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Synthesis; Characterization and Photocatalytic Activity Studying of TiO_2

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Abstract

Preparation of TiO_2 nanoparticles (NPs) and X-ray diffraction (XRD).and scanning electron microscopy (SEM) analysis of the nanoparticles. The synthesis of TiO_2 nanoparticles was carried out consuming the sol-gel and direct precipitation methods. The TiO_2 nanoparticles were calcined for 2 hours at temperatures of 200°C. X-Ray diffraction. (XRD) and scanning electronic microscopy were used to explore the structural, morphological, and chemical aspects of produced TiO_2 nanoparticles in the second half (SEM). The range of 90 nm, the average crystallite sizes and particle sizes of catalyst nanoparticles were estimated. In this example, however, the crystallite size as determined by particle size was 50 nm. The structural analysis of TiO_2 nanoparticles using XRD patterns revealed that anatase is the predominant phase and mixed phases are present in all of them.

Keywords: TiO_2, Nanoparticle, XRD, SEM.

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Introduction

Nanotechnology is a newfangled science that has the potential to bring a wide range of new habits and better technologies for a variety of applications.

One of the main reasons for the high level of interest is because nanotechnology allows for the controlled fabrication of nanomaterials with at least one dimension of less than 100 nanometers [1-4].

The first investigations on the photoelectrochemical sterilization of microbial cells using titanium dioxide nanoparticles (TiO_2-NPs) in microbiology were published in 1985 [5-7].

Recent research [8] has focused on the prospect of employing TiO_2-NPs in oncology. Adsorption, photocatalysis, electrochemistry, optics, microelectronics, dye production, ceramics, cosmetics, gas sensors, inorganic membranes, dielectrics, and synthesis of mesoporous film coatings, as well as catalysts for environmental cleaning processes have all benefited from colloidal nanoparticle production in the modern era [9-12].

Because of their low-cost production processes, extremely single-crystalline surfaces, and new shapes, many metal oxides in nanostructured forms have piqued curiosity.

Their applications in gas sensor technology have been investigated experimentally and theoretically, and in many situations, the new devices outperform existing thin film metal oxide sensors for detecting hazardous or environmental gases [13-15]. The last ten years have seen significant changes in the field [16-18]. TiO_2 NPs exhibit a variety of physicochemical features and are thought to be low soluble and small toxicity particles [19]. According to Shi et al. [20], titanium dioxide (TiO_2) nanoparticles (NPs) are generated in enormous numbers around the world for usage in a variety of applications. Hydrolysis, drying, and calcinations are some of the methods utilized to make nano-TiO_2. Various strategies for preparing nano-TiO_2 with $TiCl_4$ have been documented in the literature [21-25].

Zhou, et al. [26] used a hydrothermal approach to synthesize anatase TiO_2 nanospindles, then used a dip-coating process to fabricate an AC/TiO_2 composite using distributed TiO_2 on the surface of activated carbon.

In compared to pure anatase TiO_2 nanospindles, the AC/TiO_2 composite has been successful in removing organic pollutants from waste water and has an outstanding degradation rate. TiO_2 was used in this research.

Experimental

Germany ethanol (CH_3CH_2OH) Sigma–Aldrich, nitric acid (HNO_3).Sigma–Aldrich, sodium hydroxide (NaOH) BDH, titanium isopropoxide (TIP) Sigma–Aldrich.

Synthesis of Titanium Dioxide

To create TiO_2 nanoparticles, researchers employed a sol gel approach [27].

4 milliliters of TIP were added drops to 50 milliliters of ethyl alcohol. In ambient conditions, the reaction was carried out in a fume hood with a magnetic stirrer. Then 10 ml of deionized water was additional to the resulting solution, drop by drop. The rate at which TIP and water were added was fixed at 10 drops in minute.

The produce solution was vaporized using a drying technique at 85°C for 4 hours to complete assimilation. After seven days, the white suspension was created. The white precipitate was then filtered and deionized water washed 3 times. Finally, TiO_2 nano powder was made by drying it for 24 hours at room temperature.



