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# Special issue on "Ultrasound meets photocatalysis: recent trends in photocatalyst synthesis, hybrid processes, and piezo-enhanced strategies"

The Special Issue titled *"Ultrasound meets Photocatalysis: Recent Trends in Photocatalyst Synthesis, Hybrid Processes, and Piezo-Enhanced Strategies"* presents a thorough examination of the innovative intersection between ultrasound technology and photocatalysis. This convergence is explored across various domains, including wastewater treatment, air purification, water splitting and $CO_2$ reduction, addressing the common challenges of limited reaction rates and potential catalyst deactivation in traditional photocatalytic methods.

This special issue serves as a remarkable confluence of research on the intersection of ultrasound technology and photocatalysis. It highlights significant advancements in photocatalyst synthesis and explores innovative methods for enhancing photocatalytic efficiency through hybrid processes and piezo-enhanced strategies. The issue encompasses eleven original contributions and three reviews demonstrating the practical applications of these advancements in environmental remediation and energy conversion.

The synthesis of new photocatalysts, examined in several articles, reveals the potential of ultrasonic techniques in creating more efficient and sustainable materials. Furthermore, the exploration of hybrid processes in this issue underscores the synergy between ultrasonic waves and photocatalysis. These studies illustrate how combining these technologies can lead to enhanced reaction rates, improved degradation of pollutants, and efficient energy conversion, thereby addressing some of the most pressing environmental challenges of our time. These advancements not only contribute to the fundamental understanding of photocatalytic mechanisms but also open avenues for industrial applications.

Overall, this special issue represents a significant milestone in the field, offering a comprehensive overview of current trends and future directions in the integration of ultrasonics and photocatalysis. It is a valuable resource for researchers, engineers, and practitioners looking to explore innovative solutions for sustainable technology development.

Central to this issue is the exploration of ultrasound-assisted synthesis of photocatalysts. Contributions from researchers like Constantinou, Dimitratos, and colleagues [1] emphasize the criticality of reactor setup in scaling up these processes. The issue also highlights the effectiveness of sonication in achieving controlled deposition during the synthesis of composite materials and heterojunctions. For example, Djellabi and colleagues [2] demonstrate how ultrasound-assisted methods outperform other techniques in the dispersion of g-$C_3N_4$ on activated carbon, leading to enhanced photocatalytic pollutant oxidation. Moreover, Zhai et al. [3] proved how the combination of ultrasound and surfactants can promote the loading concentration of $MoS_2$ in photocatalytic coatings.

Despite its benefits, the limitations of ultrasound-based syntheses are critically analyzed. Verbruggen and colleagues [4], for instance, challenge the purported benefits of sonochemical treatment in generating defects in $TiO_2$ powders, suggesting that increased optical absorption may instead result from probe erosion.

The Special Issue also delves into the realm of hybrid processes, where ultrasound and light irradiation are combined to enhance photocatalytic performance. The work of Jeon, Raghu, and their team [5] on $InVO_4/In_2S_3$ heterostructures exemplifies this, showing their efficiency as sonophotocatalysts in degrading pesticides. Further, the research by Sarvothaman et al. [6] illustrates how acoustic cavitation can be optimized to promote the photocatalytic degradation of challenging hydrophilic pollutants like phenols.

Exploring the interplay of photocatalyst properties in these processes, researchers like Neppolian and coauthors [7] investigate combinations like a MOF (Cu-BTC) with zinc tungstate for improved degradation of tetracycline, attributing their success to the formation of an S-scheme heterojunction. Similarly, the study by Zhang et al. [8] on rare earth doped BiOCl underscores the synergistic effects in sonophotocatalytic activities.

A unique angle is presented by Sadeghi Rad et al. [9], who show that also sonocatalytic reactions can be enhanced by light irradiation, using materials like CoCr layered double hydroxide (LDH) combined with graphene oxides.

The emerging field of piezo-enhanced photocatalysis is also a significant focus. Contributions from Guo, Wu, and coauthors [10] review the advancements in Bi-based materials as effective photo- and piezocatalysts. Studies such as those by Moan et al. [11] and Wang et al. [12] further illustrate the benefits of forming heterojunctions in piezo-photocatalysts, leading to substantial improvements in processes like water splitting and pollutant degradation. Zhu et al. [13] enhanced $CO_2$ reduction using $Au_{25}$(p-MBA)$_{18}$ nanocluster-modified red graphitic carbon nitride (RCN), exploiting the piezoelectric effect and Schottky junction to prevent recombination, resulting in a CO production rate more than triple that of pristine RCN.

The issue is rounded off with a comprehensive review by Li et al. [14], covering the main applications of ultrasound in photocatalysis over the past five years, offering valuable insights into this evolving field.

In conclusion, this Special Issue acknowledges the instrumental contributions of Prof. Muthupandian Ashokkumar, the editor-in-chief, as well as the support of Elsevier staff, particularly Ms. Stella Duo, in bringing together this compilation of cutting-edge research at the nexus of ultrasound technology and photocatalysis.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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