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A Review on Green Synthesis of TiO_2 Nanoparticles and its Applications

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ABSTRACT

Now days, green synthesis of nanomaterials have great interest in the development of nanoscience and nanotechnology due to its eco-friendly, cost effective, low risk of contamination, non requirement of toxic chemicals and sustainable procedure to produce several metals, their oxides, etc. Bio molecules present in the plant extract play an important role and magnificent attributes to the resulting nanomaterials. Due to its non hazardous effects on environment green synthesis techniques are most acceptable for many practical applications. In this article we have reviewed different synthesis techniques for the green synthesis of titanium dioxide (TiO_2) nanoparticles (NPs) and their applications in different areas.

1. Introduction

Nowadays in all over the world environmental safety is a big challenge. Since, this 21st century is the era of nanoscience and nanotechnology, therefore nanoscience have the responsibility to accept this challenge [1-2]. To resolve this challenge, green synthesis technique will be the first step towards this. Many researchers are working to solve this environmental problem. There are so many environmental problems such as water pollution, global warming, air pollution, soil pollution etc. and many health related problems due to use of toxic chemicals. Green synthesis reduces the use of toxic chemicals in synthesis of nanomaterials by using biological extracts as a reducing agents. Before this the synthesis techniques of nanomaterials are chemical vapor deposition, micro emulsion, chemical precipitation, hydrothermal crystallization, and sol–gel methods [3-10]. All these methods required high temperature, pressure and toxic chemicals and thus these are not suitable for the health related problems and other industrial uses.

Amongst other nanoparticles Titanium dioxide nanoparticles exhibit unique properties and morphologies due to which it is widely used in textiles, papers, plastics, cosmetics, and food industries and these industries covered about 90% of the environmental problems. Thus, the green synthesis of TiO_2 NPs may help the world against these global challenges. Hence, eco-friendly and cost-effffective green synthesis technique is needed to synthesize TiO_2 NPs on larger scale in these industries [11-12]. The bio-mediated TiO_2 NPs have many other applications such as in manufacturing of surgical tools, tissues, imaging, sensing, energy production and agricultural tools [14-15]. Among these, TiO_2 with band gap energy of 3-3.5 eV promotes the photo catalytic behavior in a considerable way [15]. The electron transfer mechanism in TiO_2 from valance band to conduction band during exposure to UV or visible light generates a hole, which further contacts with water to form an OH radical. This OH radical will act as a strong oxidizing agent and stands responsible for removing organic pollutants, pesticides and heavy metals like lead from the waste water through photo oxidation mechanism [16].

This review provides a brief discussion on different green synthesis techniques using different bacteria, fungi, plants and other biological microorganism and its potential applications in different industries and biological uses for human and environment are also here studied.