Figure 2: Synthesis Setup (Addition Process)

Characterization Methods

SEM measurements were performed on a JEOL JSM-6700. F instrument with a secondary electron detector (SE) at a 2.0 kV accelerating voltage.

The change in composition of titanium dioxide was studied using X-ray diffraction (XRD).

After centrifugation, aliquots were examined using a Perkin Elmer Lambda UV spectroscopy.

Results and Discussion

Catalysts Characterization

The TiO_2 and the AC/TiO_2 composite were characterized using Raman spectroscopy, XRD, FTIR and SEM techniques [28-29].

X-ray Diffraction Spectroscopy (XRD)

The XRD pattern of the synthesized TiO_2 is displayed in Figures 4. The average crystallite diameters (D) were calculated in nanometers using Scherrer's formula.

XRD is used to measure of graphitization. Figure 3 shows the XRD patterns of the TiO_2. The equal peaks in TiO_2 at 25.4∘, 37.7∘, 48.1∘, 53.8∘, and 62.6∘ were the diffractions of (101), (004), (200), (211), and (204) planes of anatase, respectively, and peaks at 27.5∘, 36.2 ∘ , 41.3∘, and 54.4∘ belonging to the diffraction peaks of (110), (101), (111), and (211) planes of rutile, thus indicating that the TiO_2. The average crystallite size of the TiO_2 was deliberate by Debye- Scherer formula. According to the control, the average crystallite size of the TiO_2 was 50nm.

