Synthesis of titanium dioxide nanoparticles using *Spirulina platensis* algae extract

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DOI: [https://doi.org/10.22271/tpi.2022.v11.i7Sd.13643](https://doi.org/10.22271/tpi.2022.v11.i7Sd.13643)

Abstract

An investigation of green synthesis of titanium dioxide nanoparticles using *Spirulina platensis* algae extract was undertaken in the Department of Sericulture, Forest College and Research Institute, Mettupalayam. The nanoparticles formation, particle size, exterior morphology and shape of synthesized TiO$_2$ NPs were analyzed through UV-Vis absorbance spectroscopy, X-Ray diffraction and Scanning electron microscope (SEM) respectively. The results showed that the absorbance spectra of synthesized NPs were observed at 300nm. X-Ray diffraction analysis revealed that the formation of good crystalline TiO$_2$ NPs with anatase phase. The synthesised NPs were in spherical shape and dispersed irregularly. The green synthesised of TiO$_2$ NPs is a simple approach, inexpensive and eco-friendly process which having potential applications in various fields.

Keywords: TiO$_2$ NPs, green synthesis, *S. platensis*, characterization

Introduction

The nanomaterials are receiving considerable attention because of their exceptional physicochemically properties over bulk counterparts. Nanotechnology is a field of science with enormous potential in medicine. Nanotechnology plays an extremely significant role in present research as it is the most proficient technology that can be used in almost all the fields such as cosmetics, pharmaceuticals, environmental health, food and feed, chemical industry, agricultural science, energy sector, drug and gene delivery, mechanics and space industry. The synthesis of nanomaterials using chemical methods is very expensive, requires complex steps and leads to the absorption of toxic chemicals on the surface that may have an adverse effect on the agricultural application and are hazardous to the environment. Therefore, the development of clean, biocompatibility, non-toxic and eco-friendly methods using microorganisms, enzymes and plant extract is gaining importance in nanotechnology.

Titanium dioxide nanoparticles are natural mineral oxide widely used in pharmaceuticals, cosmetics, food colouring and implantable biomaterials because of their physicochemical properties such as photocatalyst, antimicrobial agent and preservatives (Gao et al., 2003) [1]. Synthesis of nanoparticles under eco-sustainable, nontoxic green conditions is of greater importance to combat the rising concerns about the toxicity of metallic nanomaterials in medical and technological applications. Plant extracts may act both as reducing agents in the synthesis of nanoparticles. The source of plant extract is known to have an impact on the characteristics of nanoparticles (Kumar and Yadav, 2009) [2]. Among various semiconductor nanoparticles, titanium dioxide (TiO$_2$) nanomaterial has been broadly recognised as semiconductors as they are a more ideal component for environment and energy applications because of their identical properties (Mohamed, 2012) [3].

Green synthesis of nanoparticles from plant extracts and microbes has attracted the attention of researchers in recent years. Biosynthesis of nanoparticles is considered better than chemical synthesis because of the formation of toxic chemical species which are adsorbed on the particle surface after chemical synthesis. Moreover, they are cost-effective and environmental friendly in nature due to a biological process, which makes them superior to chemical and physical synthesis (Parashar et al., 2009) [4].

The blue-green algae *Spirulina platensis* contains various minerals and 18 amino acids such as glycine, glutamine, histidine, lysine, methionine, cysteine, creatine, phenylalanine, serine, proline, tryptophan, asparagine, pyruvic acid, and pivotal vitamins like tocopherol, biotin, thiamine, niacin, riboflavin, proterozoic acid, folic acids, beta-carotene and vitamin B12, etc.
(Soliman and Mohamed, 2021). In this study, we have synthesized TiO$_2$ NPs exploiting aqueous extract of $S$. platensis a green reducing material and stabilising agent. These biogenically synthesized TiO$_2$ NPs were characterized using UV-Vis spectroscopy, XRD and Scanning electron microscopy (SEM).

**Materials and Methods**

**Algae**
The dried powder of Spirulina was collected from R.K. Algae Centre in Mandapam, Tamil Nadu, India. The confirmation of algal species was done at Botanical Survey of India, Coimbatore, Tamil Nadu.

