Pure Sciences International Journal of Kerbala

Year:2024 Volume : 1 Issue : 2 ISSN: 6188-2789 Print 3005 -2394 Online

Inam Joudah Radhi , Saad Aziz Hassan , Nahlah Jaber Hussein , The characterization / photoreduction of ternary Pt/AgI/ZnO nanocomposites: A review , Pure Sciences International Journal of Kerbala, Vol. 1 No.2, (2024) 69-74

2024 ,Volume 1 , Issues 2 PSIJK 69-74

Pure Sciences International Journal of Kerbala

Journal Homepage:https://journals.uokerbala.edu.iq/index.php/psijk

The Characterization / Photoreduction of Ternary Pt/AgI/ZnO Nanocomposites: A review

Inam Joudah Radhi[1] , Saad Aziz Hassan[2] , Nahlah Jaber Hussein[3]

[1, 3] The department of chemistry, college of education for pure science, university of Karbala, Karbala, Iraq.
[2] The department of chemistry, faculty of education for girls' education, university of Kufa, Iraq.

P A P E R I N F O

Paper history:
Received 2 March 2024
Accepted 16 April 2024
Published 30 June 2024

Keywords:
Pt/AgI/ZnO, Photosynthesis, nanomaterials, SPR and characterization.

A B S T R A C T

Since photo-catalysis uses light energy to drive chemical processes, it is commonly considered a green technology to help us handle the more pressing environmental and energy issues facing human society. Enhancing the properties of photocatalysts has been a major focus of research and development up to now. Thanks to their remarkable stability and strong catalytic performance, noble metal–ZnO nanocomposites are garnering a lot of interest as potential candidates for catalytic applications in the future.

This research focuses on photosynthesis-inspired studies that tackle global, environmental, and sociological issues such as sustainable agriculture, maintaining the balance of ecosystems, and producing clean energy. This review study presents a thorough explanation of this new class of nanostructures and emphasizes its potential applications across multiple fields, with the goal of encouraging researchers to integrate, investigate, and use multiple new ternary systems.

1. INTRODUCTION

One of the most popular processes for producing nanomaterials is hydrothermal synthesis. In essence, it is a solution-reaction based approach. Through hydrothermal synthesis, nanomaterials can be created at room temperature or exceedingly high temperatures [1].

Photosynthesis is one of the most robust and effective cycles found in natural processes. All of life's energy sources, such as feeding, burning fossil fuels, and, more recently, the industrial synthesis of value-added compounds or bioenergy, are powered by this amazingly simple system [2,3].

Zinc oxide (ZnO) is a cheap, non-toxic catalyst that has fascinating photocatalytic potential, particularly for the removal of pollutants from water. Nevertheless, due to its low efficiency, photocorrosion, and expensive energy recovery, its application has not yet been looked into.Further, (ZnO) is one of the most commonly used benchmark standard photocatalysts in environmental applications. Nevertheless, ZnO's total photocatalytic efficacy is constrained by its wide band gap and frequently occurring photogenerated charge carrier recombination, particularly at the nanoscale [4,5].

[4], ZnO has a wide range of applications. For example, due of its high degree of biocompatibility and optical emission in the visible region, it has recently been used for biotherapeutic applications in the health industry. These qualities have been used in many medical applications, such as the treatment of cancer [6,7,8].

The textile business has a lot of detrimental effects on the environment. The following substances are released into the atmosphere: dust, sulfur, sulfur dioxide, nitrogen oxides, and volatile organic compounds [9,10].

Silver (Ag) is regarded as one of the greatest choices for dopant selection because it may generate an electrical field and increase galvanic owing to surface plasmon resonance (SPR) [11,12]. ZnO/noble metal nanoparticles were produced via the solvothermal technique. The effects of reaction time, the presence of noble metals, and the kind of noble metal (Ag or Pt) have all been studied [13].

This study's photosynthesis-based research tackles global, environmental, and socioeconomic issues such as sustainable agriculture, clean energy generation, and ecosystem balance Figure 1.

