Review Paper

Studies on the titanium dioxide nanoparticles: biosynthesis, applications and remediation

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Abstract

Nanoparticles have wide applications in various fields due to their small size. Titanium dioxide nanoparticles are bright with high refractive index (n = 2.4) which makes them suitable for industry dealing with toothpaste, pharmaceuticals, coatings, papers, inks, plastics, food products, cosmetics and textile. Three crystalline phases of titanium dioxide, are anatase (tetragonal), rutile (tetragonal), and brookite (orthorhombic) in which brookite has no commercial value. Due to their self cleaning and antifogging property, they are used in the preparation of cloths, windows, tiles and anti-fogging car mirrors. Titanium dioxide nanoparticles also serve as environment sanitizing agent. Sol–gel route, flame hydrolysis, co-precipitation, impregnation and chemical vapor deposition like techniques are used for the synthesis of TiO_2 nanoparticles. Biosynthesis of titanium dioxide nanoparticles has gained wide interest among researchers due to its cost effective, eco-friendly and reproducible approach. The sol–gel route remediation of the titanium dioxide from the environment is an important step and it can be achieved by using physical processes like sedimentation and filtration. The biosynthesis of titanium dioxide nanoparticles can be used in comparison to chemical synthesis. The titanium dioxide nanoparticles have wide applications, viz., reducing toxicity of dyes and pharmaceutical drugs; waste water treatment; reproduction of silkworm; space applications; food industries; etc., and so have immense industrial importance. The applications of nanoparticles synthesized by biological approach will be advantageous for the industries; environment and agriculture.

Keywords Sedimentation · Filtration · Antifogging · Refractive index · Titanium dioxide nanoparticles

1 Introduction

India is the reservoir of two chief minerals of titanium viz., Ilmenite (FeO.TiO2) and rutile (TiO_2). Titanium dioxide (TiO_2) exists in rutile, anatase (octahedrite) and brookite form. Brookite is not found in abundance, it is an altered product of some titanium minerals. The reservoirs of TiO_2 in different states are shown in Table 1. The TiO_2 nanoparticles have many merits viz., high specific-surface area, proper electronic band structure, high quantum efficiency, chemical innerness and stability [1]. The research is gaining immense interest for the synthesis of TiO_2 on a large-scale by biological way which will be cost-effective.

There is report on TiO_2 nanoparticles synthesized using microbes viz., *Lactobacillus* sp. and *Sachharomyces cerevisae* which is low-cost [3, 4]; using *Aspergillus flavus* TFR7 [5, 6], Chromohalobacter *salexigens* strain PMT-1 [7]. There is a report on biologically synthesized of TiO_2 nanoparticles using *Bacillus subtilis* (FJ460362) for the study of photo catalytic activity in controlling aquatic biofilm [8]. Nanoparticles have wide applications specially the TiO_2 particles viz., cosmaceutical, pharmaceutical, optical, commercial applications [9].

There are reports on applications of TiO_2 nanoparticles. Cyanide annual world production is 1.4 million tons and is mainly used for gold mining. But, most of the cyanide from

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