Supplementary Martial

Synergetic Efficiency: In Situ Growth of Novel 2D/2D Chemically Bonded $Bi_2O_3/Cs_3Bi_2Br_9$ S-Scheme Heterostructure for Improved Photocatalytic Performance and Stability

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Fig. S1. A. Photocatalytic instrument, B. Top view of the instrument

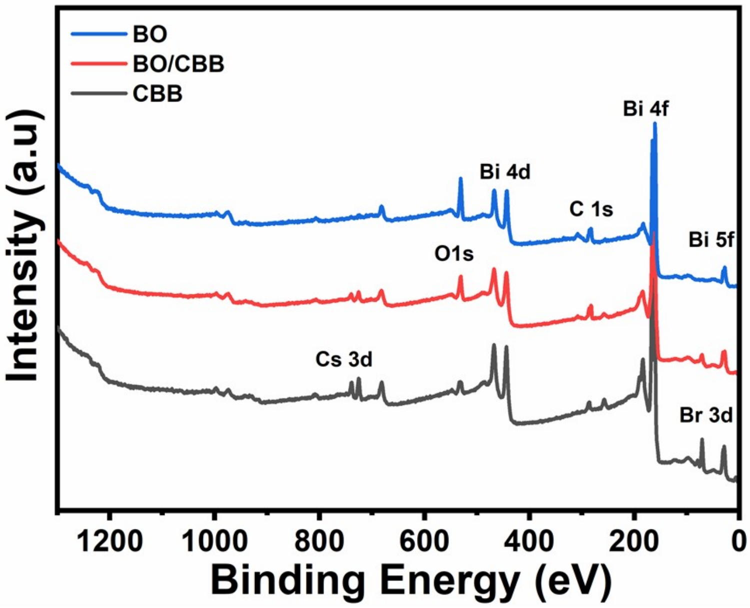

Fig. S2. Survey spectra of BO, CBB, and BO/CBB 28%

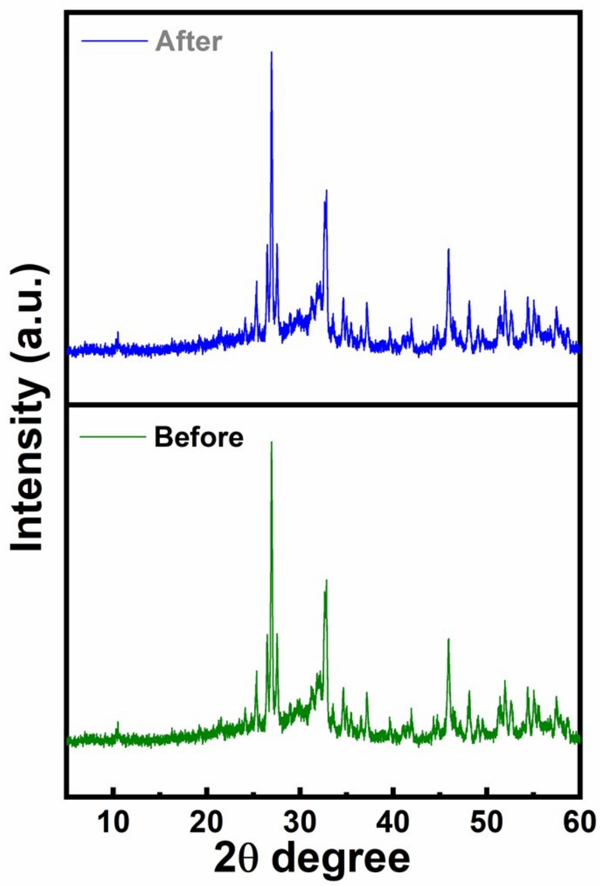

Fig. S3. XRD patterns of BO/CBB28% before and after four repeated cycles.

Table S1: Comparison of photocatalytic performance of various photocatalysts for degradation of dyes.

