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論文 / 著書情報
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	融合理工学 系 地球環境共創 コース	申請学位（専攻分野）： Academic Degree Requested	博士 （工学） Doctor of
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

The thesis is entitled "Modification and Functionalization Methods of Semiconductor Photocatalysts for Improved Wastewater Treatment Performance] and consists of five main chapters.

[Chapter 1: Introduction and Study Background] discusses about the issue of water pollution in which the problem is aggravated by the growing world population and the challenge of rapid industrialization. The chapter introduces several modification and functionalization methods for photocatalysts, particularly semiconductor-based photocatalysts, to improve its activity in treating wastewater. This was done by improving factors that play an important role in supporting photocatalytic pollutant degradation activity, namely: photon absorption, exciton separation, carrier diffusion, carrier transport, mass transfer, and separability.

[Chapter 2: Synthesis of N-doped Mesoporous TiO_2 by Facile One-step Solvothermal Process for Visible Light Photocatalysis], highlights the modification of TiO_2 bandgap to make it visible light active by nitrogen doping through facile solvothermal method. Based on the synthesis condition such as N doping amount, reaction time and temperature, the optimized bandgap reduction was obtained. Furthermore, under the same process, surfactant CTAB template was done to induce surface mesoporosity resulting in high specific surface area. As an outcome, the performance of synthesized N-doped mesoporous TiO_2 tested for both degradation of methylene blue and methyl orange dyes under visible light was improved as compared with synthesized undoped TiO_2 or other commercial photocatalyst. Also, the mesoporous structure resulted to the high specific surface area resulting to higher performance. The synthesized catalysts have relatively larger particle size that results to shorter settling time for faster recoverability. However, although the settling time has been shorten significantly as compared with other catalysts, it still takes hours for it to fully settle, therefore there is a need to obtain a more effective way to further improve the catalyst separability.

[Chapter 3: $Fe_3O_4/BiVO_4$ Composite Magnetic Catalyst for Simultaneous Cr (VI) Reduction and Methylene Blue Degradation] demonstrates the solution on more effective separation brought by $Fe_3O_4/BiVO_4$ as magnetic composite material. In this chapter, Fe_3O_4 was introduced for its magnetic property and high cathodic bandgap as p-type semiconductor. Whereas, $BiVO_4$ that has suitable deep band level position in relation to Fe_3O_4. The two compounds could act as tandem in the form of p-n heterojunction structure. Nanosized Fe_3O_4 crystal has been successfully synthesized to ensure the likelihood of superparamagnetic property. Fe_3O_4-grafted on $BiVO_4$ surface as the matrix composite structure leads to new bandgap property and enable induced magnetic functionalization which aid in its instantaneous separation. Moreover, the synthesized composite also comes with added performance in reducing toxic Cr (VI) heavy metal in addition to methylene blue degradation. The optimum loading ratio was determined to be that of Fe:Bi = 1:4, which come with improvement in the photocatalyst activity for simultaneous Cr(VI) photocatalytic reduction and MB degradation. The improvement came from improved charge carrier separation and the sensitization effect brought by Fe_3O_4 in efficiently trapped photoexcited electron that reduced $BiVO_4$ surface recombination. In higher Fe:Bi ratios, it was observed that without the presence of mediator, the formed heterojunction tends to form into direct charge transfer mode resulting in low overpotential problem with lower photocatalytic activity.

[Chapter 4: Si@Au (core@shell) in $CuBi_2O_4/BiVO_4$ as Plasmonic Z-scheme Photocatalyst for Effective Photocatalytic Removal of Phenol] emphasizes the development of novel plasmonic material in the form of Si@Au (core@shell) nanostructure. Au nanoparticles (NPs), Si NPs and novel Si@Au (core@shell) nanostructure material has been successfully synthesized through solution-reduction method. The synthesized Au NPs has characteristic {311} lattice fringe and average particles size of around 5 nm. Whereas the Si NPs emitted photoluminescence (PL) under UV light irradiation, indicating successful alteration towards direct bandgap by quantum confinement effect in zero-dimensional (0D) structure.

The Si@Au (core@shell) nanostructure were confirmed under HR-TEM and SAED, with the obtained LSPR spectrum conformed to the FDTD simulation pattern for the corresponding core@shell result. Moreover, FDTD-based numerical simulation observed that electric field intensity within near vicinity of the surface could be enhanced up to more than 5x that would help an increase in photogenerated charge carrier. The vanishing photoluminescence in Si@Au nanostructure indicated that the Au layer help suppress the charge recombination that was initially observed in Si NPs, suggesting efficient charge carrier utilization for photocatalytic reactions. The integration to create Si@Au/$CuBi_2O_4$ (CBO)/ $BiVO_4$ (BVO) photocatalyst and its activities in visible light for phenol degradation exhibited remarkable improvement with complete phenol degradation within 3 hours. The improvement in photocatalytic activity indicate Si@Au novel plasmonic material could serve as effective solid-state redox mediator to drive charge transfer towards Z-scheme photocatalyst system that comes with high photoredox potential in addition to charge separation.

[Chapter 5: Conclusion] outlines the general conclusions of the research, the application of research findings, and future recommendation. By utilizing the appropriate modification/functionalization that has been introduced throughout each chapter such as doping for bandgap engineering, composite heterojunction for magnetic separation, and plasmonic Z-scheme system for improved charge separation and high photoredox potential, this study managed to overcome the limiting factors, resulting to enhanced semiconductor based photocatalysts performance.

備考 : 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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