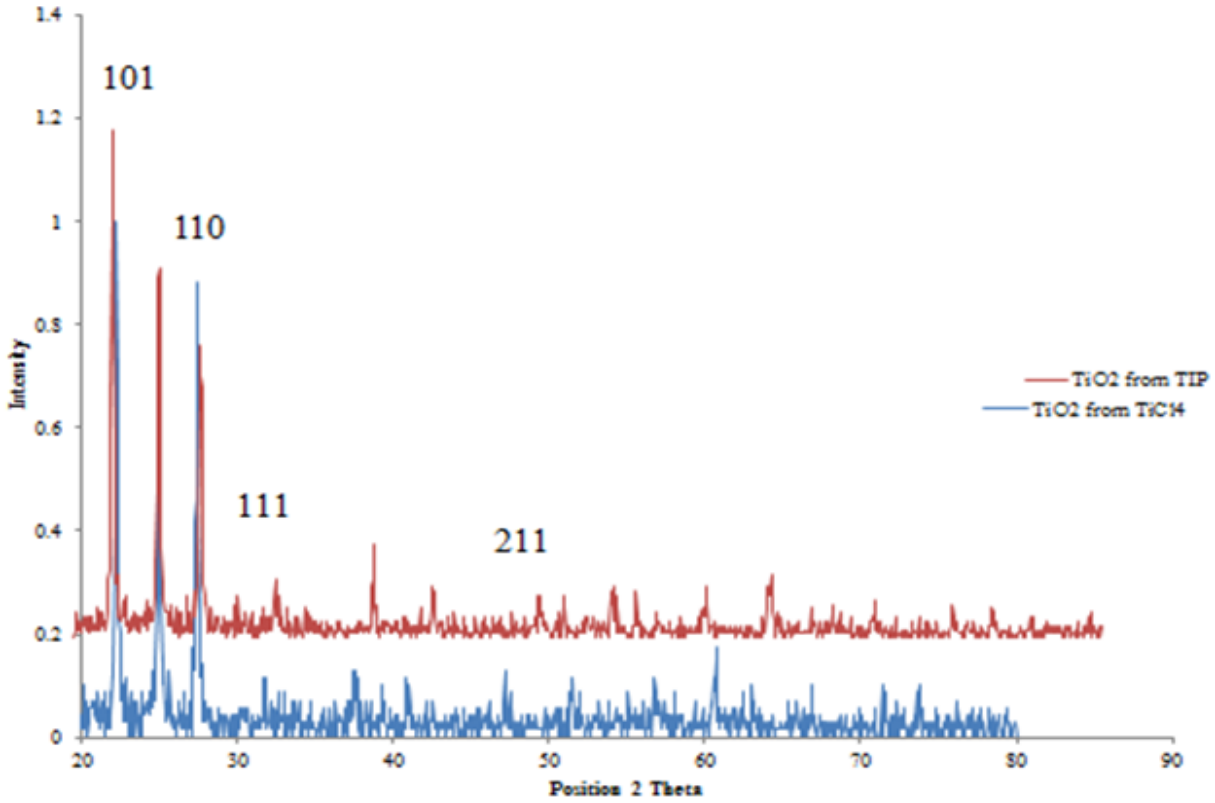
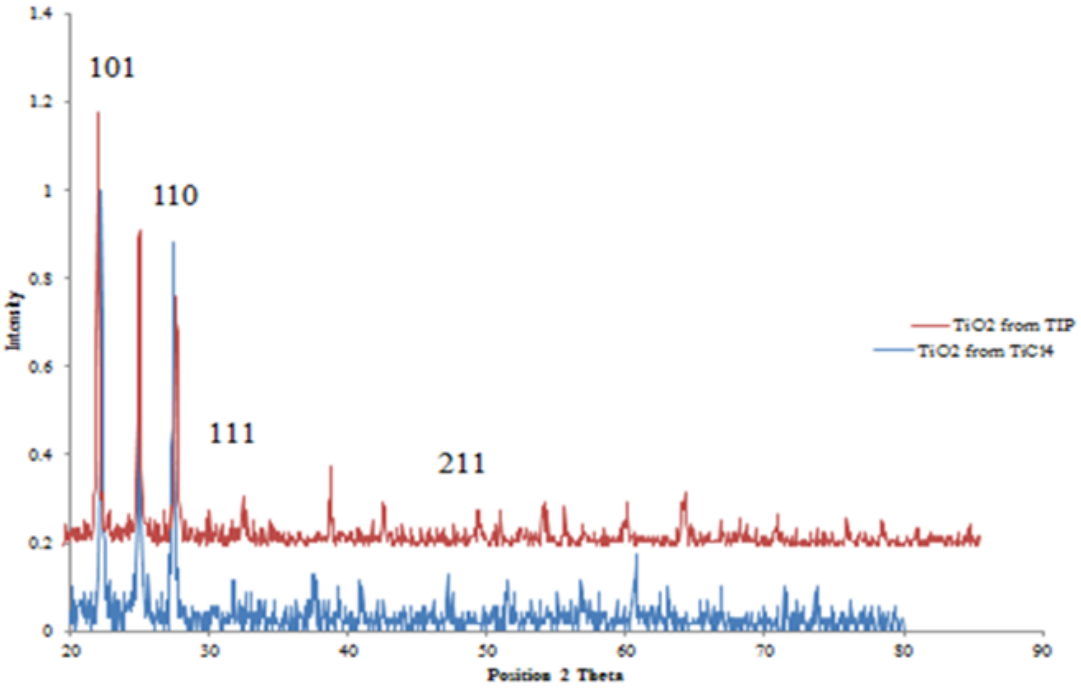