*Corresponding Author Institutional Email:
anaam.j@uokerbala.edu.iq (Inam Joudah Radhi)

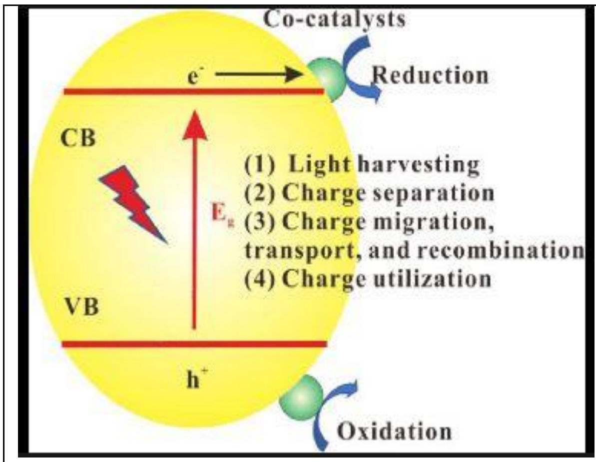

Figure 1. This figure shows the four fundamental stages of photocatalysis [11].

2.PHOTOVOLTAIC CELLS WITH HYDROTHERMAL HEATING

Hydrothermal processing, or "Hydrothermal Upgrading (HTUs)," was created by the Shell Oil Company as a method of converting biomass. The world's population is expanding and businesses are developing quickly.This causes energy demand to constantly rise. Since the industrial revolution, an over use of fossil fuels including coal, oil, and natural gas has resulted in environmental degradation. Fossil fuel combustion results in the atmospheric release of greenhouse gases, such as CO, CO2, NOx, SOx, and CH4. The greenhouse effect and global warming have been connected to these gases. This takes place because the increase in CO2 concentration that is correlated with the effect is what most people perceive to be the main cause of global warming. Unless there is a significant decrease in the quantity of carbon dioxide released into the atmosphere [14,15].

3. NANOCOMPOSITES OF NOBLE METAL/ SEMICONDUCTOR PT/AG/ZNO

Noble metals (Ag, Pt, Cu, and Au) exhibit the tiniest form of surface plasmon resonance (SPR) because their free electrons are able to freely flow through the nanomaterial. A coherent oscillation of all conduction electrons at the metal surface may occur under resonance conditions when the wavelength of the stimulated light is greater than the size of the nanoparticle [16].That is to say, when the excitation radiation and the free confined electrons oscillate at the same frequency, a phenomenon called the Localized Surface Plasmon Resonance (LSPR) is produced [1]. Ag, Pt, Pd, and Au-ZnO nanocomposites exhibit reduced electron-hole pair recombination, which can be used to improve the nano-photocatalytic characteristics of ZnO materials. This is because ZnO-based nanocomposites contain photo-catalytic holes and metal-accumulated electrons. It is possible to use (Ag, Pt, Pd, Au). The (Ag, Pt, Pd, and Au-ZnO) nanocomposites demonstrate reduced electron-hole pair recombination because ZnO-based nanocomposites comprise photo-catalytic holes and metal-accumulated electrons. Noble metal–ZnO nanocomposites have better qualities than ZnO materials.Accordingly, they might eventually take the place of ZnO materials in applications including photocatalysis, energy production, sensors, and converters. Moreover, several topologies of noble metal–ZnO nanocomposites have been described, indicating that noble metal–ZnO may find widespread application in nanotechnology [17, 18]. Numerous studies have been conducted employing tourmaline, graphene, TiO2, and noble metals including Ag, Pt, and Au to increase ZnO's photocatalytic activity. Ag nanoparticles are said to hold the excited electrons as compared to pure Ag metal, resulting in a 34% increase in photocatalytic activity. Ag nanoparticles prevent electron-hole recombination from occurring. ZnO-Ag nanocomposite materials are made by hydrothermal, solvothermal, precipitation, electrodeposition, and sol-gel processes.

