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Impact of Carbon Content in Single-Wall Carbon Nanotube-Titanium Dioxide Composites Interfacial Modulation and Catalytic Behavior

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Advanced oxidation processes driven by natural sunlight are the key to the next generation of water treatment technologies. Photocatalysis using semiconductor materials constitutes a promising approach to degrade organic contaminants in wastewater with minimal generation of secondary pollutants. In this scenario, carbon-based nanomaterials have emerged as promising modifying co-catalysts. The incorporation of the carbon structure manages to enhance the photocatalytic activity under visible light and the overall yield of the reaction. The improved behavior is attributed to the adsorption behavior associated with this type of nanostructures and the newly developed highly-extended heterojunction. More specifically, single-walled carbon nanotubes (SWCNTs) have been anticipated as superior modifiers to enhanced the photocatalytic performance of catalysts like TiO2. However, the characterization of the synthesized photocatalysts unveiled intriguing interfacial phenomena directly associated with the presence of important electronic effects at the interface. With these premises, this study presents a comprehensive investigation into the effect of the quantitative modification of commercial titanium dioxide - P25 - using four distinct ratios of single-walled carbon nanotubes (SWCNTs) 5, 10, 20, and 30 % w/w. Physicochemical characterization revealed a porosity-constrained material with high crystallinity and well-disperse titania-carbon phases. In particular, XPS analysis suggests augmented electron-hole mobility at the carbon/oxide interface, which was also confirmed by RAMAN spectroscopy. The photocatalytic performance was assessed for Rhodamine-B (RhB) removal. Overall, complete degradation was achieved promptly under visible-light exposure. These promising results are attributed to intrinsic physicochemical alterations at the formed heterojunction structures and the composite's dual-role capability of simultaneous adsorption and photodegradation of RhB. Notably, the induced structural features are in correspondence with the composite's potential for improved photocatalytic performance. These findings validate our initial hypothesis and underscore the crucial importance of thoughtful design in synthesizing photocatalytic materials, particularly for applications aimed at environmental remediation.

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