2021「中技社科技獎學金」

2021 CTCI Foundation Science and Technology Scholarship

境外生研究獎學金

Research Scholarship for International Graduate Students

Nanoengineered Synthesis and Characterizations of Multifunctional Photo(electro)catalytic Systems for Sustainable Environmental and Energy Applications

用於可持續環境和能源應用的多功能光（電）催化系統的納米工程合成和表徵

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Abstract

The rational design and development of environmentally sustainable photocatalysts are of great interest among researchers working in various fields, including energy production and solar-energy conversion applications. Advanced oxidation processes (AOPs) via semiconductor photocatalysis got significant attention in solar energy conversion due to their highly simplified processing methods, reusability, and sustainability. The rational designing of photocatalytic nanocomposites via band engineering would enhance the solar-light harvesting, excellent charge separation, lower recombination rate and high photocatalytic efficiency. In this perspective, the various novel hybrid semiconductor-nanocomposites such as P90–TiO_2/g-C_3N_4, α-Fe_2O_3–NCs@CN-SAF, and $Bi_xFe_{1-x}VO_4$/SCN were successfully synthesized using pristine/modified g-C_3N_4 as a base material for the environmental remediation & energy applications.

Research focus

Research goals & Applications

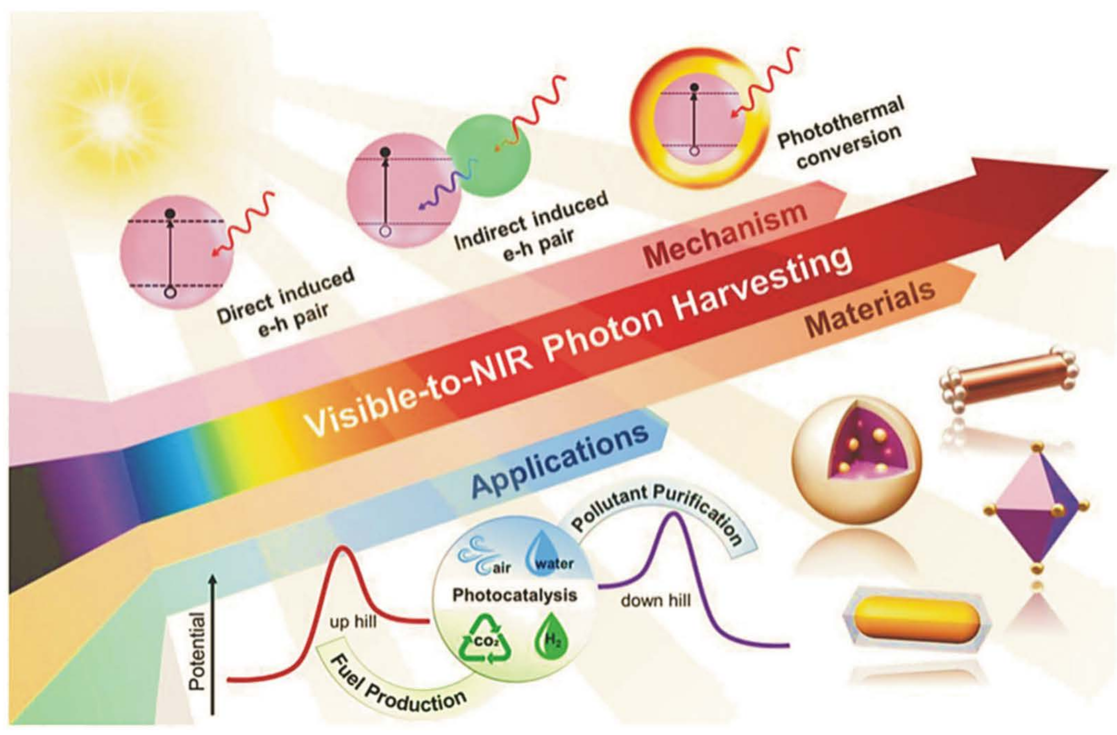


Fig. 1 Schematic representation of the mechanisms and applications of the visible-NIR-driven photocatalytic system.

