Synthesis and Application of Phosphate Based Solar-light-driven Composite Photocatalysts

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Chapter 4 Conclusion

4.1 Concluding remarks

This thesis developed two kinds of photocatalyst by different methods for the application of wastewater treatment, photodynamic therapy and water splitting.

Chapter 1 described the development and modification of photocatalysts. Besides, their applications and prospects were systemically introduced.

Chapter 2 described the synthesis, characterization and application of $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$. This composite was prepared by sol-gel method, and followed by characterizations. It showed higher UV-vis spectra, high electron-hole separation and higher photocatalytic activity for Rh B degradation and photodynamic therapy for cancer cells, compared with pure TiO_2.

Chapter 3 described the synthesis, characterization and application of $Ag/Ag_2O/BiPO_4/Bi_2WO_6$. This composite was successfully synthesized by hydrothermal method. The influences of ratio of Bi to Ag, calcination temperature, calcination time and PO_4^{3-} content were investigated on photocatalytic performance for Rh B degradation. Optimized $Ag/Ag_2O/BiPO_4/Bi_2WO_6$ composite showed higher UV-vis spectra, lower PL intensity and higher photocatalytic activity, compared with Bi_2WO_6, $BiPO_4/Bi_2WO_6$ and $Ag/Ag_2O/Bi_2WO_6$.

In summary, $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ and $Ag/Ag_2O/BiPO_4/Bi_2WO_6$ were successfully synthesized and showed extremely high photocatalytic activity and stability. Co-doping with those particles could largely inhibit the crystal grain growth, increase the specific surface area and decrease its original band gap. Moreover, formed heterostructure with consistent stability benefits the charge transfer within the hybrid structure and largely reduces the recombination of photoinduced electron-hole pairs. The synergistic effect of these factors contributes to the excellent photocatalytic performance of $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ and $Ag/Ag_2O/BiPO_4/Bi_2WO_6$. On the basis of their efficient photocatalytic ability and stability under simulated solar light, as-prepared phosphate based composite photocatalyst shows promise for practical applications in environmental purification of organic pollutants, water splitting, photodynamic therapy and even disinfection of bacteria in future. In conclusion, fabricating phosphate based composite photocatalysts was a successful strategy for developing efficient solar-light-driven photocatalysts, as the structures of PO_4^{3-} in those composite could act as the reusable active sites for chemical reactions.

4.2 Future prospects

In further research, in order to systemically investigate the photocytoxicity for cancer cells, other cancer cells, such as MG63 could be studied by using $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ photocatalyst. To further improve the stability and biocompatibility, PEG and BSA could be used to modify $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ particles. Besides, $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ photocatalyst could be applied for bacterial disinfection, due to its enhanced photocatalytic activity.

In addition, $Ag/Ag_2O/BiPO_4/Bi_2WO_6$ would be further systemically investigated for the hydrogen and oxygen generation. The influence of different solvent, dosage, time, and light intensity should be discussed on the photocatalytic water splitting. Also, the possibility of photocatalytic water splitting by $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ photocatalyst need to be further studied, in comparison with $Ag/Ag_2O/BiPO_4/Bi_2WO_6$ photocatalyst.

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List of publications and awards

Publications:

1. Xiaohong Hu, Qi Zhu, Xinlong Wang, Naoki Kawazoe and Yingnan Yang, Nonmetal–metal–semiconductor-promoted $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ photocatalyst with superior photocatalytic activity and stability, J. Mater. Chem. A, 3 (2015) 17858-17865. IF: 8.262

2. Xiaohong Hu, Zhibin Gu, Qi Zhu, Nan Zhang, Dawei Li and Yingnan Yang, Wastewater treatment by sonophotocatalysis using PEG modified TiO_2 film in a circular photocatalytic-ultrasonic system, Ultrasonics Sonochemistry, 36 (2017) 301-308. IF: 4.556

3. Qi Zhu[1], Xiaohong Hu[1], Mishma S. Stanislaus, Nan Zhang, Ruida Xiao, Na Liu and Yingnan Yang, A novel $P/Ag/Ag_2O/Ag_3PO_4/TiO_2$ composite film for water purification and antibacterial application under solar light irradiation ([1] These authors contributed equally to this work.), Science of the Total Environment, 577 (2017) 236-244. IF: 3.976

4. Xinlong Wang, Xiaohong Hu, Jingchao Li, Adriana C. Mulero Russe, Naoki Kawazoe, Yingnan Yang and Guoping Chen, Influence of cell size on cellular uptake of gold nanoparticles, Biomater. Sci., 4 (2016) 970–978. IF: 3.614

5. Xinlong Wang, Xiaohong Hu, Naoki Kawazoe, Yingnan Yang and Guoping Chen, Manipulating cell nanomechanics using micropatterned surfaces, Advanced Functional Materials, 26 (2016)7634–7643. IF: 11.38

6. Xinlong Wang, Xiaohong Hu, Ida Dulinska-Molak, Naoki Kawazoe, Yingnan Yang and Guoping Chen, "Discriminating the independent influence of cell adhesion and spreading area on stem cell fate determination using micropatterned surfaces" Scientific Reports, 6 (2016) 28708. IF:

5.228

7. Xinlong Wang, Yingjun Yang, Xiaohong Hu, Naoki Kawazoe, Yingnan Yang and Guoping Chen, Morphological and mechanical properties of osteosarcoma microenvironment cells explored by atomic force microscopy, Analytical Sciences, 32 (2016) 1172-1182. IF: 1.174

8. Nan Zhang, Silvia Mishma Stanislaus, Xiaohong Hu, Chengyu Zhao, Qi Zhu, Dawei Li and Yingnan Yang Strategy of mitigating ammonium-rich waste inhibition on anaerobic digestion by using illuminated bio-zeolite fixed-bed process, Bioresource Technology, 222 (2016) 59-65. IF: 4.932

9. Yingnan Yang, Qi Zhu, Dawei Li and Xiaohong Hu, Degradation of rhodamine B by highly efficient photocatalyst TiO_2-Ag/Ag^+ under simulated sunlight irradiation, Advanced Materials Research, 1051 (2014) 112-116. IF: 0.23

10. Hanying Zheng, Dawei Li, Mishma S. Stanislaus, Nan Zhang, Qi Zhu, Xiaohong Hu and Yingnan Yang, Development of a bio-zeolite fixed-bed bioreactor for mitigating ammonia inhibition of anaerobic digestion with extremely high ammonium concentration livestock waste, Chemical Engineering Journal, 280 (2015) 106–114. IF: 5.310

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2. Best poster design award, International agricultural ESD symposium. November 18^{th}-19^{th}, 2016, Tsukuba, Japan.

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