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Development of BiFeO3-based piezo-photocatalyst nanocomposites for the degradation of organic pollutants

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Water scarcity poses as a critical global challenge, threatening human survival and environmental well-being. Industrial activities, notably the release of organic compounds such as dyes, exacerbate water pollution, underscoring the urgency for effective effluent treatment solutions. This study delves into the development of heterogeneous piezo-photocatalysts via mechanical synthesis, leveraging the properties of BiFeO3 (Bismuth Ferrite, BFO) nanoparticles. We explore the synthesis of piezo-photocatalysts through cryomilling technique, which involve milling materials at very low temperatures using liquid nitrogen as coolant. This process helps produce nanostructured ceramic powders with unique properties suitable for the degradation of organic pollutants. Additionally, heterojunctions with Magnetite nanoparticles are created to possible enhance the catalytic performance by preventing charge recombination and allow the magnetic recovering of the piezo-photocatalytic composite. Employing advanced characterization techniques including Scanning Electron Microscopy, Kelvin Probe Microscopy, and X-ray diffraction, we analyzed the physical, chemical, structural and efficiency properties of the synthesized composites. The use of cryomilling in the synthesis of BFO nanoparticles was able to improve the degradation of Methylene Blue (MB) from more than 300 min to 180 min. The heterojunction of BFO and Magnetite synthesized by cryomilling, in turn, was able to reduce the degradation time even more, reaching 80 min. Furthermore, the use of mechanical excitation associated with visible light irradiation, over BFO-Magnetite composites, on the degradation process (piezo-photocatalysis) were able reduce the time required for the full degradation of MB by another 15%. These impressive improvement of the degradation of MB could be addressed by the nanostructuration promoted by cryomilling process that increasing the BFO surface area, induced the creation of dislocation defects and changed its of surface potential. Also, the creation of heterojunction with Magnetite were responsible for the reduction of electron-hole recombination, which allied to the use of mechanical excitation, in piezocatalysis, reduced even more the degradation time of MB. In this sense piezo-photocatalysis assays demonstrated the great potential of BiFeO3-based nanocomposites, synthesized by cryomilling, for wastewater treatment. Through this rigorous assessment, we unveil the efficiency of these catalysts in degrading organic compounds, thereby preparing the ground for transformative advancements in water treatment technologies.