Preparation procedures

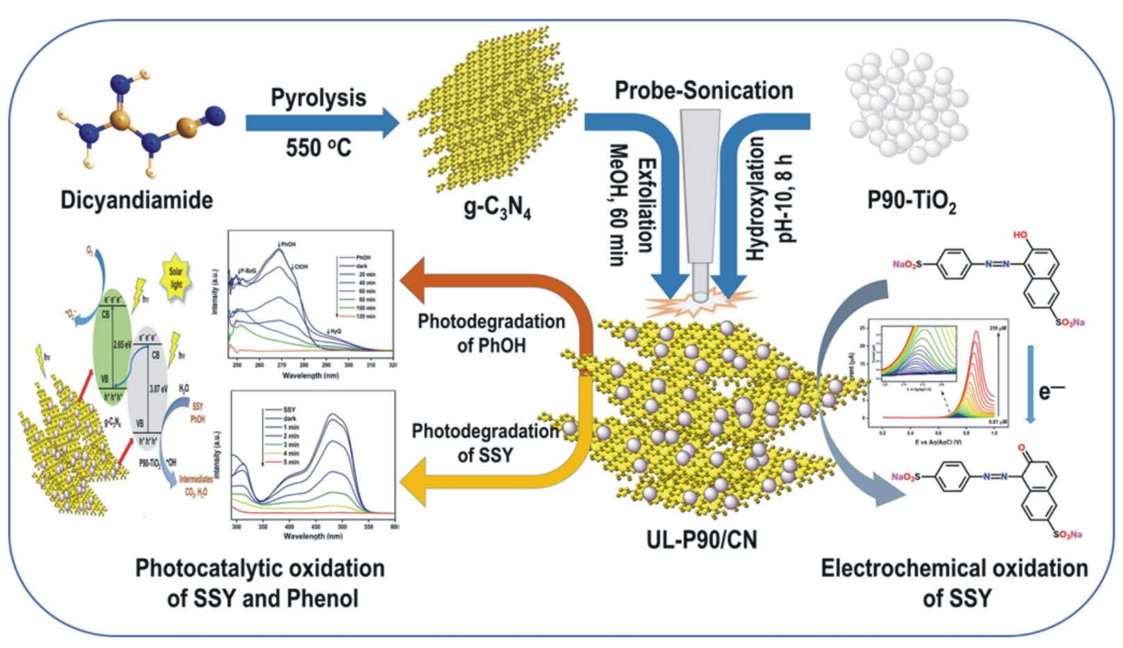
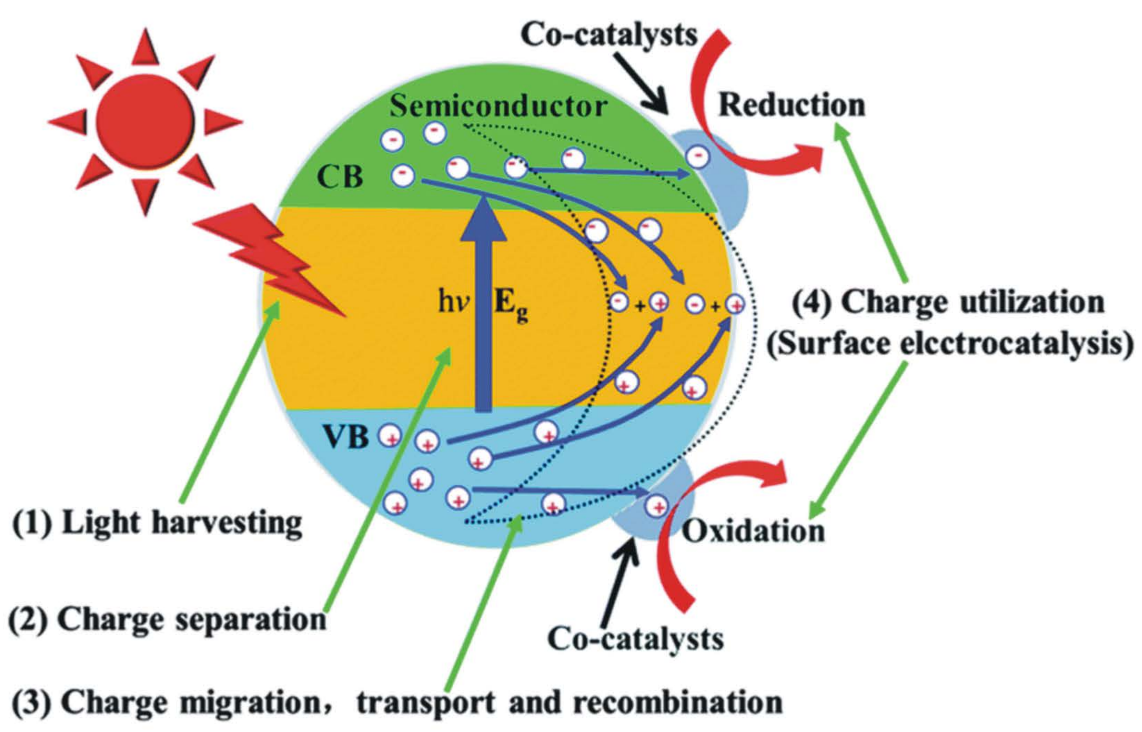


Fig. 2 The schematic illustration for the preparation of UL-P90/CN nanocomposite for the applications of photocatalytic degradations of SSY, PhOH and electrochemical sensing of SSY **[3]**.