2. Synthesis Techniques

There are several synthesis techniques to synthesis the TiO_2 nanoaprticles. K.G. Rao et.al. prepared the TiO_2 nanoaprticles aloe vera extract [17]**.** They synthesized the TiO_2 nanoparticles by dropwise addition of aloe vera extract into 1.0 M of Titanium Chloride under constant stirring up to achieve pH of solution became 7. The sizes of the synthesized NPs were 20 nm with tetragonal structure. K.G. Rao et.al also prepared TiO_2 NPs using orange fruit waste [18]. They take 50 gm of orange peel in the beaker and with 150 ml of water and heating it for 2 hours at 90^0 C. After cooling at room temperature this solution was filtered through filter paper to get the extract of the peel. This extract was drop wise added into 100 ml of 1.5 M of titanium tetra iso propoxide with constant stirring to get TiO_2 NPs. S. Marimuthu et.al. used calotropis gigantea to synthesis the TiO_2 nanoparticles [19]. It is a common medicinal plant in India and has purgative, anthelmintic, anti-convulsant, sedative and anti-pyretic effect. The fresh flower of calotropis gigantea aqueous extract was mixed with 10 mM $TiO(OH)_2$ and stirred for 6 h. The mixture was subjected to ultra sonication for 30 mins to separate out the agglomerates formed. The powder was filtered and then dried at 90C for 2 hours to get the synthesized TiO_2 NPs. For the purification of synthesized TiO_2 NPs, 5 mL of 1 mM sucrose and 5 mL of 95% ethanol were added into the solution as a linking conjugate between $TiO(OH)_2$ and aqueous flower extract. The size of the NPs were about 11nm. P. Singh synthesized the TiO_2 NPs using Bacillus subtilis [20].. M. Sundrarajan et.al. synthesized the TiO_2 NPs by the reaction of 0.4M of titanium tetraisoproxide in ethanolic leaf extract of nyctanthes arbor-tristis during stirring at 50°C for four hours [21]. The synthesized TiO_2 NPs were obtained by centrifugation at 10000 rpm for 15 minutes. The size of the particles were about 100-150 nm . A. A. Kashale et.al synthesized TiO_2 NPs using dry Bengal gram beans, they process 20 g of dry Bengal gram beans (Cicer arietinum L.) soaked in 100 mL distilled water for 6 h at room temperature. Thereafter, the soaked seeds were removed and the extract was filtrated using a glass-fiber filter to be free from particulate matter. 10 mL of $TiCl_4$ solution was added to 10 mL of the gram bean extract and diluted to 50 mL. The ammonia is added in the diluted solution to make pH of the solution to 7 and formation of titanium-hydroxidepectin gel, which shrinks and inhibits the further growth of the nanoparticles. The obtained precipitate was centrifuged and dried in air to get powered sample and subsequently calcined at 500 °C to remove the organic contaminants and found uniform and non aggregated nanoparticles with narrow size distribution with size ~14 nm [22]. A. K. Jha et.al. synthesised TiO_2 nanoparticles by two methods firstly by Lactobacillus cells and secondly by yeast [23]. In the first method the culture of Lactobacillus cells were made. 25 ml of the culture was taken and diluted four times by adding 75 ml of distilled water containing nutrients. This diluted culture solution was again allowed to grow for another 24 h. Now, 20 ml of 0.025M $TiO{\cdot}(OH)_2$ solution was added to the culture solution with heating at 60 ◦C for 10–20 min, then white deposition starts to appear at the bottom of the flask, indicating the initiation of transformation. Now the culture solution was cooled and allowed to incubate at room temperature for 12–48 h to get the TiO_2 NPs. In the second method TiO_2 NPs are synthsizsed by yeast. The culture of yeast cells were grow in presence of suitable carbon and nitrogen source for 36 h. This was treated as source culture. A small portion of it (25 ml) was filtered and diluted four times by adding 30% Et-OH containing nutrients. This diluted culture was again allowed to grow for another 24 h until it attains a light straw colour. Now, 20 ml of 0.025(M) $TiO{\cdot}(OH)_2$ solution was added to the culture solution and it was heated at 60 ◦C for 10–20 min until white deposition starts to appear at the bottom of the tube, indicating the initiation of transformation. Now the culture solution was cooled and allowed to incubate at room temperature in the laboratory ambience. After 12–48 hours, the culture solution was observed to have distinctly markable coalescent white clusters deposited at the bottom of the tube. R. Dobrucka converted bulk TiO_2 into nanosized TiO_2 using Echinacea purpure herba. Echinacea purpurea contains alkamides, cichroic acid and polysaccharides which may used to treat chronic infections of respiratory tract and lower urinary tract and kill bacteria such as staphylococci. Echinacea purpurea has potent to activate macrophage cytotoxicity actions against tumor cells and micro organisms. To get the extract of Echinacea purpurea, Dobrucka take 10 g of fresh and clean herba in 50 mL of double distilled water and boiled it at 90 °C for 20 min and then filtered to get the final extract of the herb. Now, 1 mM TiO_2 solution was stirred for 2 h at 25 °C and then 20 mL of this solution was added with 10 ml of the extract with stirring for 4 hours to get the TiO_2 NPs and the colour of the solution become green indicating formation of TiO_2 NPs [24]. M. Hudlikar et. al. Prepared TiO_2 nanoparticles by using aqueous extract of Jatropha curcas L. latex [25]. In a typical reaction, 1 ml crude latex is diluted to 300 ml using deionized water. Equal volumes of latex solution and 2.5 mM aqueous TiO $(OH)_2$ solution are mixed. The mixture is heated on the steam bath at 50 °C for 10 min until white deposition starts to appear at the bottom of the flask. Reaction mixture is then allowed to stand and cool to room temperature in laboratory ambience. After 12 h, solution was observed to have distinctly markable coalescent white clusters deposited at the bottom of the flask and thus TiO_2 is synthesized.

