



Editorial

Special Issue “Synthesis of TiO₂ Nanoparticles and Their Catalytic Activity”

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The current advances in the development of technologies for solar light utilization are largely due to the environmental and energy crisis caused by the rapid consumption of fossil fuels, and consequently, various applications have been implemented in domestic heating devices, the field of spaceflight, vehicles with clean energy, self-cleaning devices, the bio-pharmaceutical field, etc. To efficiently utilize abundant solar energy, different light harvesting technologies such as solar–thermal conversion, solar cells, solar focusing light, photocatalytic water splitting, CO₂ conversion, organic synthesis, etc., have been developed as promising alternatives. In recent decades, research on solar energy conversion has developed rapidly, especially on the use of titanium dioxide (TiO₂) as photocatalysts, resulting in a remarkable increase in energy conversion efficacy and photocatalytic performance. Besides photocatalytic energy conversion, TiO₂ can also be used in bioactive coatings for bioimplant applications to effectively promote the formation of reactive oxygen species for the enhancement of antibacterial activity. Thus, the advances in catalytic applications using TiO₂ nanomaterials could facilitate the utilization of photocatalysts in real conditions.

This Special Issue contains 10 research and review articles showcasing the latest developments in the synthesis of black TiO₂, defective TiO₂, rutile TiO₂, and TiO₂-based heterojunctions for the applications of photocatalytic water splitting, environmental remediation, antibacterial applications, and bioimplants, which could shed light on the challenges, opportunities, and research trends of TiO₂-based nanoparticles and their catalytic activity.

Eight research publications amassed in this issue showcase the work of researchers from around the globe seeking to provide fundamental insights into the synthesis and photocatalytic applications of TiO₂-based materials. To boost the photocatalytic tetracycline degradation efficiency, Hu et al. prepared Ti₂O₃@TiO₂ core–shell heterojunctions via a facile heat treatment process that led to a 2.5-fold improvement compared with the pristine Ti₂O₃ [1]. The enhanced photocatalytic activity was ascribed to the formation of the built-in electric field in the heterojunction interface, which can be regulated by altering the ratio of Ti₂O₃/TiO₂ [1]. To effectively increase the photogenerated charge carrier separation efficiency, Wang et al. presented a simple hydrothermal treatment to construct TiN@anatase-TiO₂/rutile-TiO₂ Z-type composites with boosted plasmonic effect [2]. Under visible light irradiation, the as-synthesized heterojunctions significantly enhanced the photodegradation activity of rhodamine B, thereby providing the possibility of the removal of photocatalytic pollutants using solar light [2]. In another study, Alyami reported an ultra-violet-assisted scalable method to construct TiO₂ photocatalysts with abundant oxygen vacancies for photocatalytic dye removal [3]. The defective TiO₂ with Ti³⁺ exhibited stronger visible light absorption and much higher removal efficiency of methylene blue under visible light illumination than pristine TiO₂ [3]. Similarly, Wang et al. developed B-doped g-C₃N₄/black TiO₂ Z-Scheme heterojunctions with enhanced charge separation efficiency and increased tetracycline sorption ability [4]. Heterojunctions with abundant defects and a bandgap of 2.13 eV could degrade 65% tetracycline hydrochloride in 30 min in the presence of visible light [4].



Citation: Zhou, W. Special Issue “Synthesis of TiO₂ Nanoparticles and Their Catalytic Activity”. *Nanomaterials* **2023**, *13*, 2544. <https://doi.org/10.3390/nano13182544>

Received: 29 August 2023

Accepted: 29 August 2023

Published: 12 September 2023



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Some applications in bioactive coatings have also been highlighted. Chifor et al. deposited TiO₂ nanoparticles on titanium foil together with Au/Ag nanoparticles and lysozyme for dental implants [5]. The metal-modified TiO₂ coatings demonstrated high antimicrobial activity against *M. lysodeicticus*, while the bare TiO₂ could maintain enzymatic activity [5]. Using a simple molten-salt method, Ngo et al. synthesized rutile TiO₂ microrods with uniform sizes [6]. Oxygen vacancies were generated in rutile TiO₂, leading to varied photoluminescence emission properties from the wavelength of 400 to 900 nm [6]. Hu et al. prepared Ti³⁺-doped TiO₂ nanospindles with an enhanced visible light photocatalytic activity using a facile solvothermal process [7]. The crystallinity, morphologies, and photodegradation efficiency of rhodamine B of Ti³⁺/TiO₂ were severely influenced by the amount of triethanolamine in the synthetic process [7]. Based on the reduced graphene oxide/mesoporous TiO₂ nanotube heterostructures (rGO/TiO₂), Li et al. constructed efficient charge migration paths to significantly improve photocatalytic activity [8]. With much promoted charge transfer efficacy, the rGO/TiO₂ heterojunction demonstrated decent photocatalytic H₂ evolution efficiency of ca. 933 μmol/g/h in the presence of sunlight [8].

In addition, two review articles highlighting various aspects of TiO₂-based materials in the research area of photocatalysis have also been included in this Special Issue, providing an overview of the current developments of TiO₂ nanoparticles for varied applications. Liao et al. summarized the recent progress in black TiO₂ nanomaterials, including the recently developed techniques for the preparation of black TiO₂, element doping, metal modification, heterojunction formation, and the corresponding photocatalytic applications [9]. They also outlined different techniques regarding photocatalytic water splitting and pollutant removal using black TiO₂-based nanomaterials, as well as challenges and opportunities for energy conversion [9]. To analyze the safety and complexity of Ti oxides in disinfection and bioimplants and provide useful information about residual and dark catalysis, Querebillo reviewed the advances in TiO₂ catalysis and the formation mechanism of reactive oxygen species w/o light irradiation and discussed the microbicidal effects of Ti oxides and prospects for bioimplant utilization [10].

We would like to thank all the authors and reviewers for their contributions to this Special Issue. We also hope that the publications presented here generate interest and inspiration for their designs, concepts, and conclusions and can unveil new perspectives in the field of nanomaterials and catalysis.

Conflicts of Interest: The author declares no conflict of interest.

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