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*Research Article*

# Application of Titanium Dioxide Nanoparticles Synthesized by Sol-Gel Methods in Wastewater Treatment

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Nanotechnology from titanium dioxide has been deposited, and its application in desalination and water treatment has been investigated by using sol-gel methods. Homogeneously dispersed sphere shapes of titanium dioxide nanoparticles were observed from scanning electron microscope micrographs and decrease in size as aging time increases from 40 min to 60 min. SEM micrographs of highly transparent nanopowders show that they are detected in the visible region from UV/visible and that their red shift around maximum wavelength increases with increasing aging time due to an increase in water quality. The energy band gap of the generated nanosheet has narrowed as the aging time has increased, which is related to the red shift of the absorption spectrum edge in the sheet. The structural behaviors of deposited nanoparticles have also been investigated, which confirms the existence of anatase as well as rutile levels in the liquid phase. The findings of the PL allowed us to determine the total strength of the intensity. This shows that applying photodegradation by a solar absorber could play a vital role in desalination and water treatment.

## 1. Introduction

The important thing for human life is clean water which is a critical feedstock in a variety of key productions including electronics, pharmaceuticals, and nutrition [1]. The biosphere is encrusted with difficult challenges in consultation rising difficulties of pure water as obtainable provisions of freshwater are declining because of lengthy droughts, resident's growth, more rigorous health-based protocols, and contending demands from multiplicity of customers. As reports show, only three percent of all existing water on earth is actually freshwater; seawater is the most abundant obtainable foundation of drinking water as well as water for manufacture use in several regions and novelties in the growth of new [2]. The welfares of nanotechnology in case of water treatment claim have been intensive in 3 main sites: cure and remediation, sensor and recognition, and waste control. It has produced massive advancement in numerous fields like the engineering of electronics, telecommunications, and medicals. Nanotechnology has a vital role in addressing essential issues of the atmosphere and sectors of water. Nanotechnology apparatuses used to desalinate water are highly exhilarating as well as hopeful [3].

The charge of desalination, either heating or thermal, is enormously high. Improvements in nanoscale technology and engineering have created an unparalleled opportunity to produce more cost-effective as well as environmentally favourable acceptable water refinement systems [4, 5]. Developments in nanotechnology recommend that several of the current difficulties concerning water quality can be determined or greatly perfected by using nanocatalysts, nanosorbents, bioactive nanoparticles, nanostructured catalytic sheaths, and nanoparticle which improved clarification from other yields and procedures subsequent from the improvement of nanotechnology [6]. Moreover, nanotechnology derivative merchandises that minimize the concentrations of poisonous amalgams to sub-ppb stages can support in the accomplishment of water quality values and healthiness advisories [7]. There are very few wastewater treatment reports as general in sol-gel method. For the first time, titanium dioxide nanosheet or nanomembrane is used in application of desalination and water treatment. Throughout this work, we technologically advanced novel nanomaterials and procedures for treatment of surface water contaminated with toxic metal ions, organic and inorganic solutes, bacteria, and viruses [8]. In addition, we discuss some of the risks and challenges associated with the development of cost-effective and environmentally acceptable functional nanomaterials for water purification. Since the last few years, desalination technology has been used progressively all over the world to yield pure drinking water from briny groundwater and seawater, to recover the feature of prevailing provisions of freshwater for consumption and engineering dedications, agricultural needs and luxury manufacturing [9–12].

$TiO_2$ nanosheets were prepared by using CBD. The maximum resistivity and less optical transmission of such tools limit their application as optical ingredients for thermoelectric materials, requiring the essential to grow their optical as well as electrical behaviors. In addition, there is a shortage of information on the properties of $TiO_2$ nanoparticles in a chemical medium. Nanosheets prepared in alkaline have environmental pollution; usually, they yield hydroxides, which can reduce the quality of nanosheet prepared. It would be difficult to depose the maximum quality of $TiO_2$ nanoparticles intimate of an alkaline chemical immerse environment unless the challenge of $TiO_2$ preparation is overcome [13–18]. The influence of hydroxide is diminished when $TiO_2$ is prepared in an acidic bath. The most metallic ions are widely utilised in chemical bath deposition procedures; it is correct to generalise that no hydroxide exists in these conditions and that synthesis occurs via an ion by ion procedure. The objective of the current study was to synthesize and characterize $TiO_2$ nanoparticle sheets as solar absorber and study its application in wastewater treatment and desalination, deposited under different aging times at 40 min, 50 min, and 60 min. It is employed in the synthesis of tints, fabrics, sheets, polymers, cosmetic, and foodstuffs, as well as in the production of dyes. The biomediated $TiO_2$ nanoparticles have a wide range of purposes including illness diagnosis, therapy, manufacture of medical equipment, regenerative medicine, imaging, detection, energy production, and farming [19–25].

