Supplementary data for

Engineering Z-scheme TiO_2 -OV-BiOCl *via* oxygen vacancy for photocatalytic degradation of imidacloprid

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The calculation of intensity-average lifetime of samples:

In this work, the time-resolved photoluminescence (TRPL) decay spectra was applied to study the effective transfer of photo- generated electrons intuitively. As shown in Fig. 5(d), all of the TRPL spectra is consistent with a multi-exponential decay process. And their decay dynamics can be obtained through fitting to a biexponential function [1,2]:

$$I(t) = A_1\exp(- t/\tau_1) + A_2\exp(- t/\tau_2) \quad (1)$$

where I(t) indicates the PL intensity, A_1 and A_2 are used to represent the amplitude (or weighting factors). the τ_1 and τ_2 represent the corresponding lifetime. The average lifetime (τ_m) is often used to evaluate carrier separation efficiency of photogenerated charges, and the τ_m was calculated according to the following equation:

$$\tau_m = (A_1\tau_1^2 + A_2\tau_2^2)/(A_1\tau_1 + A_2\tau_2) \quad (2)$$

The short lifetime component (τ_m) stems from the nonradiative recombination of the τ_1 photogenerated electrons with the surface defects. And, the long lifetime component (τ_2) is derived from the interband recombination of the free-excitons [3]. The experimental decay profiles of TiO_2-OV-BiOCl samples are listed in Table. S1. For TiO_2-OV-BiOCl, the two exponential constants (τ_1 and τ_2) are 2.207 ns and 2.261 ns, which are longer than that of TiO_2/BiOCl (τ_1 =3.779 ns and τ_2 = 8.059 ns) and BiOCl (τ_1 =2.207 ns and τ_2 = 0.245 ns). Therefore, TiO_2-OV-BiOCl possess a longer average lifetime (τ_m = 5.83 ns) than that of TiO_2/BiOCl (τ_m = 4.76 ns) and BiOCl (τ_m = 4.33 ns).

Sample	A_1	τ_1 (ns)	A_2	τ_2 (ns)	τ_{ave} (ns)
TiO_2-OV-BiOCl	0.6348	5.978	0.276	2.261	5.83
TiO_2/BiOCl	0.624	3.799	0.803	8.050	4.76
BiOCl	0.363	2.207	0.276	6.245	4.33

Table S1. The fitted parameters of the TRPL decay profiles.

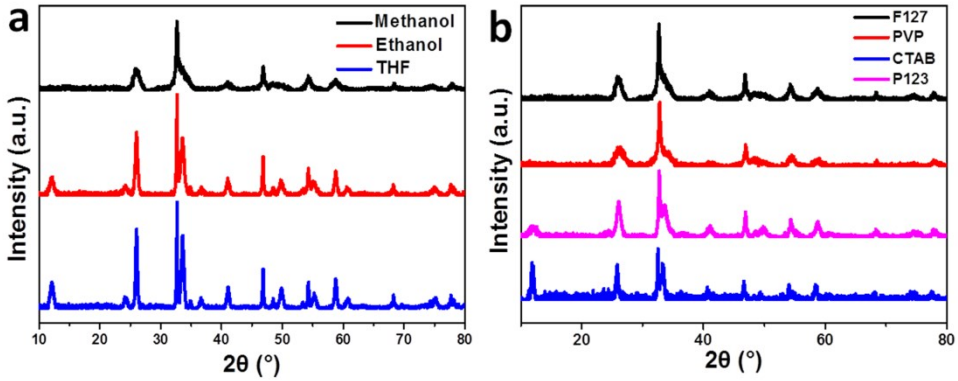

Fig. S1. The prepared TiO_2/BiOCl using F127 as the surfactant in other solvents (a) and in the methanol solvent using other surfactants (b).