3. Applications of TiO_2 NPs

The TiO_2 NPs are widely used in cosmetics, pigments, catalysts, sunscreens, solar cells, water purifier, paints, papers, medicines, toothpaste, environmental purification, food industries etc. In hospitals it may used as a disinfectant, and this antibacterial property is used in textile and cotton industries to make antibacterial fabric. P. singh studied the antibacterial effect of the TiO_2 NPs on escherichia coli [20]. She found that TiO_2 NPs are very effective on escherichia col bacteria. A. A. Kashale study the electrochemical performance of TiO_2 NPs. The electrochemical performance of Bio-TiO_2 evaluated in half-cell confifiguration (Li/Bio-TiO2) between 1-3 V in room temperature at current density 33 mA g^{-1} exhibited high reversible capacity of 164 mA g^{-1} after 60 cycles with 98% capacity retention [22]. This result concludes that this Bio-TiO_2 NPs may be more better option for the anodes in high-power Li-ion batteries.

4. Conclusion

The different synthesis methods of TiO_2 NPs has been reported with different sizes and morphologies such as nanospheres, nanostructured, nanotubes, nanowires and nanofibers structures depending upon different bacteria, fungi, plants and other biological microorganism and hence they are appropriate for different application fields. Hence, green synthesis is an alternative option for synthesizing TiO_2 nanoparticles which is simple, eco-friendly, cost effective and reduces the use of toxic chemicals. The green synthesized TiO_2 NPs have many application such as antibacterial, anti pollutant and many other medical properties and also applicable in food, electronics, cosmetics, catalysts, sunscreens, solar cells, water purifier, paints, papers, toothpaste, environmental purification, food industries etc. which are beneficial for human being.

References

1. A.K. Gupta, K.K. Tiwari, “Synthesis of Nanomaterials and their selected Applications: A Review”. Res. Rev. Int. J. Multi. 4 (1) (2019) 741-743.
2. K.K. Tiwari, “Dislocations & Plastic Deformation and Mechanisms of Plastic Deformation in Metals: A Review”, Res. Rev. Int. J. Multi. 4 (2) (2019) 176-178.
3. Y. Kitamura, N. Okinaka,T. Shibayama, O. O. P. Mahaney, D. Kusano, B. Ohtani, T. Akiyama,“Combustion synthesis of TiO2 nanoparticles as photocatalyst, Powder Technology”, 176 (2007) 93.
4. K.Thangavelu, R. Annamalai, D. Arulnandhi, “Preparation and Characterization of Nanosized TiO2 Powder by Sol-Gel Precipitation Route, International Journal of Emerging Technology and Advanced Engineering, 3(1) (2013) 636.
5. H.P.Shivaraju, K.Byrappa, T.M.S. V. Kumar, C.Ranganathaiah, “Hydrothermal Synthesis and Characterization of TiO2 Nanosturctures on the Ceramic

Support and their Photo-catalysis Performance" , Bulletin of the Catalysis Society of India, 9 (2010) 37.