Sol- (solution-) gel (molten) systems are from the most encouraging and effective methods used in nanoparticle fabrication. This technique yields high crystal oxides by permitting regulator in nanoparticles size and surface morphology as well as phase configuration in different concentration precursors, and it is easy to operate. The present study is aimed at desalinating and treating water by using $TiO_2$ nanoparticle sheets as solar absorber with varying aging times at 40 min, 50 min, and 60 min.

## 2. Materials and Methodology

*2.1. Materials.* Titanium isopropoxide, hydrochloric acid (HCl), double-distilled water, ethanol, etc. were gained from chemical shop best chemicals Ltd., Addis Ababa, Ethiopia. Deionized water was used to make aqueous mixtures of essential concentrations. Completely, the chemicals were served as expected from the providers without any desalination [7].

*2.2. Production of Titanium Dioxide Nanoparticles.* The laboratory setup involves a magnetic stirrer. The reaction solution was regained at a constant temperature of 32°C with the magnetic stirrer revolving at 300 rpm. In this study, $TiO_2$ NPs were produced through sol-gel techniques; for that, 10 milliliters of titanium tetraisopropoxide was added into 120 milliliters of ethanol in a bath container with volume 500 milliliters. And total solution was agitated for 25 min by using a magnetic stirrer. In case of hydrolysis mixture, 5 milliliters of distilled water and 4 milliliters of HCl were mixed to the reaction by small drops. The reaction mixture was stirred constantly for hours to get a uniform solution. The pH of the total solutions was kept in the acidic medium of pH 5; after 20 hours of development, the gels generated were dehydrated and heated in an oven at 300°C. Lastly, the prepared nanoparticle changed to molten state by using double-distilled water; then, coated substrate was used to get $TiO_2$ nanosheet for the solar panel absorber.

*2.3. Photodegradation of Wastewater Using Prepared $TiO_2$ Nanoparticle Sheet as Solar Panel.* All the experiments have been performed at a constant volume of 100 wastewater liter by using the aqueous solution concentration. The solar power used is 80 W. Photodegradation has been investigated as shown in Figure 1. The initial pH of the solution has been observed as 5, and the acidity effect of pH was achieved. All the experiments were performed for a period of 160 min, and samples were taken out at different time ranges of 40 min, 50 min, and 60 min for further analysis.

## 3. Result and Discussions

A photodegradation experiment of wastewater was carried out by pouring 100 ml in a bottle and leaving it overnight. The effect of the amount of catalyst panes on the performance of degradation was being investigated in this experiment by altering the desalination time. All sheets have an area of $10 \times 20\ cm^2$. Wastewater without substance was used as control laboratory conditions [8]. Through the laboratory experiment, the water bottle was protected by a transparent acrylic to evade the influence of vaporizations on the

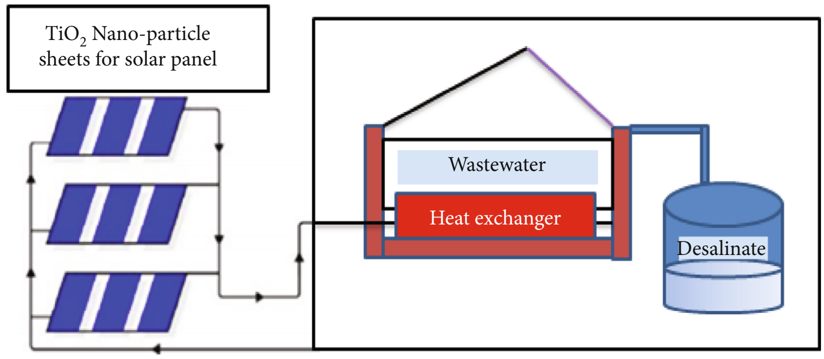


FIGURE 1: The schematic diagram of application of $TiO_2$ nanoparticles as nanosheet for desalination and water treatment.

