Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Fabrication of magnetic ternary $ZnFe_2O_4/TiO_2$/RGO Z-Scheme system with efficient photocatalytic activity and easy recyclability

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Preparation of GO

GO was synthesized by modified Hummer's method [1]. Briefly, 1 g graphite powder, 0.5 g $NaNO_3$ and 23 mL H_2SO_4 were mixed by stirring for 0.5 h at 0 °C. 3 g $KMnO_4$ was slowly added to the mixture with stirring under 15 °C. And then the mixture was stirred for another 0.5 h at 35 °C. Subsequently, 46 mL DI water was added into the mixture and further stirred for 0.5h at 98 °C. Later, 100 mL DI water and 10 mL H_2O_2 were added into the mixture followed by stirring. The color of the mixture was changed to yellowish. Then GO was washed with HCl and DI water for several times. The purified solid was dried by freezer dryer (-56 °C for 24 h).

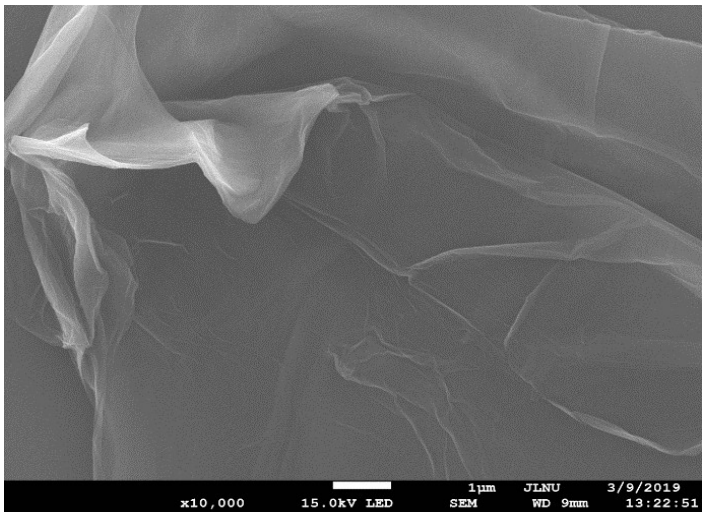

Figure S1 SEM image of GO

The calculation of E_g, E_{VB} and E_{CB} of the prepared samples

The band gap energies of $ZnFe_2O_4$ and TiO_2 can be calculated by the following formula:

$$ahv = A\ (\ hv - E_g\ )^{n/2} \qquad (1)$$

The α is the absorption coefficient, v is the light frequency, A is a constant and E_g is the band-gap energy. The n values of TiO_2 and $ZnFe_2O_4$ are 4 and 1, respectively [2,3]. As illustrated in Fig. 2b, according to formula (1), the E_g of TiO_2 and $ZnFe_2O_4$ can be calculated as 2.95 eV and 1.91 eV, respectively. Therefore, the band positions of TiO_2 and $ZnFe_2O_4$ were calculated by formulas (2) and (3):

$$E_{VB} = X - E^e + 0.5E_g \qquad (2)$$

$$E_{CB} = E_{VB} - E_g \qquad (3)$$

The E_{VB} is the valence band edge potential, E_{CB} is the conduction band edge potential, X is the electronegativity of the semiconductor (for TiO_2 = 5.81 eV [4] and for $ZnFe_2O_4$ = 5.05 eV [5]), E^e is the energy of free electrons on the hydrogen scale (border on 4.5 eV). Acorrding to formula (2) and (3), the calculated E_{VB} and E_{CB} of TiO_2 are 2.785 eV and -0.165 eV, respectively. And for $ZnFe_2O_4$, E_{VB} and E_{CB} are 1.505 eV and -0.405 eV, respectively.