Figure 4: XRD for TiO_2 Synthesized



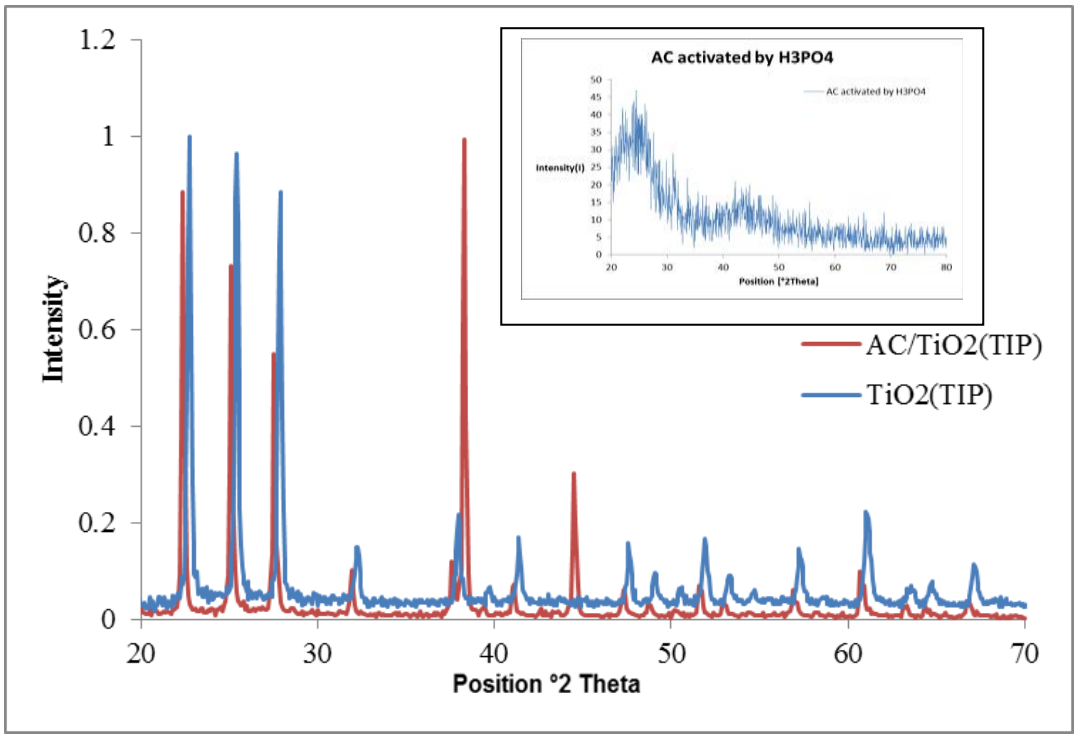


Figure 5: XRD for AC/TiO_2 (TIP) and TiO_2 (TIP)

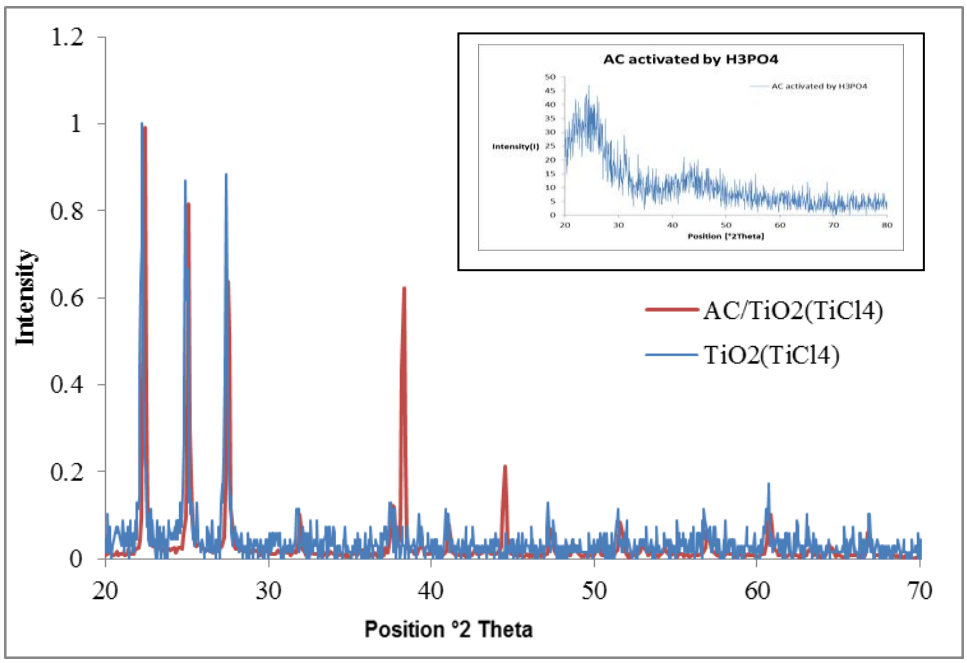


Figure 6: XRD for AC/TiO_2 ($TiCl_4$) and TiO_2 ($TiCl_4$)

The Scanning Electron Microscope (SEM)

SEM images were used to study the morphology of the AC/TiO_2 composite, and also to measure the average particle sizes. Figure 7 show the SEM images for the AC/TiO_2 (TIP) composites.