The disadvantage of these procedures is that they necessitate numerous processing steps that must be followed by additional steps to remove impurities or leftovers [19,20]. In contrast to ZnO semiconductor which has a broad band gap, AgX (X = I, Br), a type of plasmonic semiconductor, has a tight band gap. This allows AgX to perform exceptionally well in photocatalysis and visible light sensitivity. As a result, AgX has garnered a lot of interest in photocatalysis [21, 22]. Ag/AgBr particles were created by Wang *et al*. using a twofold jet technique. In a different work, Lin *et al*. used a simple in situ ion exchange technique to manufacture AgI/Ag/AgBr. Additionally, when exposed to visible light, it demonstrated outstanding photocatalytic activity for the destruction of MO. AgX's properties make it a popular modification material for wide band gap semiconductors, allowing the semiconductor's light absorption edge to be shifted from the ultraviolet to the visible light area [23-25]. These days, semiconductor photocatalysis has garnered a lot of interest as a successful solution to address these challenges. Additionally, it's generally accepted that composite photocatalysts exhibit superior photocatalytic performance compared to solitary ones. Because these photocatalysts have distinct electronic energy levels, their improved photocatalytic activity can be attributed to the driving force of the internal electric field, which can increase the rate at which photo-generated electron-hole pairs separate and decrease their rate at which they recombine [26-29].

4. PHYSICOCHEMICAL PROPERTIES AND CHARACTERIZATION

Nanoparticles' physicochemical characteristics are important because they show how they interact with the environment or could interact with it under certain conditions. Depending on the intended purpose of the created nanomaterial, specific physicochemical features will take precedence over others. There will always be worries about the composition, texture, optical and electrical qualities, morphological attributes, structure, and potential reaction mechanisms in addition to the stability, reusability potential, and interface system [30,31]. When a substance is brought down to nanometric sizes, significant changes in its properties may occur. To ensure a thorough and credible investigation, these traits must be measured using trustworthy characterization techniques. The sections that follow provide a variety of intriguing ZnO-graphene nanoparticle characterization methods [32-34]. To the best of the researcher's knowledge, resistive random access memory (ReRAM) has been considered a competitive option for next-generation NVM devices. Owing to its exceptional features, which include a low threshold voltage, low power consumption, quick switching times, a simple structural design, and superior storage density, it is beneficial .Resistive switching has been seen in a wide range of materials, including complex oxides, binary metal oxides, and organic compounds. However, the complex production technology of multicomponent oxides impedes their advancement because to the difficult doping control and ReRAM integration [35].

Moreover, it is challenging to use organic materials as a function layer to improve the molecular stability and structure of the ReRAM, which results in lengthy retention and remarkable endurance [36]. Using direct current (DC) magnetron sputtering, three sets of transparent conductive ZnO/Ag/ZnO, or ZAZ, multilayer coatings were produced. Zinc (Zn) and silver (Ag) metallic targets were used for sputtering. Various analytical techniques were used to investigate the effects of the thickness of the Ag layer and the ZnO top layer on the characteristics of the ZAZ multilayer system. Using X-ray diffraction, the effects of the thicknesses of the Ag and ZnO top layers on the structural properties were investigated [37]. Materials with distinct properties at the nanoscale are generally distinct from those at the macroscopic level. Researchers are studying the special biological properties of nanoscale materials with a high volume to surface area ratio for use in a range of applications. ZnO has unusual piezoelectric, optical, and semiconducting characteristics. ZnO-NPs can be produced using a variety of physical and chemical processes, such as sol-gel, pyrolysis, solvothermal, hydrothermal, vapor deposition, laser/vapor deposition, epitaxy, and thermal evaporation**.** Despite being extremely effective, these methods have several disadvantages, like the creation of hazardous waste through chemical reactions and significant energy needs for physical operations [38]. As a result, they have received a lot of attention in the degradation of various contaminants, microorganism disinfection, carbon dioxide photoreduction, hydrogen generation, synthesis of fine chemicals, a crucial component of heterogeneous photocatalysis reactions are semiconductor materials.

