 2079), *Pseudomonas aeruginosa* (ATCC10145) and *Bacillus substilis*(NCIM2439). in addition, nanoparticles were characterised by various strategies, for example, XRD, FTIR and SEM to exhibit the morphological properties of formed nanoparticles.

Furthermore, Haghi *et al.,* 2012 emphasis more on the outcome of antibacterial activity of TiO_2 nanoparticles on infective strain of *E. coli.* Moreover, investigator analysed that the E. Coli was unaffected to all of the antibiotics used in this research. Decrease in Optical density (OD) was monitored whereas concentration of titanium nanoparticles increases. Kirby-Bauer test measurements revealed that the zone of inhibition increases with the surge in tio2 concentration. In the study, the experimenter also discussed the Antibacterial potential of different concentrations of Tio_2 were studied. *E. Coli* is one of the prime causative agents of hospital- acquired infections and resistant to most of the broad-spectrum antibiotics. Because of overusing of the antibiotics, Antibiotic resistance of microbes is highly extended. Maurya *et al*., 2012 presented different method to utilize TiO_2 and botanical extract composite for antibacterial action. XRD assessment have committed the presence of TiO_2 in the preformed plant extract/TiO_2 composite samples. UV-vis study revealed an amplified absorption capacity and subsequently improved photocatalytic capability of herbal extract/TiO_2 composites. The herbal concentrate/TiO_2 composite represented tremendously improved antibacterial activity against *E.faecalis* and *Ecoli* .

Table No.1: - Green synthesis of titanium dioxide nanoparticles from different plant extracts

Sr. No.	References	Plant species	Common name	Part used	Characterization
a)	Swathi*N et al.,* 2019	*Cassia fistula*	Golden shower	Leaves	FTIR, Electron microscopy
b)	Patidar *et al.,* 2017	*Moringa olifera*	Drumstick tree	Leaves	UV-Visible spectroscopy, XRD.
c)	Kumar *et al.,* 2014	*Hibiscus rosa-Sinensis*	Shoe flower	Flower	XRD, FTIR, SEM.
d)	Dobrucka et *al.,* 2017	*Echinacea purpurea*	Purple cone flower	Leaves	UV-Visible spectroscopy, SEM, FTIR, TXRF.
e)	Maurya *et al.,* 2012	*B.variegatea* and *T.cordifolia*	Red flowered bauhinia and giloy respectively.	Leaves and Stem	XRD, UV-Visible spectroscopy.
f)	Ajmal *et al*., 2019	*Prunus domestica*, *Prunus persia, L.Actinidia Deliciosa*	Plum, Kiwi and Peach	Fruits Peel	XRD, FTIR, SEM, UV- Vis Spectroscopy
g)	Sundrarajan *et al.,* 2011	*Nyctanthes arbortritis*	Night flowering jasmine	Leaves	XRD, SEM, PSA
h)	Santhosh kumar *et al*., 2014	*Psidium guajava*	Guava	Leaves	FTIR, Electron microscopy

CONCLUSION

In a nutshell, it is concluded that during the last decade many efforts have been made for the development of green synthesis. Green synthesis gives remarkable progression over chemical and physical methods as it is cost-effective, eco-accommodating and effectively scaled up for large-scale synthesis. An increasing awareness towards green chemistry and utilization of green route for production of metal NPs, especially titanium-NPs led a desire to develop eco-friendly methods. Advantages of synthesis from plant extracts are provision of hygienic working environment, health and environment shielding, lesser wastages and most stable products. Titanium-NPs synthesized by green route have important aspects of nanotechnology through numerous applications. Titanium dioxide-NPs have emerged with a variety of applications such as diseases diagnostics, treatment, and manufacturing of surgical tools, tissue engineering, imaging, sensing, energy production and agriculture.

REFERENCES

Ajmal, N., Saraswat, K., Bakht, M.A., Riadi, Y., Ahsan, M.J. and Noushad, M., (2019). Cost- effective and eco-friendly synthesis of titanium dioxide (TiO2) nanoparticles using fruit's peel agro-waste extracts: characterization, in vitro antibacterial, antioxidant activities. *Green Chemistry Letters and Reviews*, *12*(3), pp.244-254.

Dobrucka, R., (2017). Synthesis of titanium dioxide nanoparticles using *Echinacea purpurea herba*. *Iranian journal of pharmaceutical research: IJPR*, *16*(2), p.756.

Haghi, M., Hekmatafshar, M., Janipour, M.B., Gholizadeh, S.S., Faraz, M.K., Sayyadifar, F. and Ghaedi, M., (2012). Antibacterial effect of TiO2 nanoparticles on pathogenic strain of *E.coli*. *International Journal of Advanced Biotechnology and Research*, *3*(3), pp.621-624.

Kumar, P.S.M., Francis, A.P. and Devasena, T., (2014). Biosynthesized and chemically synthesized titania nanoparticles: Comparative analysis of antibacterial activity. *J. Environ. Nanotechnol*, *3*(3), pp.73- 81.

Maurya, A., Chauhan, P., Mishra, A. and Pandey, A.K., (2012). Surface functionalization of TiO2 with plant extracts and their combined antimicrobial activities against *E. faecalis and E. coli*. *Journal of Research Updates in Polymer Science*, *1*(1), pp.43-51.

Nadeem, M., Tungmunnithum, D., Hano, C., Abbasi, B.H., Hashmi, S.S., Ahmad, W. and Zahir, A., (2018). The current trends in the green syntheses of titanium oxide nanoparticles and their applications. *Green Chemistry Letters and Reviews*, *11*(4), pp.492-502.

Patidar, V. and Jain, P., (2017). Green synthesis of TiO2 nanoparticle using *Moringa oleifera* leaf extract. *Int Res J Eng Technol*, *4*(3).

Rafique, M., Sadaf, I., Rafique, M. S., & Tahir, M. B. (2017). *A review on green synthesis of silver nanoparticles and their applications. Artificial cells, nanomedicine, and biotechnology*, *45(7),* 1272-1291.

Santhoshkumar, T., Rahuman, A.A., Jayaseelan, C., Rajakumar, G., Marimuthu, S., Kirthi, A.V., Velayutham, K., Thomas, J., Venkatesan, J. and Kim, S.K., (2014). Green synthesis of titanium dioxide nanoparticles using *Psidium guajava* extract and its antibacterial and antioxidant properties. *Asian*

Pacific journal of tropical medicine, *7*(12), pp.968-976.

Sundrarajan, M. and Gowri, S., (2011). Green synthesis of titanium dioxide nanoparticles by *Nyctanthes arbor-tristis* leaves extract. *Chalcogenide Lett*, *8*(8), pp.447-451.

Swathi, N., Sandhiya, D., Rajeshkumar, S. and Lakshmi, T., (2019). Green synthesis of titanium dioxide nanoparticles using *Cassia fistula* and its antibacterial activity. *International Journal of Research in Pharmaceutical Sciences*, *10*(2), pp.856-860.

Trouiller, B., Reliene, R., Westbrook, A., Solaimani, P. and Schiestl, R.H., (2009). Titanium dioxide nanoparticles induce DNA damage and genetic instability in vivo in mice. *Cancer research*, *69*(22), pp.8784-8789.