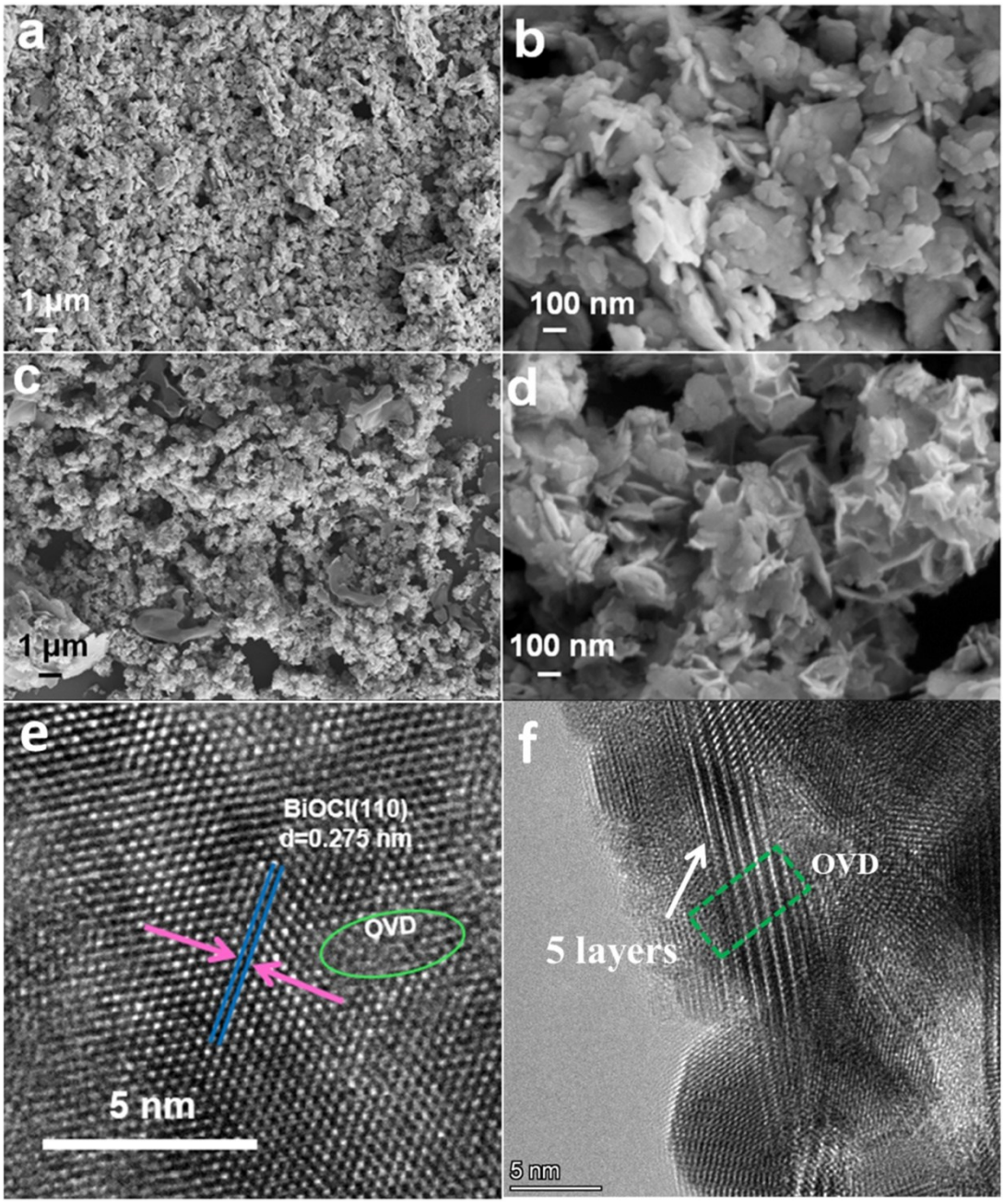

Fig. S2. SEM images of TiO_2-OV-BiOCl (a, b) and TiO_2/BiOCl (c, d); HRTEM images of TiO_2-OV-BiOCl (e-f).