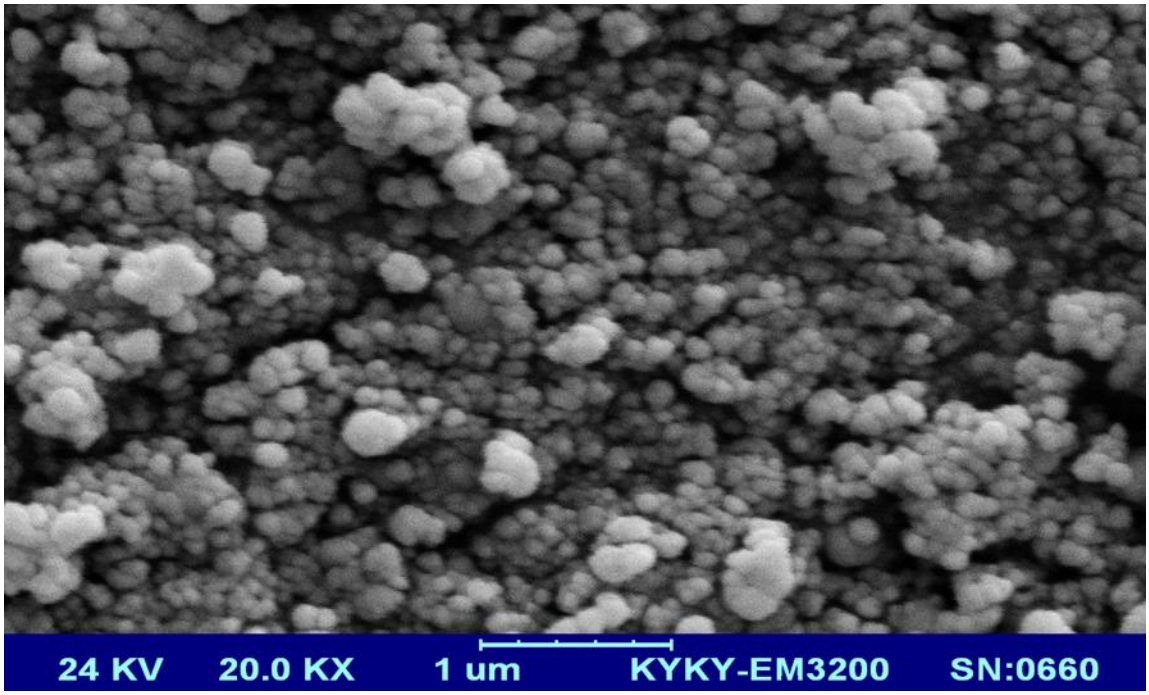


Figure 7: SEM images of AC (10%)/TiO_2 (TIP) Composite

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectra were used to detect the changes in the intensity of the peaks for TiO_2 and AC/TiO_2 composites. The spectra are shown in Figure 8.

