Supporting Information

Enhancing Photocatalytic Pollutant Degradation through S-Scheme Electron Transfer and Sulfur Vacancies in $BiFeO_3/ZnIn_2S_4$ Heterojunctions

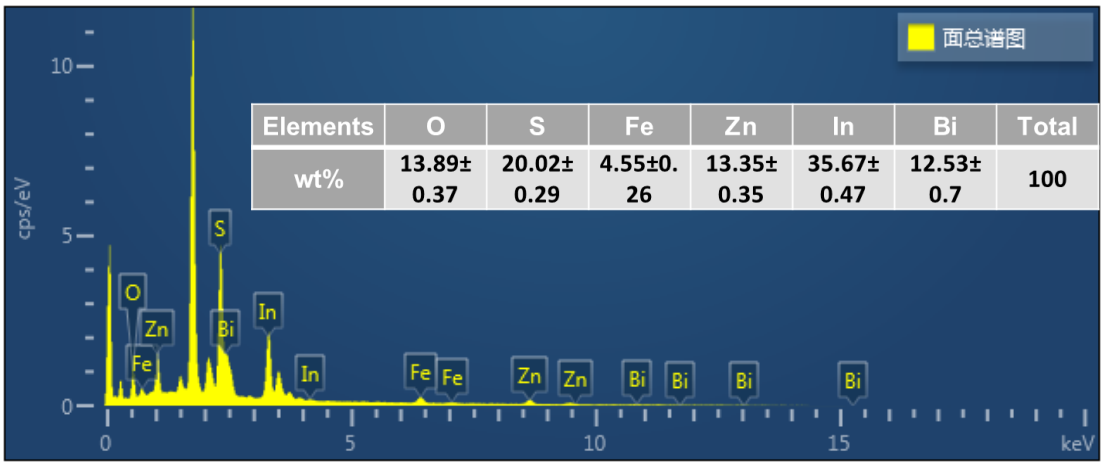
Ge-Ge Zheng[1], Xin Lin[1,2], Zhen-Xing Wen,[1] Yu-Hao Ding[1], Rui-Hui Yun[1], Gaurav Sharma[1,*], Amit Kumar[1,*], Florian J. Stadler[1,*]

Table S1 different photocatalyst and their performances to degrade Evans blue

Materials	Synthesis method	Light source	Photocatalytic degradation	Degradation efficiency	Reference
Graphene Chemically bonded TiO_2(G-TiO_2)	self-assembly method	solar light (intensity is 80000 flux)	25 mg photocatalyst into 40 ml 20 mg L^{-1} EB	100% in 60 min	[48]
$CaFe_2O_4$ NPs	sol-gel method	250 W Xe lamp with 420 nm cut-off ($\lambda > 420$ nm)	40 mg photocatalyst into 50 ml 5 mg L^{-1} EB	98.11% in 90 min	[49]
Fe_3O_4/ZnO NC	co-precipitation method	300 W tungsten vapour lamp	50 mg photocatalyst into 50 ml 5 mg L^{-1} EB	90% in 150 min	[50]
(Ag,La)co-doped $NiCo_2O_4$	sol-gel method	visible light	30 mg photocatalyst into 100 ml 1 mg L^{-1} EB	98% in 150 min	[51]
$Zn_{0.4}Co_{0.6}Fe_2O_4$ NPs	combustion method	300 W tungsten lamp	————————————	93% in 150 min	[52]
NS-rGO@Sn/Na-doped-TiO_2	self-assembly method	UV light	15 mg photocatalyst into 50 ml 5 mg L^{-1} EB	92% in 120 min	[53]
AgI-Ag_2S@g-C_3N_4	hydrothermal and pyrolysis methods	visible light	50 mg photocatalyst into 100 ml 5 mg L^{-1} EB	98.4% in 120 min	[54]
$BiFeO_3$/$ZnIn_2S_4$(VS)	microwave hydrothermal method	300 W Xe lamp	20 mg photocatalyst into 100 ml 20 mg L^{-1} EB	99% in 45 min	**This work**

Table S2 $ZnIn_2S_4$ based photocatalyst and their performances to degrade Ciprofloxacin

Materials	Synthesis method	Light source	Photocatalytic degradation	Degradation efficiency	Reference
Zn-Fe_2O_3/$ZnIn_2S_4$	solvothermal method	300 W Xe lamp with 400 nm cut-off ($\lambda > 400$ nm)	10 mg photocatalyst into 50 ml 20 mg L^{-1} CIP	95.2% in 120 min	[55]
$AgVO_3$/$ZnIn_2S_4$	hydrothermal method	250 W Xe lamp with 420 nm cut-off ($\lambda > 400$ nm)	50 mg photocatalyst into 100 ml 10 mg L^{-1} CIP	62.5% in 120 min	[56]
WSe_2/In_2S_3/$ZnIn_2S_4$	hydrothermal method	50 W fluorescent lamp	10 mg L^{-1} CIP	50.1% in 120 min	[57]
CQDs-$ZnIn_2S_4$/BiOCl	hydrothermal method	300 W Xe lamp with 420 nm cut-off ($\lambda > 420$ nm)	50mg photocatalyst into 100 ml 10 mg L^{-1} CIP	76.2% in 90 min	[58]
$ZnIn_2S_4$/$CoFe_2O_4$/bioc-har	two-step hydro-& solvent-thermal method	150 W Xe lamp	25 mg photocatalyst into 50 ml 20 mg L^{-1} CIP	96.9% in 120 min	[59]
ZnS–$ZnIn_2S_4$	hydrothermal method	300 W Tungsten/Halogen lamp	10 mg photocatalyst into 10 ml 10 mg L^{-1} CIP	65% in 75 min	[60]
$BiFeO_3$/$ZnIn_2S_4$(VS)	microwave hydrothermal method	300 W Xe lamp	20 mg photocatalyst into 100 ml 20 mg L^{-1} CIP	68% in 90 min	**This work**