**Preparation of aqueous extraction of $S$. platensis**
The aqueous extract of $S$. platensis was obtained by heating 10g of finely ground powder in 100 ml of deionized water at 90 °C for 45 mins, then the solution was filtered through Whatman filter paper No.1 to remove the debris. The resultant clear green coloured solution obtained was stored at 4-8℃ for further study (Roy *et al.*, 2019) [13].

**Synthesis of titanium dioxide nanoparticles**

*Spirulina* mediated TiO$_2$ NPs were synthesised utilising 0.01 mM titanium dioxide and aqueous extract of *Spirulina platensis* as bio-reductant and capping agent in green synthesis. Aqueous extract of 20 mL was added to 80 mL of 0.01 M TiO$_2$ solution, which was maintained at room temperature for 6 hours with continuous stirring in a hotplate magnetic stirrer. A colour change confirmed the production of TiO$_2$ NPs (pale yellow).

UV-Vis spectroscopy, XRD and SEM were used to describe the green synthesis of *Spirulina*-mediated TiO$_2$ NPs.

**UV-Vis Absorbance Spectroscopy**

The molecule size and band hole of integrated green synthesis of titanium dioxide nanoparticles were determined using UV–vis absorbance spectroscopy. Fig. 1 displays the UV absorption spectra of produced TiO$_2$, which showed a prominent absorption band at 300 nm. The present finding can be correlated with Swathi *et al.* (2019) [14] who reported that spectral image displays the absorption peaks at 350 nm for green synthesis of TiO$_2$ nanoparticles and Ahamad *et al.* (2022) indicated the presence of a titanium dioxide band at 380–400 nm. Similarly, Rathna *et al.* (2020) revealed the good crystalline nature of green route mediated AgNPs showing a peak at 420 nm indicating the formation of nanoparticles.

![Fig 1: UV-Vis absorption spectra of TiO$_2$ NPs synthesised using *S. platensis* extract](https://example.com/figure1.png)

**X-Ray Diffraction analysis**
The XRD pattern of green synthesised of TiO$_2$ nanoparticles is shown in Fig. 2. With diffraction angles of 27.79, 36.45, 41.57, 44.41, 54.65, 57.01, 63.11, 64.39, 69.22, 70.09, 76.88, 82.61, 84.47, and 88.01; it indicates the formation of good crystalline titanium dioxide with anatase phase shape. The prominent peak at 27.79 in the XRD pattern of green synthesised TiO$_2$ nanoparticles is only connected with the crystallographic plane of TiO$_2$ anatase. The final material's stoichiometry is highly dependent on the partial pressure used during the synthesis. As a result, the synthesised TiO$_2$ nanoparticles could exhibit a variety of stoichiometries. The peaks of graph are in good agreement with the literature report (Akarsu *et al.*, 2006) [8]. The location of peaks was compared to literature values and the presence of titanium dioxide particles was confirmed. The average size of the particles was calculated using Debye-Scherrer’s formula.
Scanning Electron Microscope
Scanning electronic microscopy was used to investigate the form, size, and surface features such as morphology. Fig 3 & 3a. clearly showed an SEM images of synthesised TiO2 nanoparticles made with *S. platensis* aqueous extract which are irregularly dispersed and spherical in shape. The average size of the produced nanoparticles using SEM images were found to be in the range of 90 to 150 nm. Fig 3 denotes a 5µm scale range, while fig.3a denotes a 4µm scale range. Similarly green synthesised metal nanoparticles loaded ultrasonic-assisted *S. platensis* algal extract showed rougher and irregular spores developed on the surface of UASP and confirmed that the metal nanoparticles (Ag, Cr, Pb and Zn) were successfully coated on UASP material (Gunasundari et al., 2017) [9]. In line with this result of Santhosh Kumar *et al.* (2014) [10] revealed that SEM images of *Psidium guajava* mediated TiO 2 NPs were smooth and spherical in shape with various physical morphology, particle size and aspect ratio.

Conclusion
The TiO2 nanoparticles were successfully synthesised with *S. platensis* aqueous extract. The synthesised TiO2 NPs were investigated by UV-Vis, XRD and SEM which indicated the properties of TiO2 NPs. The UV-Vis spectral result showed that nanoparticles synthesised properly, XRD result predict that the particles were crystalline, the Sem result displayed that the sample was nearly spherical in shape. The synthesis of NPs using green approach is simple, inexpensive and eco-friendly process, which reduces the use of toxic chemicals.

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