Photocatalyst	Irradiation	Pollutant	Time	Degradation	Ref.
$CsSnBr_3$	Visible light	crystal violet dye	120 min	73.1%	[S1]
$Cs_3Bi_2I_9$	Visible light	RhB	180 min	93%	[S2]
$Cs_3Bi_2I_9$-OA	Visible light	MB in water	60 min	62.1%	[S3]
$Cs_3Bi_2I_9$-OA	Visible light	MB in water	60 min	62.6%	[S3]
$Cs_3Bi_2Br_9$-OA/Ag_2S	Visible light	MB in water	60 min	40.13%	[S3]
$Cs_3Bi_2Br_9$-OA/TiO_2	Visible light	MB in water	60 min	27.6%	[S3]
$Cs_3Bi_2Br_9$	Visible light	MB in isopropanol	60 min	66.3%	[S3]
$Cs_3Bi_2Br_9$-OA NCs	Visible light	MB in isopropanol	60 min	58.8%	[S3]
Cu doped TiO_2	Visible light	MB in water	300 min	81.22%	[S4]
Ni doped TiO_2	Visible light	MB in water	300 min	71.18%	[S4]
Co doped TiO_2	Visible light	MB in water	300 min	66.17%	[S4]
Fe doped TiO_2	Visible light	MB in water	300 min	1.41%	[S4]
Mn doped TiO_2	Visible light	MB in water	300 min	16.41%	[S4]
10%Bi_2O_3@TiO_2	Visible light	MB in water	300 min	11.47%	[S4]
α-β Bi_2O_3	sunlight	RhB in water	120 min	99.6%	[S5]
$Bi_2O_2CO_3$	UV light	MB in water	300 min	64.19%	[S6]
$Cs_3Bi_2Br_9$	Visible light	MO in water	90 min	92%	[S7]
$Cs_3Bi_2Br_9$	Visible light	MB in water	90 min	80%	[S7]
$Cs_3Bi_2Br_9$	Visible light	RhB in water	90 min	85%	[S7]
Bi_2O_3	Visible light	MB in water	60 min	65%	This work
Bi_2O_3/$Cs_3Bi_2Br_9$ 56%	Visible light	MB in water	60 min	89%	This work
Bi_2O_3/$Cs_3Bi_2Br_9$ 28%	Visible light	MB in water	60 min	92%	This work

Effect of pH level: The impact of the pH level plays an important factor in achieving high-efficiency photocatalytic activity. The photocatalytic degradation of MB by the optimal BO/CBB 28% composite was carried out at different pH levels (3, 7, 9). Fig. S4 revealed that the studied sample did not show much difference in the degradation of MB with different pH levels. The photocatalytic activity in an acidic medium (pH = 3) achieved the best MB degradation efficiency among the three levels. Whereas the MB degradation in the alkaline medium (pH = 9) by the sample was lower than at pH = 7. However, this slight difference in the degradation of MB by the BO/CBB 28% composite might be attributed to the fact that the changes in the charge surface of the photocatalyst at different pH media. This result is consistent with reported studies [S8, S9].