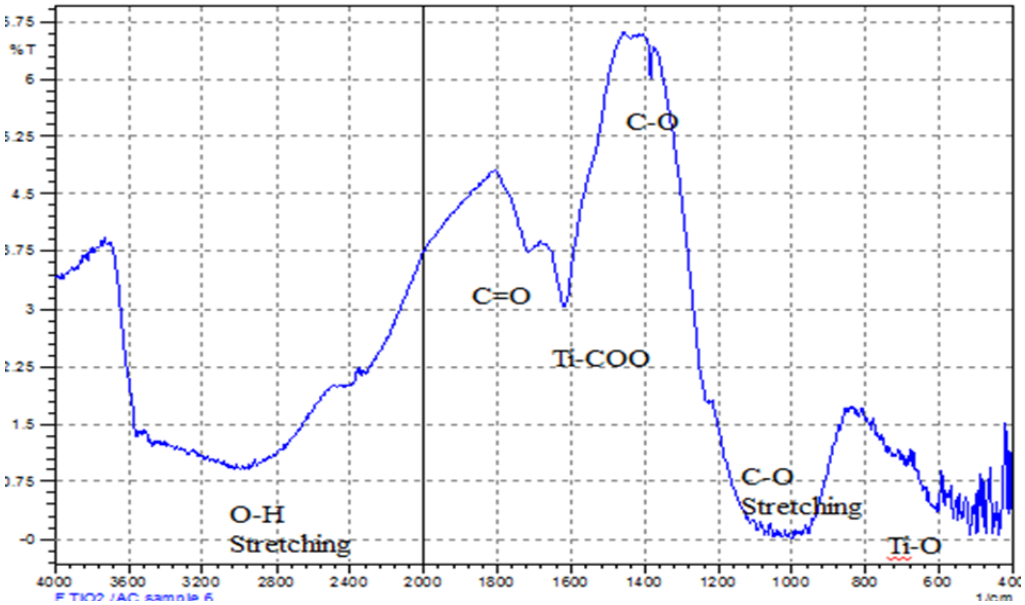


Figure 8: FTIR spectrum AC/TiO_2.

Photocatalytic Activity

The Photocatalytic activity of TiO_2 was determined by phenol decomposition in aqueous solution below an UV lamp (0.7 mW/cm2).

0.175 g TiO_2 was added to 100 mL of 60 ppm phenol aqueous solution to make the suspension solutions.

To ensure adsorption equilibrium, the suspensions were stirred in darkness for 0.5 hours before to irradiation using a magnetic stirrer.

The suspensions were sampled at regular intervals during adsorption and irradiation.

Three milliliters of the reaction mixture were taken and centrifuged for 15 minutes.

Using a syringe, the clear solution was carefully extracted and centrifuged again at the same speed and for the same period of time.

The second centrifuge was discovered to be necessary for removing tiny catalyst particles.

A UV-visible spectrophotometer was used to test the phenol's absorbance at its maximum wavelength of 269 nm after the second centrifugation.

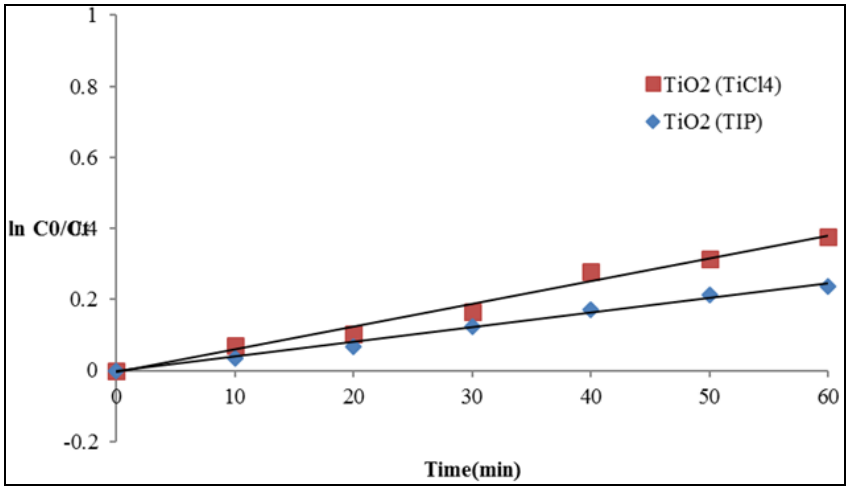


Figure 9: The Variations of LN C_o/Ct allowing to Irradiation Times at Changed TiO_2

Conclusions

Synthesis nano TiO_2 from TIP is simple and better from synthesis from $TiCl_4$ and more safety.

Photocatalytic activity of the materials was explored and it was found that TiO_2 highe photoactivity under UV-vis light irradiation.

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