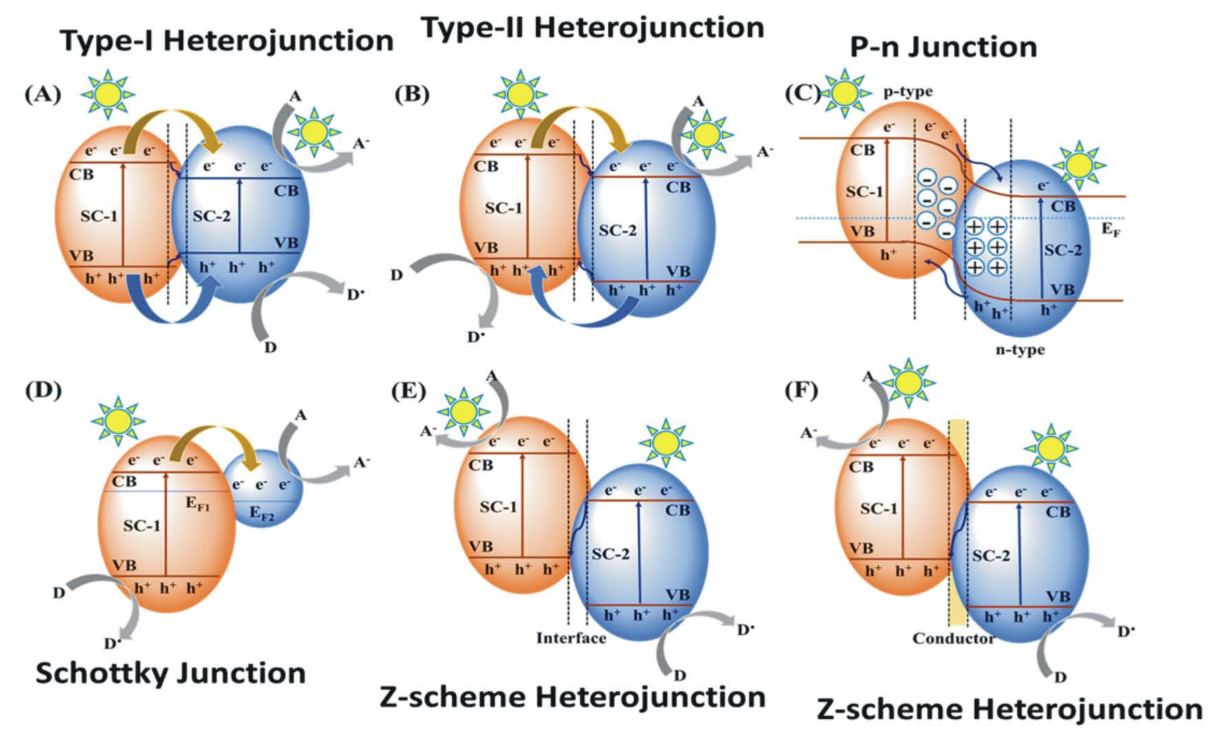
Summary

- The as-synthesized different P90–TiO_2/g-C_3N_4, α-Fe_2O_3–NCs@CN-SAF, and $Bi_xFe_{1-x}VO_4$/SCN nanocomposites were utilized for the photocatalytic degradations of environmentally hazardous pollutants (i.e. SSY, Phenol, Cr(VI), ROX) and energy productions (i.e. PEC water-splitting reactions)
- The bandgap energies of the various semiconductor materials were tuned by doping, semiconductor coupling, surface defects, functionalization techniques.
- The obtained photocatalytic efficiencies of the different nanocomposites were compared with pristine g-C_3N_4, and which results in 2.4–14.4 % enhancement. Therefore, the obtained results confirm that the staggered-aligned compositions and heterojunctions have tremendously boosted the photocatalytic activity and efficiency of pristine g-C_3N_4 through increased active sites, ultrafast charge separation and reduced recombination of photo-generated charge carriers (e^-/h^+).