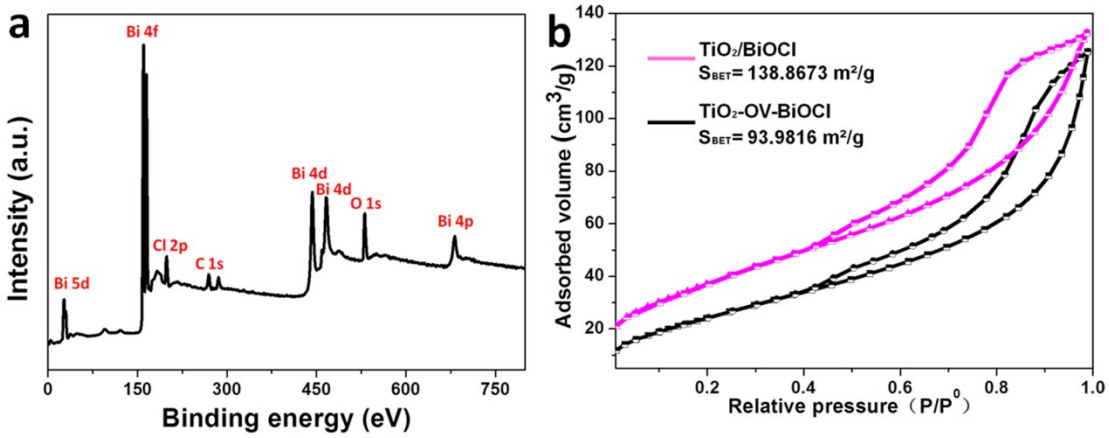

Fig. S3. The survey spectra of TiO_2-OV-BiOCl (a); The BET of prepared TiO_2/BiOCl and TiO_2-OV-BiOCl (b).

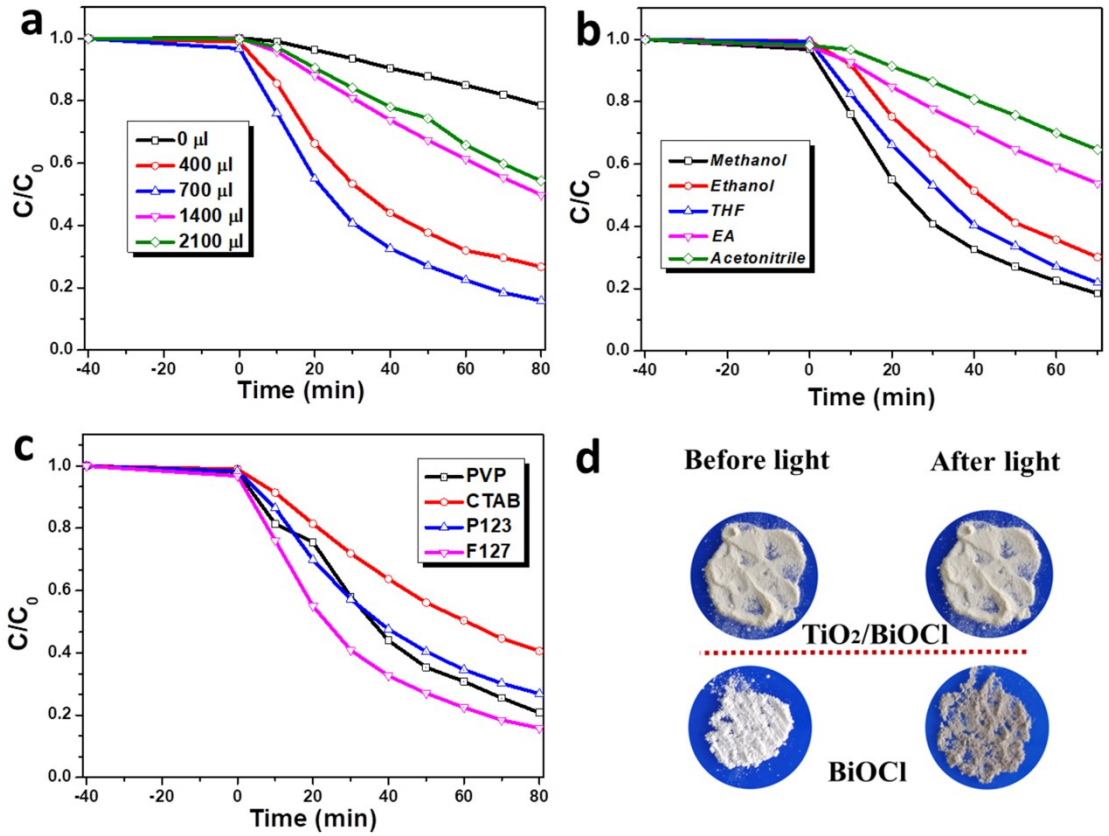

Fig. S4. Photocatalystic degradation of IMD by TiO_2-OV-BiOCl under different the additive amount of titanium trichloride solution (a), solvent systems (b) and types of surfactants (c); The change in colour of TiO_2-OV-BiOCl and BiOCl (d) before and after illumination under simulated sunlight.