Based on a survey of the literature, Ti_{O2} and ZnO are the most widely used heterogeneous photocatalysts because of their non-toxicity, low cost, and good physical and chemical stability [39]. 2,4-Dinitrophenol (DNP), a phenolic pollutant, is considered a priority pollution due to its carcinogenic properties and ability to bioaccumulate in water bodies [39]. Because DNP is extremely stable and resistant to degradation, its removal is difficult. Here, bamboo leaves were used to successfully produce Progressive Graph Convolutional Networks (Pseudo Graph Convolutional Network (PGCN)/AgI/ZnO/ CarbonQuantum Dots (CODs), a Z-scheme assisted quaternary photocatalyst, using the hydrothermal method. In order to efficiently photodegrade DNP as a harmful pollutant, the resulting heterostructure nanocomposite has a designed textural surface, improved optical and electrical characteristics, and a customizable band gap [40]. AgI has a greater negative conduction band potential than the majority of semiconductor materials.More over, when it is put onto other catalyst surfaces, it can efficiently encourage carrier separation.Consequently, it is frequently combined with other semiconductor photocatalytic materials to create innovative visible light-driven photocatalysts. Conversely, AgI's morphology is mostly described as nanoparticles, which is advantageous because it allows it to stick to the surface of substrate photocatalysts with varying topologies and form a stable heterogeneous structure. To increase their photocatalytic activity, scientists have spent the last 20 years constantly creating novel AgI-based composite photocatalysts. AgI-based composite photocatalyst research has reached a tipping point, particularly in the last two or three years Figure 2 [41].

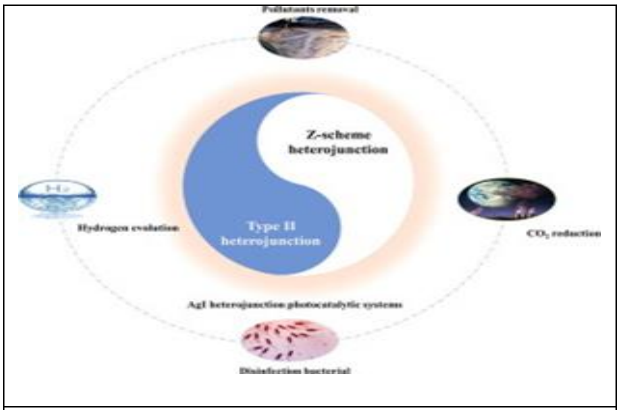

Figure 2. Explained AgI based composite photocatalysts reached a climax [41].