Elements	O	S	Fe	Zn	In	Bi	Total
wt%	13.89± 0.37	20.02± 0.29	4.55±0. 26	13.35± 0.35	35.67± 0.47	12.53± 0.7	100

Figure S1: The EDX spectrum elemental composition

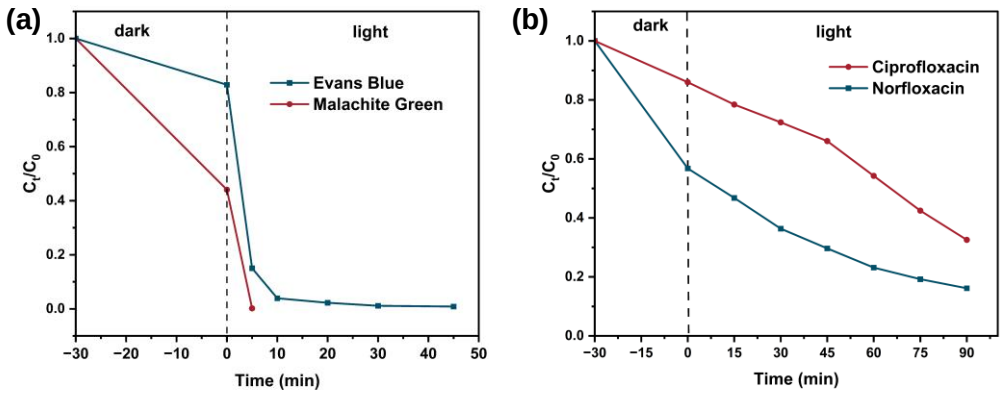


Figure S2: 30BFO/ZISS photocatalytic performance, a) Comparison of azo dyes; b) Comparison of quinolone antibiotics

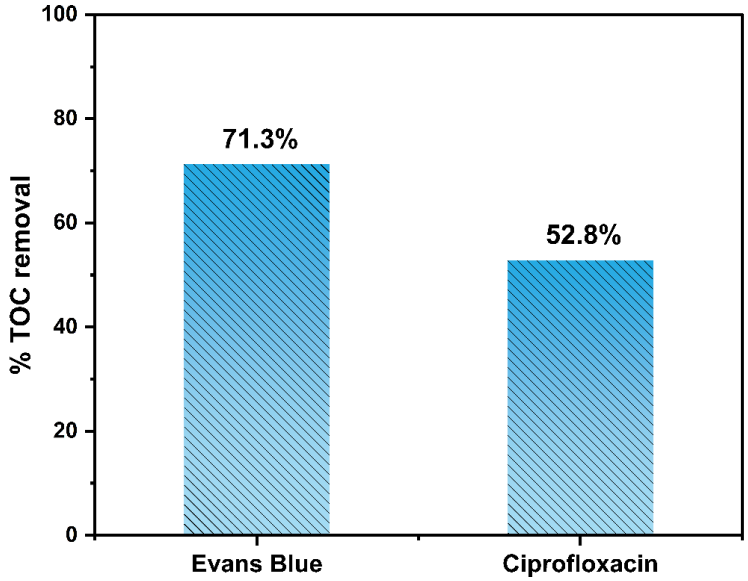


Figure S3: TOC removal for Evans Blue and Ciprofloxacin degradation by 30BFO/ZISS