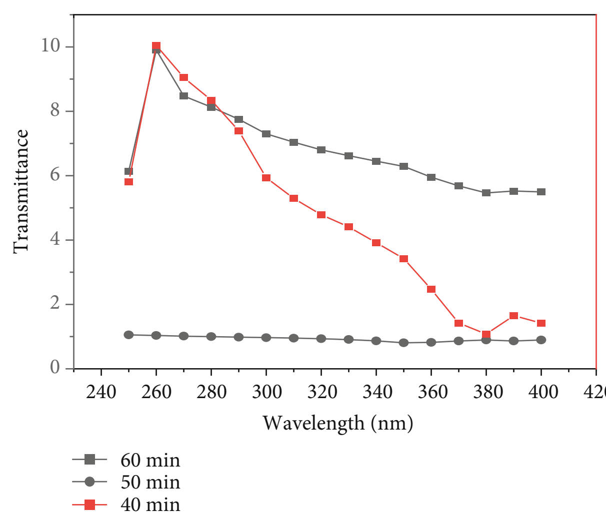


FIGURE 2: Transmittances of $TiO_2$ nanoparticle with varying aging times at 40 min, 50 min, and 60 min.

photodegradation solution wavelength in the range of UV-V which is until visible light. Even as ultraviolet-visible spectrum demonstrates, photons in the visible spectrum are required to elicit the photocatalytic reaction. Acrylic transmission peaks are shown in Figure 2 together with the experimental setup and lighting conditions. It was discovered that measuring the absorbance of a solution may be used to investigate the decolorization procedure of substances contained in wastewater. The concentration of a mixture is directly proportional to the generosity of the absorption spectra according to the Lambert-Beer principles. The reduction in the maximum absorption spectra of a solution throughout the degradation cycle implies a reduction in the concentration of waste in the water [12], which is supported by other research. As shown in Figure 2, the UV-Vis absorption spectra of batik sewage without and with a catalyst may be observed.

Photoluminescence is also used to describe the optical properties of $TiO_2$ nanoparticles that have been produced and characterized. The wavelength range between 350 and 650 nm with lower temperature is depicted in the figure. The photoluminescence (PL) spectra of the produced materials were examined in step three. When the annealing temperature is raised between 400 and 100-degree Celsius, the mean strength of photoluminescence falls as the amount of time spent aging the sample rises. The majority of the highest PL hardness is because of self-trapped exciton recombination, which is produced from particle size and is referred to as defect centres. For all elevated temperatures, the PL intensity drops instantaneously as a function of the aging time [9–24]. In comparison, the photoluminescence intensity for wavelengths of higher wavelength for 60 min and 50 min is smaller than 40 min for wavelength intensity for higher aging time. The anatase and rutile structures that have been discovered are mostly responsible for this effect.

The anatase phase is assigned to the secondary band spectra experienced at a length of 500 nm as shown in Figure 3, whilst the rutile phase is assigned to the peaks between 500 and 550 nm. When compared to the manufacturing of electron states throughout the band gap, associated faults are much more energetically attractive, and they are shaped also during description of the $TiO_2$ nanoparticle anatase stage and the 500 nm band gap happens once the structure is a combination of anatase and rutile phases at a reduced oxygen flow ratio [11–25]. The highest peak observed shows that at maximum aging the desalination of water has the highest quality.

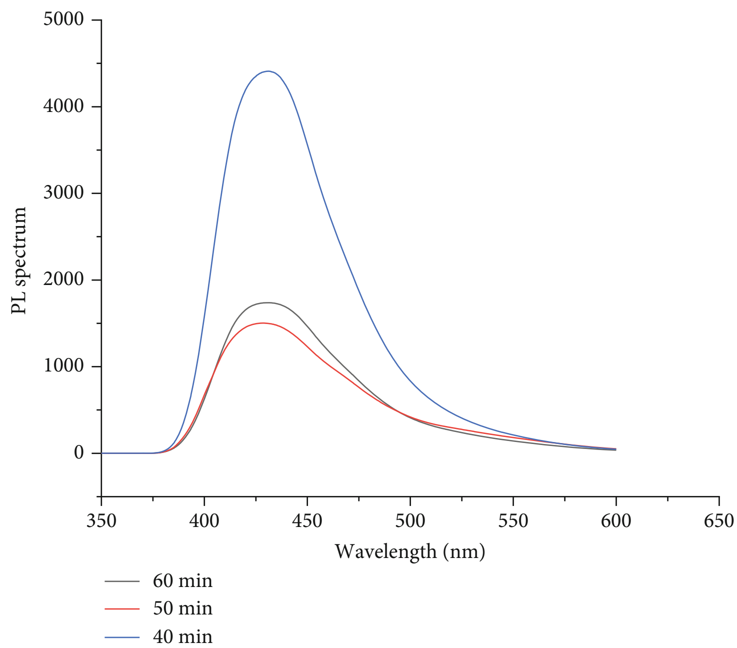


FIGURE 3: Photoluminescence spectrum of $TiO_2$ nanoparticles at different aging times at 40 min, 50 min, and 60 min.

