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Editorial

Editorial: Special Issue on “Emerging Trends in TiO_2 Photocatalysis and Applications”

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It is not an exaggerated fact that the semiconductor titanium dioxide (TiO_2) has been evolved as a prototypical material to understand the photocatalytic process and has been demonstrated for various photocatalytic applications such as pollutants degradation, water splitting, heavy metal reduction, CO_2 conversion, N_2 fixation, bacterial disinfection, etc., as depicted in Figure 1. [1,2] The rigorous photocatalytic studies over TiO_2 have paved ways to understand the various chemical processes involved and physical parameters (optical and electrical) required to design and construct diverse photocatalytic systems. [3,4] Accordingly, it has been realized that an effective photocatalyst should have ideal band edge potential, narrow band gap energy, reduced charge recombination, enhanced charge separation, improved interfacial charge transfer, surface-rich catalytic sites, etc. These studies further highlighted that single component catalysts may not be good enough to achieve the required/enhanced photocatalytic process. As a result, many strategies have been developed to design a variety of photocatalytic systems, which include doping, composite formation, sensitization, co-catalyst loading, etc. [5] The doping strategy includes cationic and anionic doping, where it is found that the essential purposeof doping is to tune the band gap energy of the photocatalyst by introducing the new energy levels of the doped elements underneath the conduction band (CB) and above the valence band (VB) of the semiconductor photocatalyst, respectively. On the other hand, the composite formation serves in multiple ways to almost meet all the requirements to achieve a quantum efficient photocatalytic process. The basis of composite formation is found to redesign the charge transport kinetics in the bulk and surface/interface of the integrated photocatalyst systems. These composite systems generally include p-n heterojunction, Z-scheme, etc. Similarly, the mechanism of sensitizing the photocatalysts includes the integration of plasmonic metal nanoparticles, carbon-based materials, 2D materials, quantum dots, and metal organic frameworks to enhance their optical absorption, electrical transportation properties, etc. [6] Interestingly, the co-catalyst loading serves as an ‘*engineered-catalytic-site*’ for the specific redox process to achieve the selective photocatalytic reactions. Furthermore, the unique systems, such as ferroelectric-based photocatalysts, are found to be more interesting as they are governed by their inherent internal electrical field and surface polarization properties. For instance, the ferroelectric properties intrinsically facilitate the adsorption of the surrounding molecules, carrier separation, and interfacial charge transfer via band bending phenomenon, etc. Similarly, the influence of defects in photocatalysis has been well studied over TiO_2, where the concepts of “self-doping”, “oxygen vacancy”, “colored TiO_2”, etc. have been well addressed in TiO_2photocatalysts.

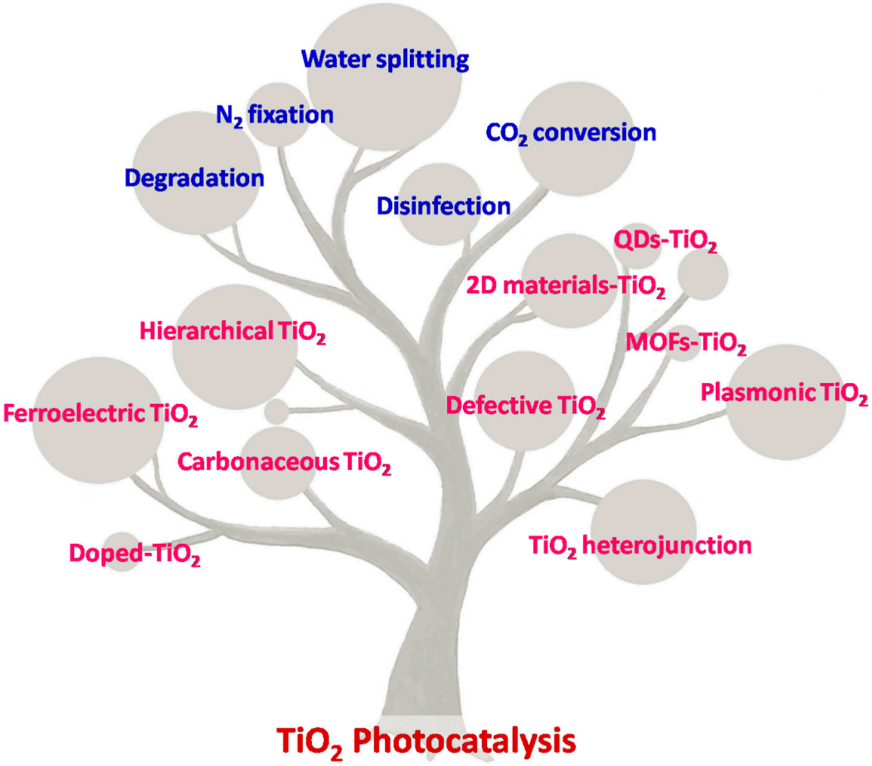

Figure 1. Overview of TiO_2-based various photocatalytic systems and their applications.

Towards highlighting the above mentioned diversities in TiO_2 photocatalysis, there have been many interesting research works on TiO_2, involving material designs for various photocatalytic applications published in this Special Issue. These material systems include TiO_2 QDs@g-C_3N_4 p-n junction, [7] oxygen defective TiO_2 nanorod array, [8] TiO_2/N-doped graphene QDs, [9] TiO_2/HKUST-1, [10] TiO_2-Carbon composite, [11] Ru-Ti oxide, [12] TiO_2 coated porous glass fiber cloth, [13] Ag/Fe_3O_4/TiO_2 nanofibers, [14] Pd-doped TiO_2, [15] N-doped TiO_2, [16] C/N/S-doped TiO_2, [17] Mo/W co-doped TiO_2, [18] Fe-doped TiO_2, [19] N-doped graphene QDs-TiO_2, [20] Nd-doped TiO_2, [21] Cu-doped TiO_2 thin film, [22] surface engineered TiO_2, [23] etc., for various photocatalytic applications, such as the degradations of a variety of pollutants, [24–30] biomass reforming, [10] heavy metal reduction, [14] and bacterial disinfections, [22] etc. In addition to these original research papers, some excellent review papers have also been published in this Special Issue, focusing on the various TiO_2-based photocatalytic systems and their mechanisms and applications. [1–6] To this end, it is highlighted that future works in TiO_2 should involve developing new material systems based on TiO_2. For instance, instead of doping N into TiO_2, the composition/phase tunable Ti oxy-nitride systems should be developed and so should the Ti oxy-phosphates, oxy-sulfurs, oxy-carbons, etc. From application perspectives, TiO_2 should be investigated for its photocatalytic efficiencies towards the production of H_2/O_2 from atmospheric vapor, dark-photocatalytic activities, hydrogen storage, biodiesel productions, etc. However, the research should also be continued on bare TiO_2 to achieve an in depth understanding of the photocatalytic mechanisms towards finding new photocatalytic applications.

Conflicts of Interest: The authors declare no conflict of interest.

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