*Proceedings of the 10th World Congress on New Technologies (NewTech'24)*
*Barcelona, Spain - August 25-27, 2024*
*Paper No. ICEPR 115*
*DOI: 10.11159/icepr24.115*

# Sn(IV) porphyrin-Incorporated Metal Oxide Nanomaterials for Visible Light-Active Photocatalytic Water Remediation

**Nirmal Kumar Shee, Hee-Joon Kim**
Kumoh National Institute of Technology
61 Daehak-ro, Gumi, Republic of Korea
nirmalshee@gmail.com; hjk@kumoh.ac.kr

## Extended Abstract

With the increasing development of civilization and industrialization, environmental pollution has become a serious problem affecting ecosystems, biodiversity, and human health worldwide. This has led to increasing scientific efforts to develop strategies for environmental remediation by wastewater treatment in the environmental and research fields. Undoubtedly, advanced oxidation processes (AOPs) are the most promising techniques for the remediation of wastewater due to their simple operation, low cost, and high efficiency in degrading hazardous pollutants to less-toxic $CO_2$ and $H_2O$ without the generation of secondary pollution. In AOPs, light absorption and ensuing electron transfer are the key factors for obtaining photocatalysts with efficient solar energy conversion.

A visible-light-active photocatalyst, SnP/AA@$TiO_2$, was fabricated by utilizing the coordination chemistry between the axial hydroxo-ligand in the Sn(IV) porphyrin complex (SnP) and adipic acid (AA) on the surface of $TiO_2$ nanoparticles. The SnP center was strongly bonded to the surface of the $TiO_2$ nanoparticles via the adipic acid linkage in SnP/AA@$TiO_2$. SnP/AA@$TiO_2$ exhibited remarkably enhanced photocatalytic activity toward the degradation of rhodamine B dye (RhB) in aqueous solution under visible-light irradiation. The RhB degradation efficiency of SnP/AA@$TiO_2$ was 95% within 80 min, with a rate constant of 0.0366 $min^{-1}$. The high degradation efficiency, low catalyst loading, and high reusability make SnP-anchored photocatalysts more efficient than other photocatalysts, such as $TiO_2$ and SnP@$TiO_2$.

Two hybrid composite photocatalysts, denoted as SnP/AA@ZnO and SnP@ZnO, were also fabricated by a reaction of SnP and ZnO with and without pretreatment of adipic acid (AA), respectively. SnP/AA@ZnO exhibited largely enhanced photocatalytic activities for the degradation of anionic amaranth (AM) dye under a visible light irradiation, compared to SnP, ZnO, and SnP@ZnO. The degradation efficiency of AM by SnP/AA@ZnO was 95% within 60 min at a rate constant of 0.048 $min^{-1}$.

Finally, SnP/SA@$Al_2O_3$ and SnP@$Al_2O_3$ were synthesized by the reaction of $Al_2O_3$ and Sn(IV) porphyrin complex with and without succinic acid (SA) pretreatment, respectively. The SA bridging anchoring groups hindered the dissociation of SnP from SnP@$Al_2O_3$ during photodegradation. Therefore, the strong association between $Al_2O_3$ and SnP via SA connections not only intensified the quantity of SnP on the surface of $Al_2O_3$ but also accelerated electron movement from the excited SnP molecules to the conduction band of $Al_2O_3$. The aforementioned mechanism demonstrates a significant improvement in the catalytic photodegradation of methylene blue (MB) dye for SnP/SA@$Al_2O_3$ compared to SnP, $Al_2O_3$, and SnP@$Al_2O_3$ under visible-light irradiation. Within 90 min of using SnP/SA@$Al_2O_3$ at a rate of 0.0406 $min^{-1}$, the photodegradation capacity of MB was found to be 98 %. The synergistic effect between $Al_2O_3$ and SnP improved the catalytic efficiency of SnP/SA@$Al_2O_3$ compared to that of both SnP and $Al_2O_3$.

This series of studies is useful for developing visible light-activated photocatalytic systems using porphyrin-incorporated metal oxide photocatalysts in advanced oxidation processes and is important for expanding water treatment applications.