5. REFRENCES

1. Gan, Yong X., Ahalapitiya H. Jayatissa, Zhen Yu, Xi Chen, and Mingheng Li. "Hydrothermal synthesis of nanomaterials." *Journal of Nanomaterials* 2020 (2020): 1-3.
2. Hu, Xinjiang, Weixuan Wang, Guangyu Xie, Hui Wang, Xiaofei Tan, Qi Jin, Daixi Zhou, and Yunlin Zhao. "Ternary assembly of g-C3N4/graphene oxide sheets/BiFeO3 heterojunction with enhanced photoreduction of Cr (VI) under visible-light irradiation." *Chemosphere* 216 (2019): 733-741.
3. Janssen, Paul JD, Maya D. Lambreva, Nicolas Plumeré, Cecilia Bartolucci, Amina Antonacci, Katia Buonasera, Raoul N. Frese, Viviana Scognamiglio, and Giuseppina Rea. "Photosynthesis at the forefront of a sustainable life." *Frontiers in chemistry* 2 (2014): 36.
4. Adnan, Mohd Azam Mohd, Nurhidayatullaili Muhd Julkapli, and Sharifah Bee Abd Hamid. "Review on ZnO hybrid photocatalyst: impact on photocatalytic activities of water pollutant degradation." *Reviews in Inorganic Chemistry* 36.2 (2016): 77-104.
5. Kumar, Amit, Sunil Kumar Sharma, Gaurav Sharma, Mu Naushad, and Florian J. Stadler. "CeO2/g-C3N4/V2O5 ternary nano hetero-structures decorated with CQDs for enhanced photo-reduction capabilities under different light sources: dual Z-scheme mechanism." *Journal of Alloys and Compounds* 838 (2020): 155692.
6. Karbakhsh, A., Othman, I., Ibrahim, Z., Malek, K. and Rincón, Nancy Cervantes, et al. "Enhanced photocatalytic performance of zinc oxide nanostructures via photoirradiation hybridisation with graphene oxide for the degradation of triclosan under visible light: Synthesis, characterisation and mechanistic study." *Journal of environmental chemical engineering* 6.5 (2018): 6554-6567.
7. Salcedo, Alma Berenice Jasso. "Synthesis and performance of nanocomposites based on ZnO for the photocatalytic treatment of water contaminated with endocrin disruptor compounds." PhD diss., Université de Lorraine, 2014.
8. Lellis, Bruno, Cíntia Zani Fávaro-Polonio, João Alencar Pamphile, and Julio Cesar Polonio. "Effects of textile dyes on health and the environment and bioremediation potential of living organisms." *Biotechnology Research and Innovation* 3, no. 2 (2019): 275-290.
9. Ahmad, Khuram Shahzad, and Shaan Bibi Jaffri. "Phytosynthetic Ag doped ZnO nanoparticles: semiconducting green remediators: photocatalytic and antimicrobial potential of green nanoparticles." *Open Chemistry* 16.1 (2018): 556-570.
10. Prajapati, Pankaj Kumar, Neha Saini, Deepak Kumar Chauhan, and Kamalakannan Kailasam. "Unravelling the redox behaviour of a carbon nitride polymer-based ternary heterostructure for CO 2 photoreduction promoted by amine coupling." *Journal of Materials Chemistry A* 11, no. 1 (2023): 385-400.
11. . Muñoz-Fernandez, Lidia, et al. "Solvothermal synthesis of Ag/ZnO and Pt/ZnO nanocomposites and comparison of their photocatalytic behaviors on dyes degradation." *Advanced Powder Technology* 27.3 (2016): 983-993.
12. Liao, Guangfu, Chunxue Li, Shi-Yong Liu, Baizeng Fang, and Huaming Yang. "Z-scheme systems: From fundamental principles to characterization, synthesis, and photocatalytic fuel-conversion applications." *Physics Reports* 983 (2022): 1-41.
13. Ye, Mao, Wei Wei, Lihua Zheng, Yuze Liu, Dewei Wu, Xiangyu Gu, and Ang Wei. "Enhanced visible light photoreduction of aqueous Cr (VI) by Ag/Bi4O7/g-C3N4 nanosheets ternary metal/non-metal Z-scheme heterojunction." *Journal of hazardous materials* 365 (2019): 674-683.
14. Tekin, Kubilay, Selhan Karagöz, and Sema Bektaş. "A review of hydrothermal biomass processing." *Renewable and sustainable Energy reviews* 40 (2014): 673-687.
15. He, Xiang, and Wei-Ning Wang. "MOF-based ternary nanocomposites for better CO2 photoreduction: roles of heterojunctions and coordinatively unsaturated metal sites." *Journal of Materials Chemistry A* 6, no. 3 (2018): 932-940.
16. Mohamed, S. H. "Effects of Ag layer and ZnO top layer thicknesses on the physical properties of ZnO/Ag/Zno multilayer system." *Journal of Physics and Chemistry of Solids* 69.10 (2008): 2378-2384..
17. Saber, Nesrine Ben, Amine Mezni, Arwa Alrooqi, and Tariq Altalhi. "A review of ternary nanostructures based noble metal/semiconductor for environmental and renewable energy applications." *Journal of Materials Research and Technology* 9, no. 6 (2020): 15233-15262.
18. Liu, Hang, Jiatai Feng, and Wanqi Jie. "A review of noble metal (Pd, Ag, Pt, Au)–zinc oxide nanocomposites: synthesis, structures and applications." *Journal of Materials Science: Materials in Electronics* 28.22 (2017): 16585-16597.
19. Li, Ji, and YJ Bill Yang. "New type ternary NiAlCe layered double hydroxide photocatalyst for efficient visible-light photoreduction of CO2 into CH4." *Materials Research Express* 5, no. 2 (2018): 026204.
20. Nurtono, Tantular, Timotius Candra Kusuma, Meditha Hudandini, Widiyastuti Widiyastuti, Manabu Shimada, Suci Madhania, Siti Machmudah, Dewi Puspitasari, Sugeng Winardi, and Kusdianto Kusdianto. "Effect of Ag content in ZnO-Ag nanocomposites prepared by spray pyrolysis method for degradation of textile dye waste." In *AIP Conference Proceedings*, vol. 2219, no. 1. AIP Publishing, 2020.
21. Gong, Shuaiqi, Yanli Niu, Xuan Liu, Chen Xu, Chuncheng Chen, Thomas J. Meyer, and Zuofeng Chen. "Selective CO2 Photoreduction to Acetate at Asymmetric Ternary Bridging Sites." *ACS nano* 17, no. 5 (2023): 4922-4932.
22. Albiter, Elim, Aura S. Merlano, Elizabeth Rojas, José M. Barrera-Andrade, Ángel Salazar, and Miguel A.