Photocatalytic mechanism



Different Photocatalytic Heterojunctions



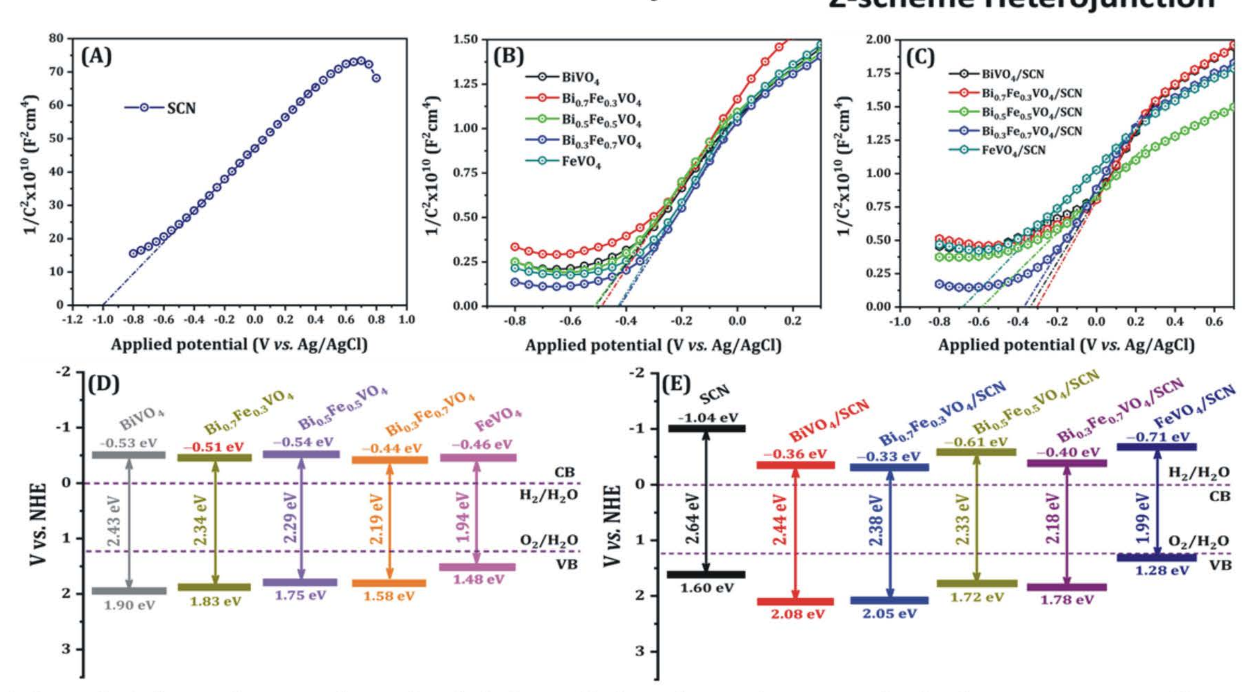


Fig. 3 The electrochemical Mott-Schottky plots and their corresponding energy level band edge diagram with respect to the VFB (vs NHE) of the as-synthesized photocatalysts **[1]**.

Research Outcomes

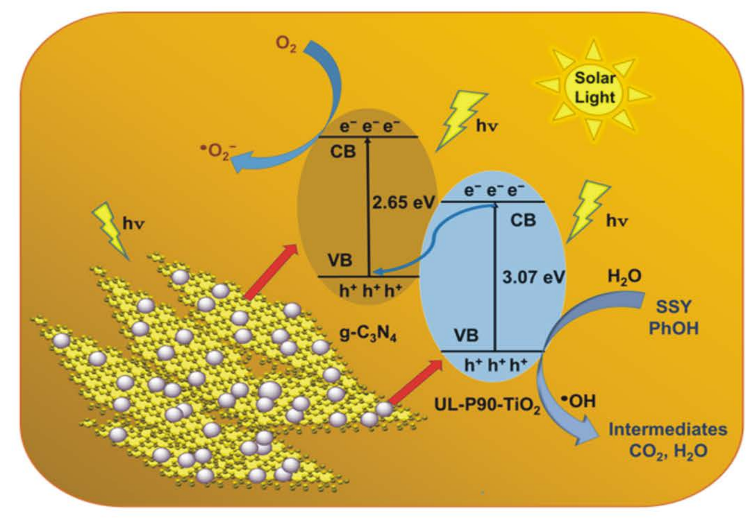


Fig. 4 The direct Z-scheme mechanism of 40 wt% UL-P90/CN hybrid nanocomposite for the photodegradation of Sunset Yellow FCF and Phenol **[3]**.