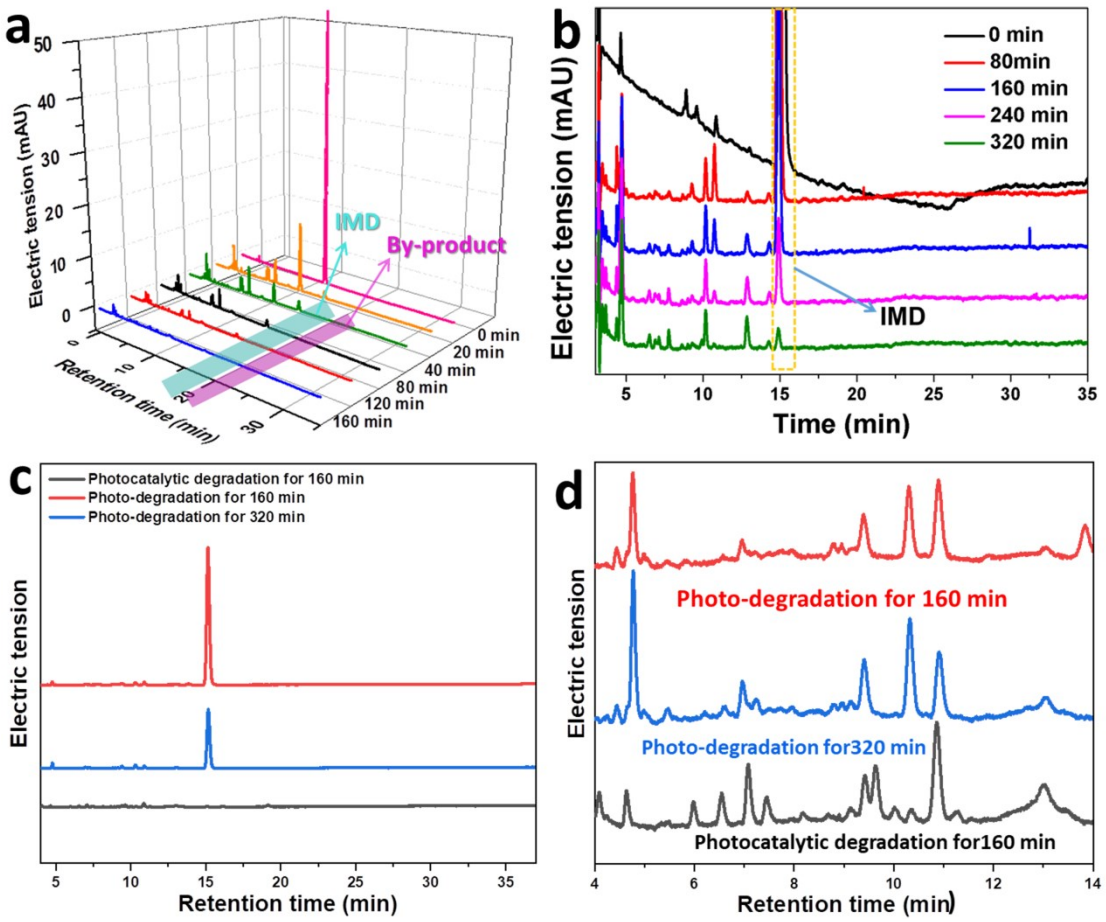

Fig. S5. (a) HPLC graph of IMD and by-products within 35 minutes retention times in IMD undergoing photocatalytic degradation (a) and photo-degradation (b) at varies reaction time; (c) HPLC graph of IMD and by-products (d) undergoing photocatalytic degradation over TiO_2-OV-BiOCl and photo-degradation by simulated sunlight at varies reaction time.