Valenzuela. "Synthesis, characterization, and photocatalytic performance of ZnO–graphene nanocomposites: a review." *Journal of Composites Science* 5, no. 1 (2020): 4.

23. Hao, Xiaojie, Ling Tan, Yanqi Xu, Zelin Wang, Xian Wang, Sha Bai, Chenjun Ning, Jingwen Zhao, Yufei Zhao, and Yu-Fei Song. "Engineering active Ni sites in ternary layered double hydroxide nanosheets for a highly selective photoreduction of CO2 to CH4 under irradiation above 500 nm." *Industrial & Engineering Chemistry Research* 59, no. 7 (2020): 3008-3015.
24. Wang, Bingqing, Zirong Deng, Xianzhi Fu, and Zhaohui Li. "MoS 2/CQDs obtained by photoreduction for assembly of a ternary MoS 2/CQDs/ZnIn 2 S 4 nanocomposite for efficient photocatalytic hydrogen evolution under visible light." *Journal of Materials Chemistry A* 6, no. 40 (2018): 19735-19742.
25. Zhao, Xiaofeng, Yi Li, Chunpeng Ai, and Dianzhong Wen. "Resistive switching characteristics of Li-doped ZnO thin films based on magnetron sputtering." *Materials* 12, no. 8 (2019): 1282.
26. Lu, Jia, Huihu Wang, Yifan Dong, Fanqiang Wang, and Shijie Dong. "Plasmonic AgX nanoparticles-modified ZnO nanorod arrays and their visible-light-driven photocatalytic activity." *Chinese Journal of Catalysis* 35, no. 7 (2014): 1113-1125.
27. Hou, Yaqi, Shengyan Pu, Qingqing Shi, Sandip Mandal, Hui Ma, Shengyang Xue, Guojun Cai, and Yingchen Bai. "Ultrasonic impregnation assisted in-situ photoreduction deposition synthesis of Ag/TiO2/rGO ternary composites with synergistic enhanced photocatalytic activity." *Journal of the Taiwan Institute of Chemical Engineers* 104 (2019): 139-150.
28. Lu, Jia, Huihu Wang, Yifan Dong, Fanqiang Wang, and Shijie Dong. "Plasmonic AgX nanoparticles-modified ZnO nanorod arrays and their visible-light-driven photocatalytic activity." *Chinese Journal of Catalysis* 35, no. 7 (2014): 1113-1125.
29. Ao, Yanhui, Jiaqiu Bao, Peifang Wang, and Chao Wang. "A novel heterostructured plasmonic photocatalyst with high photocatalytic activity: Ag@ AgCl nanoparticles modified titanium phosphate nanoplates." *Journal of Alloys and Compounds* 698 (2017): 410-419.
30. Li, Xiaoxuan, Siman Fang, Lei Ge, Changcun Han, Ping Qiu, and Weilong Liu. "Synthesis of flower-like Ag/AgCl-Bi2MoO6 plasmonic photocatalysts with enhanced visible-light photocatalytic performance." *Applied* 31. Holbrey, John D., Robin D. Rogers, Rob A. Mantz, Paul C. Trulove, Violina A. Cocalia, Ann E. Visser, Jessica L. Anderson et al. "Physicochemical properties." *Ionic liquids in synthesis* 2 (2008).
31. Egharevba, Henry Omoregie. "Chemical properties of starch and its application in the food industry." *Chemical properties of starch* 9 (2019).
32. Yasuda, H., E. J. Charlson, E. M. Charlson, T. Yasuda, M. Miyama, and T. Okuno. "Dynamics of surface property change in response to changes in environmental conditions." *Langmuir* 7, no. 10 (1991): 2394-2400.
33. Fishman, M. L., B. Levaj, D. Gillespie, and R. Scorza. "Changes in the physico-chemical properties of peach fruit pectin during on-tree ripening and storage." *Journal of the American Society for Horticultural Science* 118, no. 3 (1993): 343-349.
34. Kwon, WookHyun, Tsu-Jae King Liu, and Vivek Subramanian. "Novel Technologies for Next Generation Memory." PhD diss., 2013.
35. Mohamed, S. H. "Effects of Ag layer and ZnO top layer thicknesses on the physical properties of ZnO/Ag/Zno multilayer system." *Journal of Physics and Chemistry of Solids* 69.10 (2008): 2378-2384.
36. Hameed, Safia, et al. "Greener synthesis of ZnO and Ag–ZnO nanoparticles using Silybum marianum for diverse biomedical applications." *Nanomedicine* 14.6 (2019): 655-673.
37. Carolin, C. Femina, P. Senthil Kumar, A. Saravanan, G. Janet Joshiba, and Mu Naushad. "Efficient techniques for the removal of toxic heavy metals from aquatic environment: A review." *Journal of environmental chemical engineering* 5, no. 3 (2017): 2782-2799.
38. Pirhashemi, Mahsa, and Aziz Habibi-Yangjeh. "Preparation of novel nanocomposites by deposition of Ag2WO4 and AgI over ZnO particles: efficient plasmonic visible-light-driven photocatalysts through a cascade mechanism." *Ceramics International* 43, no. 16 (2017): 13447-13460.
39. Otitoju, Oluwaferanmi B., Moses O. Alfred, Olumuyiwa O. Ogunlaja, Chidinma G. Olorunnisola, Olumide D. Olukanni, Aemere Ogunlaja, Martins O. Omorogie, and Emmanuel I. Unuabonah. "Pollution and risk assessment of phenolic compounds in drinking water sources from South-Western Nigeria." *Environmental Science and Pollution Research* (2023): 1-20.
40. Hasija, Vasudha, Anita Sudhaik, Pankaj Raizada, Ahmad Hosseini-Bandegharaei, and Pardeep Singh. "Carbon quantum dots supported AgI/ZnO/phosphorus doped graphitic carbon nitride as Z-scheme photocatalyst for efficient photodegradation of 2, 4-dinitrophenol." *Journal of Environmental Chemical Engineering* 7, no. 4 (2019): 103272
41. Wen, Xiao-Ju, Chun-Hui Shen, Zheng-Hao Fei, Dong Fang, Zong-Tang Liu, Jing-Tao Dai, and Cheng-Gang Niu. "Recent developments on AgI based heterojunction photocatalytic systems in photocatalytic application." *Chemical Engineering Journal* 383 (2020): 123083.