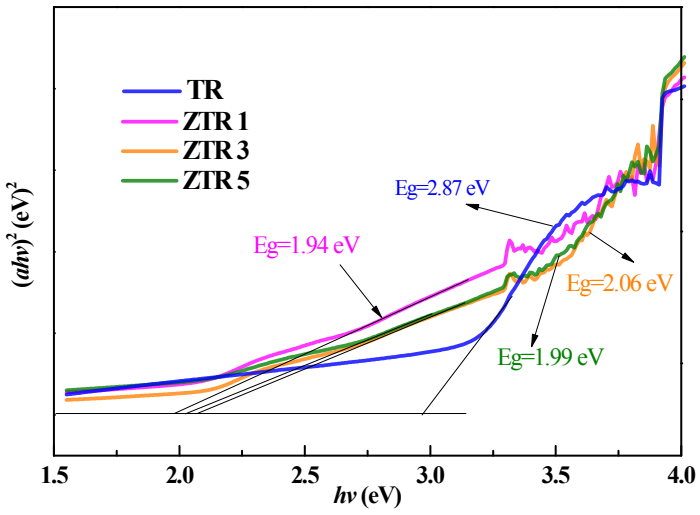

Figure S2 Calculation on the band gap energies of TR, ZTR 1, ZTR 3 and ZTR 5 composites

Furthermore, we calculated the Kubelka-Munk functions of versus the light energy of TR, ZTR 1, ZTR 3 and ZTR 5 composites, the results are shown in Fig. S2 The band

gap energy of TR, ZTR 1, ZTR 3 and ZTR 5 composites 2.87 eV, 2.06 eV, are 1.99 eV and 1.94 eV, respectively.

The EDS spectrum

Figure S3 shows EDS spectrum of the ZTR 3 composite as catalyst for photocatalytic degradation of *p*-Nitrophenol (*p*-NP). Elements C, O, Ti, Fe and Zn belong to RGO, TiO_2 and $ZnFe_2O_4$, suggesting the successful fabrication of the ternary composite.

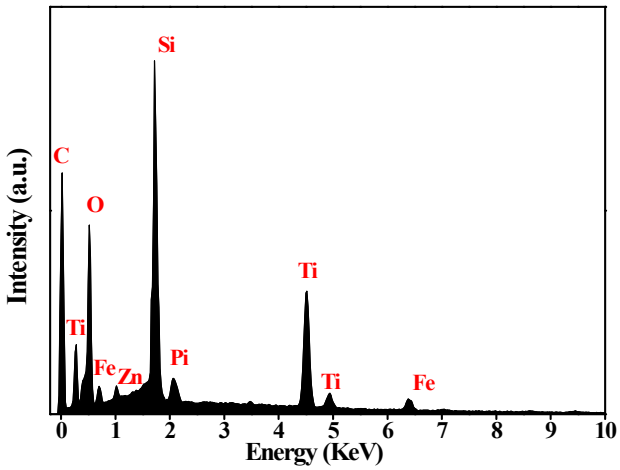

Fig. S3 EDS spectrum of the ZTR 3 composite

The active species trapping experiments

The active species trapping experiments were carried out during photocatalytic reactions. ammonium oxalate (AO), 2-propanol (IPA) and 1, 4-benzoquinone (BQ) were used as the quencher of h^+, •OH and $•O_2^-$, respectively. In a typical experiment, AO (6 mmol/L), IPA (20 mmol/L) and BQ (0.2 mmol/L) were added into the *p*-NP solution before addition of the photocatalyst to scavenge the reactive species, respectively. The subsequent experiments were the same as the previous photocatalytic degradation experiments.

References

[1] A. A. Nada, H. R. Tantawy, M. A. Elsayed, M. Bechelany, M. E. Elmowafy, Solid State Sciences, **2018**, 78, 116-125.

[2] X. Lin, X. Y. Guo, W. L. Shi, F. Guo, G. B. Che, H. J. Zhai, Y. S. Yan, Q. W. Wang, Solid State

Sciences, **2018**, 78, 116-125.

[3] R. Tao, C. C. Zhao, C. L Shao, X. H. Li, X. W. Li, J. Zhang, S. Yang, Y. C. Liu, Materials Research Bulletin, **2018**, 104, 124-133.

[4] H. Khan, M. G. Rigamonti, G. S. Patience, D. C. Boffit, Applied Catalysis B: Environmental, **2018**, 226, 311-323.

[5] X. J. Chen, Y. Z. Dai, T. H. Liu, Catalysis Communications, **2015**, 71, 21-27.