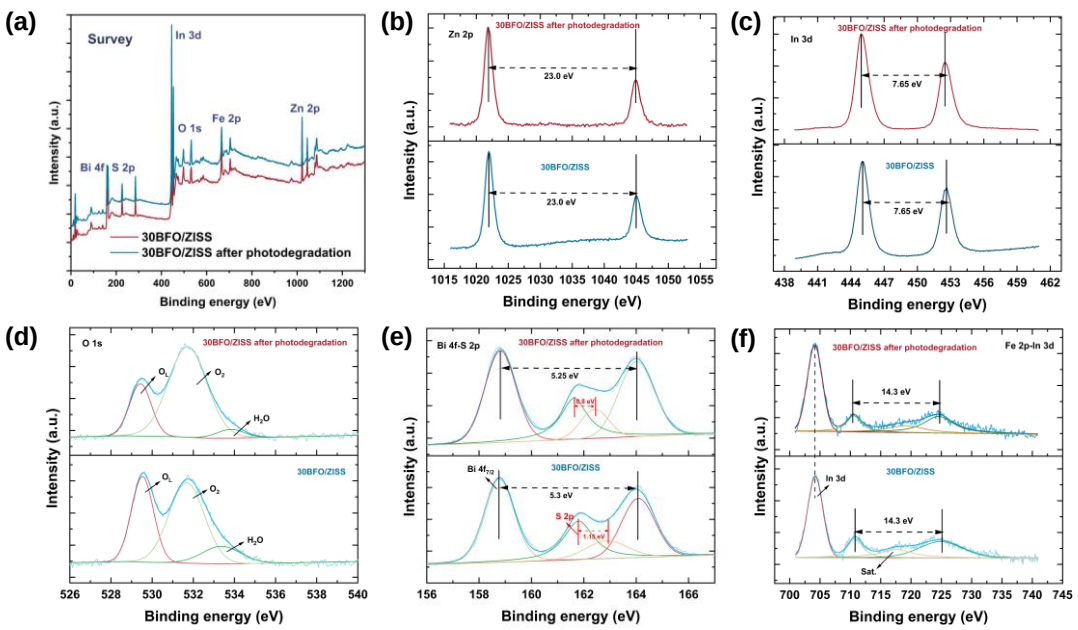


Figure S4: XPS spectra after photocatalytic degradation reaction, a) survey spectrum, b) Zn 2p, c) In 3d, d) O 1s, e) Bi 4f-S 2p, f) Fe 2p-In 3d

References

48. Kumar K Y, Saini H, Pandiarajan D, et al. Controllable synthesis of TiO_2 chemically bonded graphene for photocatalytic hydrogen evolution and dye degradation[J]. Catalysis Today, 2020, 340: 170-177.
49. Adarsha J R, Ravishankar T N, Manjunatha C R, et al. Green synthesis of nanostructured calcium ferrite particles and its application to photocatalytic degradation of Evans blue dye[J]. Materials Today: Proceedings, 2022, 49: 777-788.
50. Shashank M, Naik H S B, Nagaraju G, et al. Facile Synthesis of Fe_3O_4/ZnO Nanocomposite: Applications to Photocatalytic and Antibacterial Activities[J]. Journal of Electronic Materials, 2021, 50: 3557-3568.
51. Priya A S, Geetha D, Karthik K, et al. Investigations on the enhanced photocatalytic activity of (Ag, La) substituted nickel cobaltite spinels[J]. Solid State Sciences, 2019, 98: 105992.
52. Wang X, Chen Y. $ZnIn_2S_4$/$CoFe_2O_4$ pn junction-decorated biochar as magnetic recyclable nanocomposite for efficient photocatalytic degradation of ciprofloxacin under simulated sunlight[J]. Separation and Purification Technology, 2022, 303: 122156.
53. Jithendra Kumara K S, Krishnamurthy G, Walmik P, et al. Synthesis of reduced graphene oxide decorated with Sn/Na doped TiO_2 nanocomposite: a photocatalyst for Evans blue dye degradation[J]. Emergent Materials, 2021, 4(2): 457-468.
54. Velmurugan S, Balu S, Palanisamy S, et al. Synthesis of novel and environmental sustainable AgI-Ag_2S nanospheres impregnated g-C_3N_4 photocatalyst for efficient degradation of aqueous pollutants[J]. Applied Surface Science, 2020, 500: 143991.
55. Liu T, Wang C, Wang M, et al. The improved spatial charge separation and antibiotic removal performance on Z-scheme Zn-Fe_2O_3/$ZnIn_2S_4$ architectures[J]. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2021, 628: 127226.
56. Li C, Che H, Yan Y, et al. Z-scheme $AgVO_3$/$ZnIn_2S_4$ photocatalysts:"One Stone and Two Birds" strategy to solve photocorrosion and improve the photocatalytic activity and stability[J]. Chemical Engineering Journal, 2020, 398: 125523.
57. Wang X, Lu Q, Sun Y, et al. Fabrication of novel pnp heterojunctions ternary WSe_2/In_2S_3/$ZnIn_2S_4$ to enhance visible-light photocatalytic activity[J]. Journal of Environmental Chemical Engineering, 2022, 10(5): 108354.
58. Jiang R, Wu D, Lu G, et al. Modified 2D-2D $ZnIn_2S_4$/BiOCl van der Waals heterojunctions with CQDs: Accelerated charge transfer and enhanced photocatalytic activity under vis-and NIR-light[J]. Chemosphere, 2019, 227: 82-92.
59. Wang X, Chen Y. $ZnIn_2S_4$/$CoFe_2O_4$ p-n junction-decorated biochar as magnetic recyclable nanocomposite for efficient photocatalytic degradation of ciprofloxacin under simulated sunlight[J]. Separation and Purification Technology, 2022, 303: 122156.
60. Janani R, Melvin A A, Singh S. Facile one pot in situ synthesis of ZnS–$ZnIn_2S_4$ composite for improved photocatalytic applications[J]. Materials Science in Semiconductor Processing, 2021, 122: 105480.