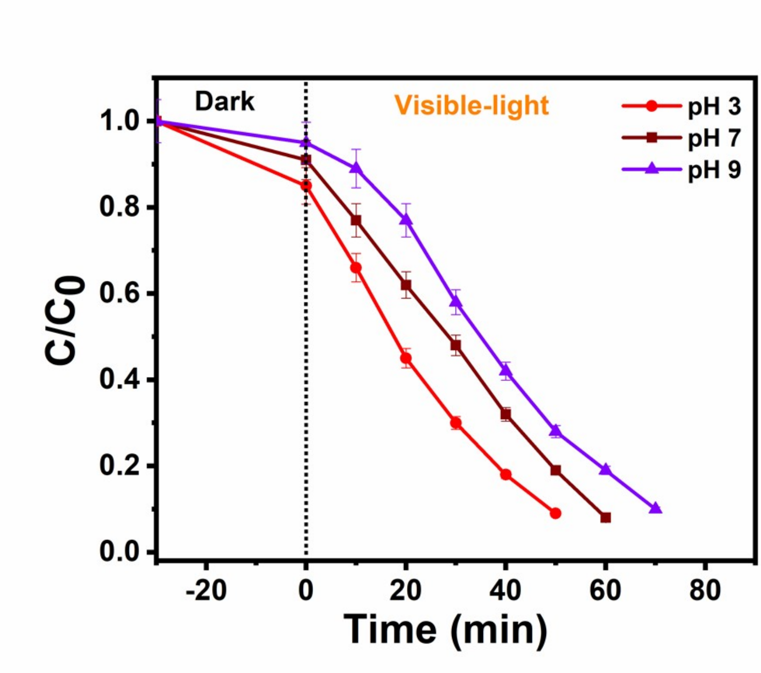

Fig. S4 pH level effect

References

[S1] Huynh KA, Nguyen DL, Nguyen VH, Vo DV, Trinh QT, Nguyen TP, Kim SY, Le QV. Halide perovskite photocatalysis: progress and perspectives. Journal of Chemical Technology & Biotechnology. 2020 Oct;95(10):2579-96.

[S2] Bresolin BM, Günnemann C, Bahnemann DW, Sillanpää M. Pb-Free $Cs_3Bi_2I_9$ perovskite as a visible-light-active photocatalyst for organic pollutant degradation. Nanomaterials. 2020 Apr;10(4):763.

[S3] Bhattacharjee S, Chaudhary SP, Bhattacharyya S. Lead-free metal halide perovskite nanocrystals for photocatalysis in water. Chem Rxiv 2019.

[S4] Kerkez-Kuyumcu Ö, Kibar E, Dayıoğlu K, Gedik F, Akın AN, Özkara-Aydınoğlu Ş. A comparative study for removal of different dyes over M/TiO_2 (M= Cu, Ni, Co, Fe, Mn and Cr) photocatalysts under visible light irradiation. Journal of Photochemistry and Photobiology A: Chemistry. 2015 Oct 1; 311:176-85.

[S5] Bera KK, Chakraborty M, Mondal M, Banik S, Bhattacharya SK. Synthesis of α-β Bi_2O_3 heterojunction photocatalyst and evaluation of reaction mechanism for degradation of RhB dye under natural sunlight. Ceramics International. 2020 Apr 15;46(6):7667-80.

[S6] Nguyen TT, Le TT, Nguyen TB, Thi TN, Tran LB, Nguyen TQ, Nguyen NH. Effect of pH on the Performance of $Bi_2O_2CO_3$ Nanoplates for Methylene Blue Removal in Water by

Adsorption and Photocatalysis. Bulletin of Chemical Reaction Engineering & Catalysis. 2022 Jun 30;17(2):331-9.

[S7] Masri M, Girisha KB, Hezam A, Qahtan TF, Alkanad K, Masri F, Namratha K, Byrappa K. Enhanced photocatalytic activity and stability of 2D $Cs_3Bi_2Br_9$ perovskite nanosheets synthesized via modified antisolvent method. Colloids and Surfaces C: Environmental Aspects. 2024 Nov 1; 2:100024.

[S8] Prabhu S, Nithya A, Mohan SC, Jothivenkatachalam K. Synthesis, surface acidity and photocatalytic activity of WO_3/TiO_2 nanocomposites–an overview. InMaterials Science Forum 2014 Jun 1 (Vol. 781, pp. 63-78). Trans Tech Publications Ltd.

[S9] Meng J, Ashry AG, Abou-Elyazed AS, Zhang Z, Li X, Sharara TZ, El-Demerdash SH. Highly Efficient Visible-Light Photocatalysts: Bi_2O_3@TiO_2 Derived from Ti-MOFs for Eriochrome Black T Degradation: A Joint Experimental and Computational Study. Catalysts. 2024 Nov 17;14(11):829.