6. N.Chandrasekharan, P.V. Kamat, "Improving the photochemical performance of nanostructured TiO2 fifilms by adsorption of gold nanoparticles', J. Phys. Chem. B 104 (2000) 10851–10857.
7. Cao-Thang Dinh, Thanh-Dinh Nguyen, F. Kleitz, Trong-On Do, "A Solvothermal Single-Step Route Towards Shape-Controlled Titanium Dioxide Nanocrystals", The Canadian Journal of Chemical Engineering, 90 (2012) 8.
8. Hanbin Lee, Minsik Choi, Younhee Kye, Myoungyoung An, and Ik Mo Lee, Control of Particle Characteristics in the Preparation of TiO2 Nano Particles Assisted by Microwave, Bull. Korean Chem. Soc, 33(5) (2012) 1969.
9. V. Mishra, R. Sharma, N.D. Jasuja, D. K. Gupta, "A Review on Green Synthesis of Nanoparticles and Evaluation of Antimicrobial Activity",International Journal of Green and Herbal Chemistry, 3(1) (2014) 081.
10. J. Wu, G.R. Bai, J. A. Eastman, G. Zhou, V. K. Vasudevan, "Synthesis of TiO2 Nanoparticles Using Chemical Vapor Condensation", Mat. Res. Soc., 879E, Z7, 12. (2005) 1.
11. A.V.Kirthi, A.A. Rahuman, G.Rajakumar, S.Marimuthu, T.S.kumar, C. Jayaseelan, G.Elango, A.A. Zahir, C.Kamaraj, A.Bagavan, "Biosynthesis of titanium dioxide nanoparticles using bacterium Bacillus subtilis", Mater Lett , 65 (2011) 2745–2747.
12. Y. Zhao, C. Li, X. Liu, F. Gu, H. Jiang, W. Shao, "Synthesis and optical properties of TiO2 nanoparticles, Mater. Lett. 61 (2007) 79–83.
13. K. Prasad, A.K. Jha, A.R. Kulkarni, "Lactobacillus assisted synthesis of titanium nanoparticles", Nanoscale Res. Lett. 2 (2007) 248–250.
14. P.R. Mishra, A.K. Singh, O.N. Srivastava, "Synthesis of nanostructured TiO2 by sol-gel technique for PEC application and its advantages", Ind. J. Phys. 78A (2004) 81–84.
15. Y. Li, T. White, S.H. Lim, "Structure control and its inflfluence on photoactivity and phase transformation of TiO2 nanoparticles, Rev. Adv. Mater. 5 (2003) 211–215.
16. D.Chen, A.K.Ray, "Removal of toxic metal ions from wastewater by semiconductor photocatalysis", Chem. Eng. Sci. 56 (2001) 1561-1570.
17. K. G. Rao, CH. Ashok, K. V. Rao, CH. Shilpa Chakra, P. Tambur, "Green Synthesis of TiO2 Nanoparticles Using Aloe Vera Extract" Int. J. Adv.Res. Phys. Sci., 2, IA, 2015, 28-34.
18. K. G. Rao, CH. Ashok, K. V. Rao, CH. Shilpa Chakra, V. Rajendar, "Green Synthesis of TiO2 Nanoparticles from Orange Fruit waste", Int. J. Multi. Adv. Res. Trd. II (I) (2015) 82-90.
19. S. Marimuthu, A. A. Rahuman, C. Jayaseelan, A. V. Kirthi, T. Santhoshkumar, K. Velayutham, A. Bagavan, C. Kamaraj, G. Elango, M. Iyappan, C. Siva, L. Karthik, K. V. B. Rao, "Acaricidal activity of synthesized titanium dioxide nanoparticles using Calotropis gigantea against Rhipicephalus microplus and Haemaphysalis bispinosa", Asian Pacific Journal of Tropical Medicine, (2013) 682-688.
20. P. Singh, "Biosynthesis of TiO2 NPs and their antibactirial property",Int. J. Chem. and Mole. Engg. 10 (2) (2016) 275-278.
21. M. Sundrarajan, S. Gowri, "Green Synthesis of Titanium Dioxide Nanoparticles by Nyctanthes Arbor-Tristis leaves extract" Chalcogenide Letters, 8 (8) (2011) 447-451.
22. A. Kashale, K.P. Gattu, K. Ghule, V.H. Ingole, S. Dhanayat, R. Sharma, J-Y Chang, A.V. Ghule, "Biomediated green synthesis of TiO2 nanoparticles for lithium ion battery application", Composites Part B, 99 (2016) 297-304.
23. A.K. Jhaa, K. Prasad, A.R. Kulkarni, "Synthesis of TiO2 nanoparticles using microorganisms" Colloids and Surfaces B: Biointerfaces 71 (2009) 226–229.
24. R. Dobrucka, "Synthesis of Titanium Dioxide Nanoparticles Using Echinacea purpurea Herba" Ira. J. of Pharm. Res. 16 (2) (2017) 753-759.
25. M. Hudlikar, S. Joglekar , M. Dhaygude, K. Kodam, "Green synthesis of TiO2 nanoparticles by using aqueous extract of Jatropha curcas L. latex",Mat. Lett. 75 (2012) 196–199.