Arabic Abstract

بما أن التحفيز الضوئي يستخدم الطاقة الضوئية لدفع العمليات الكيميائية، فإنه يعتبر عادةً تقنية خضراء لمساعدتنا في التعامل مع القضايا البيئية والطاقة الأكثر إلحاحًا التي تواجه المجتمع البشري. لقد كان تعزيز خصائص المحفزات الضوئية محورًا رئيسيًا للبحث والتطوير حتى الآن. بفضل ثباتها الملحوظ وأدائها التحفيزي القوي، تحظى المركبات النانوية المصنوعة من المعدن النبيل وأكسيد الزنك بالكثير من الاهتمام كمرشحين محتملين للتطبيقات الحفزية في المستقبل.
يركز هذا البحث على الدراسات المستوحاة من عملية التمثيل الضوئي والتي تتناول القضايا العالمية والبيئية والاجتماعية مثل الزراعة المستدامة، والحفاظ على توازن النظم البيئية، وإنتاج الطاقة النظيفة. تقدم هذه الدراسة المراجعة شرحًا شاملاً لهذه الفئة الجديدة من الهياكل النانوية وتؤكد على تطبيقاتها المحتملة عبر مجالات متعددة، بهدف تشجيع الباحثين على دمج الأنظمة الثلاثية الجديدة المتعددة والتحقيق فيها واستخدامها.