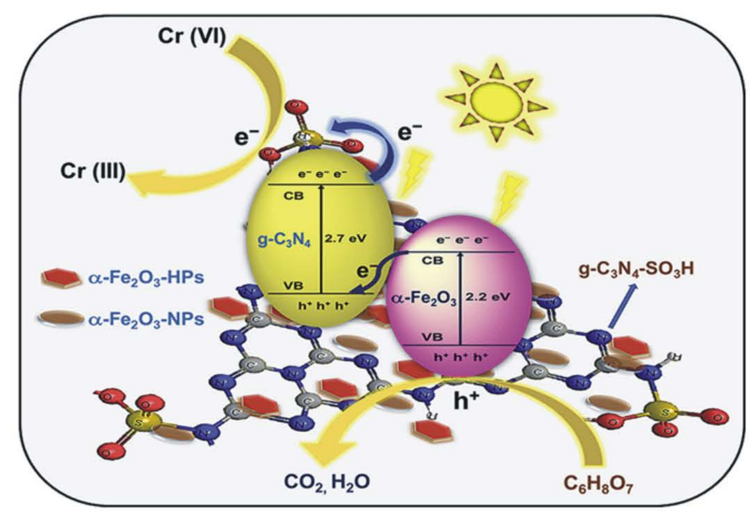


Fig. 5 The direct Z-scheme mechanism for the photocatalytic reduction of Cr (VI) of α-Fe_2O_3–NCs@CN-SAF **[2]**.

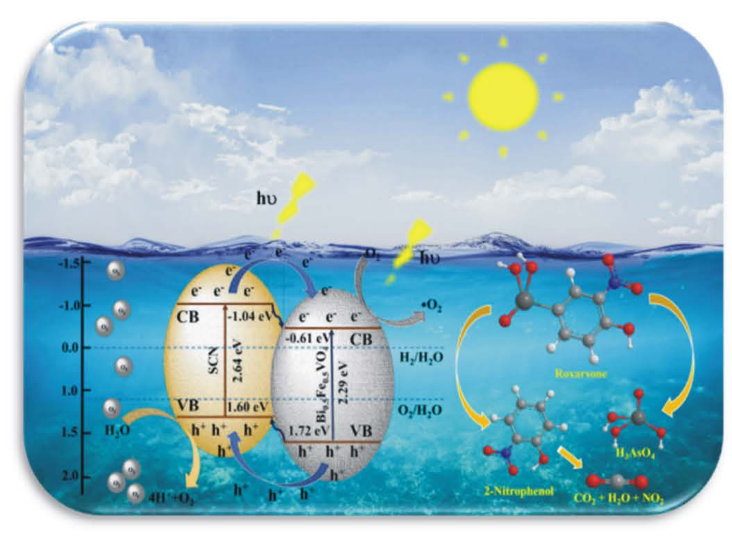


Fig. 6 Schematic illustration of the type-II heterojunction photocatalytic charge transfer mechanism on $Bi_{0.5}Fe_{0.5}VO_4$/SCN nanocomposite towards the degradation of ROX and OER **[1]**.

Selected Journal Publications

1. **Sridharan Balu**, Yi-Lun Chen, Shih-Wen Chen, Thomas C.-K. Yang*, "*Rational synthesis of $Bi_xFe_{1-x}VO_4$ heterostructures impregnated sulfur-doped g-C_3N_4: A visible-light-driven type-II heterojunction photo(electro)catalyst for efficient photodegradation of roxarsone and photoelectrochemical OER reactions*", ***Applied Catalysis B: Environmental*** (2021) 120852.
2. **Sridharan Balu**, Yi-Lun Chen, R.-C. Juang, Thomas C.-K. Yang*, Joon Ching Juan, "*Morphology-controlled synthesis of α-Fe_2O_3 nanocrystals impregnated on g-C_3N_4–SO_3H with ultrafast charge separation for photoreduction of Cr (VI) under visible light*", ***Environmental Pollution*** 267 (2020) 115491.
3. **Sridharan Balu**, Yi-Lun Chen, Thomas C.-K. Yang*, Jyy-Ning Chen, Shih-Wen Chen, "*Effect of ultrasound-induced hydroxylation and exfoliation on P90–TiO_2/g-C_3N_4 hybrids with enhanced optoelectronic properties for visible-light photocatalysis and electrochemical sensing*", ***Ceramics International*** 46 (2020) 18002–18018.