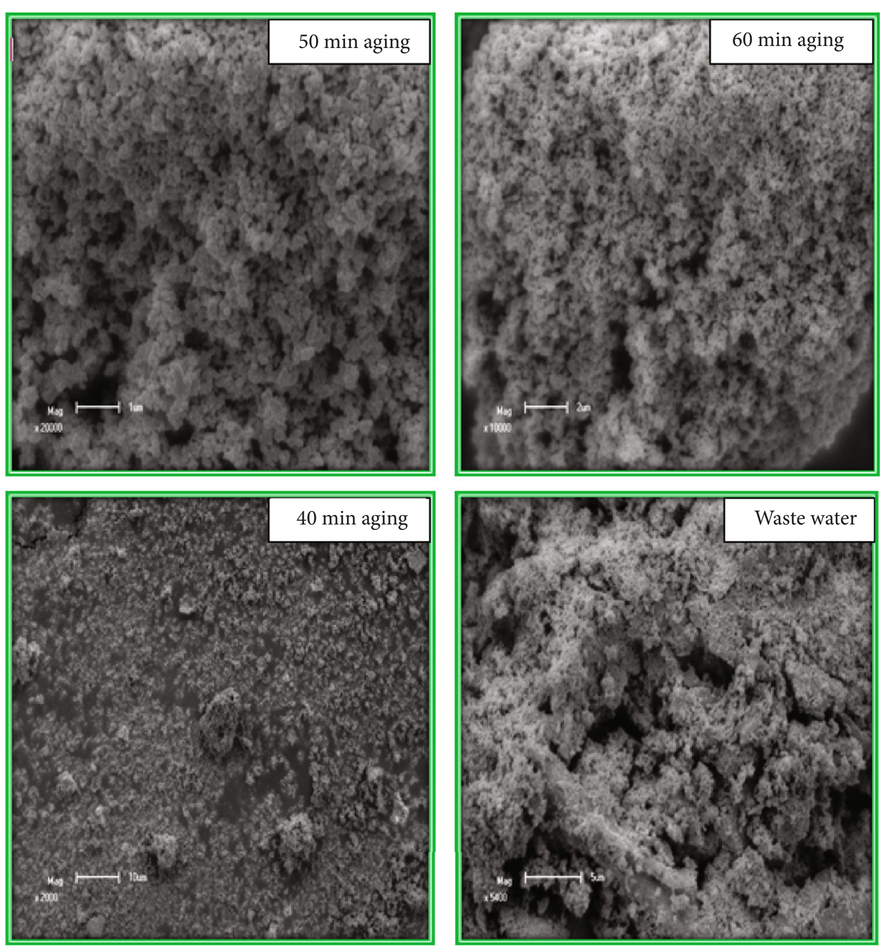


FIGURE 4: SEM analysis of $TiO_2$ nanoparticles for desalination and water treatment at different aging time at 40 min, 50 min, and 60 min.

The titanium nanoparticles were analyzed by a scanning electron microscope. The micrograph results reveal that sphere-like structure of titanium nanoparticles having 50-60 nm diameter, as explained in Figure 4. As aging time increased from 40 min to 60 min, the shape obtained confirms the pureness of water and this result is in good agreement with that previously reported [12–45].

## 4. Conclusions

In this research, we have successfully prepared nanoparticle of $TiO_2$ and its application in desalination and water treatment with related photodegradation of technologically advanced photocatalytic covering with acrylic by inserting a solution of visible light-receptive titanium dioxide nanoparticles at different aging times. We verified the possibility of solar absorber coating by sol-gel on a commercially available ITO substrate. Succeeding treatment with UV photo light occasioned on heterogeneous surface with intercalating long aging time. Our nanosheet could recuperate the fluidity upon visible light treatment. We qualified this to the photodegradation of the collected wastewater when applied visible light treatment. We contrived a device that empowered the constant departure and desalination of water mixture that was melted with organic substances that were adsorbed. It was established that the nanosheet prepared from $TiO_2$ has a potential to absorb photo light and able to recover its infuse flux in situ when applied under visible light treatment. We visualized that our nanosheet would have numerous applications, like wastewater treatment, fuel purification, and desalinating drinking water and water in industry. We also conclude that $TiO_2$ nanosheet has a wide range of uses, including wastewater treatment, fuel purification, desalination of drinking water and industrial water.

## Data Availability

The data used to support the findings of this study are included within the article.

## Disclosure

The research was performed as a part of employment of the authors from Dambi Dollo University Ethiopia.

## Conflicts of Interest

The authors declare that there are no conflicts of interest.

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