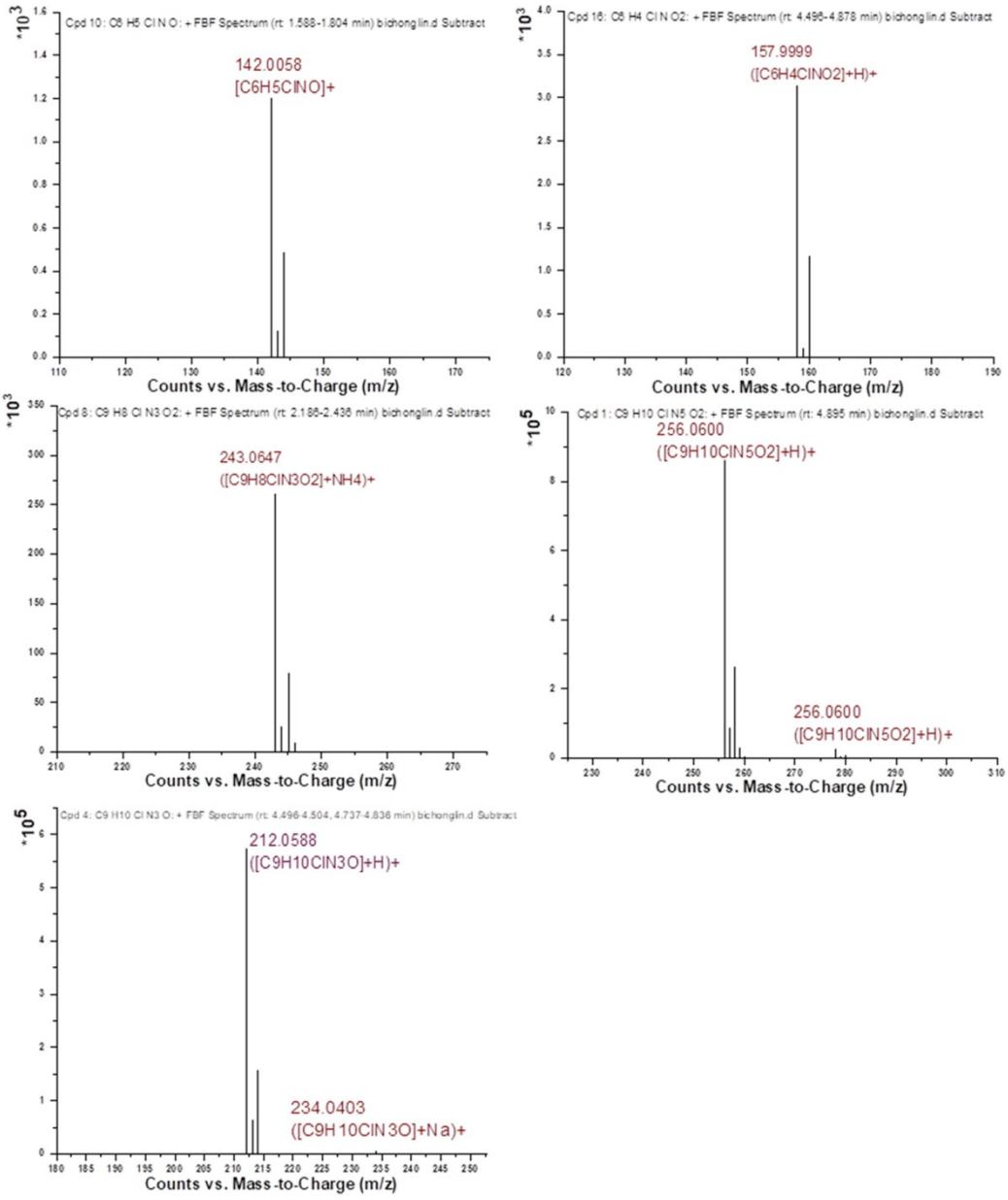

Fig. S6. The iron spectra at different retention time of photocatalytic degradation for IMD under irradiation at 40 min.

Reference:

[1] L. Zhang, C. Niu, X. Zhao, C. Liang, H. Guo, G. Zeng, *ACS Appl. Mater. Inter.,* 2018, 46 (10) 39723-39734.

[2] H. Gao, R. Cao, X. Xu, S. Zhang, Y. Huang, H. Yang, X. Deng, J. Li, *Appl. Catal. B: Environ.,* 2019, 245 399-409.

[3] X. Wang, C. Liow, A. Bisht, X. Liu, T. C. Sum, X. Chen, S. Li, *Adv. Mater.,* 2015, 27, 2207-2214.