**Supporting Information**

# Ascorbic acid surface modified $TiO_2$-thin layer as a fully integrated analysis system for visual simultaneous detection of organophosphorus pesticides

Shunxing Li,[1, 2]* Wenjie Liang,[2] Fengying Zheng,[1, 2] Xiaofeng Lin,[2] Jiabai Cai[2]

[1] Fujian Province Key Laboratory of Modern Analytical Science and Separation Technology, Zhangzhou, China, 363000

[2] College of Chemistry and Environment, Minnan Normal University, Zhangzhou, China, 363000

Corresponding author: Prof. Dr. Li Shun-Xing

E-mail: lishunxing@mnnu.edu.cn; shunxing_li@aliyun.com

Tel.: +86 596 2591395

Fax: +86 596 2591395

## Quantitative Image Processing

Data processing was performed with the software ImageJ. JPEG images were opened with ImageJ in RGB color format. Adjustment of the color threshold was achieved as follows:

1. The “Color Threshold” window is accessed through the ImageJ menu by selecting “Image” → “Adjust” → “Color Threshold.” Each image was seted by adjusting the hue, saturation, and brightness then the optimum color of interest was visible. Concrete parameters were set as follows: hue (0, 255), saturation (0, 255), brightness (153, 255). The thresholding method and threshold color were Huang and white, respectively.

2. After threshold adjustment the images were then converted to 8-bit grey scale (“Image” → “Type” → “8-bit”), and then inverted (“Edit” → “Invert”) so that darker color could yield greater intensity.

***Note:*** All the TLC plate must be photographed in the same conditions and the threshold ranges set for each images were all the same. After processing with the above section 1 and 2, all the backgrounds of rufous from AA–$TiO_2$@PS were converted to 8-bit grey scale and then the background was eliminated.

3. In the “Set measurements window,” found from the ImageJ menu by selecting “Analyze” → “Set measurements”. Each area to be measured was selected using the wand tool, which automatically finds the edge of an object and traces its shape. Grey intensity of the outlined area is measured selecting “Analyze” → “Measure.”

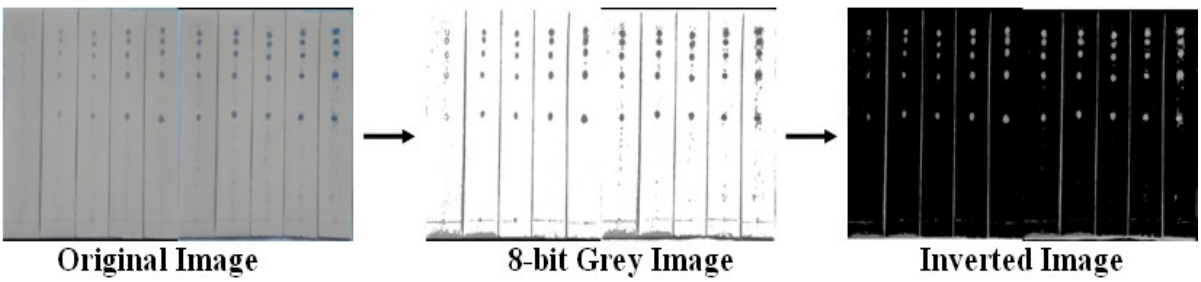



**Figure S1**. Effects of color threshold adjustment,

8 bit grey scale conversion and inversion on an image.

The loading amount of $TiO_2$ in PS spheres was investigated by thermogravimetry (TG). As shown in **Figure S2,** the PS spheres could be decomposed at 450℃ and the loading amount of $TiO_2$ on PS spheres was about 54%.

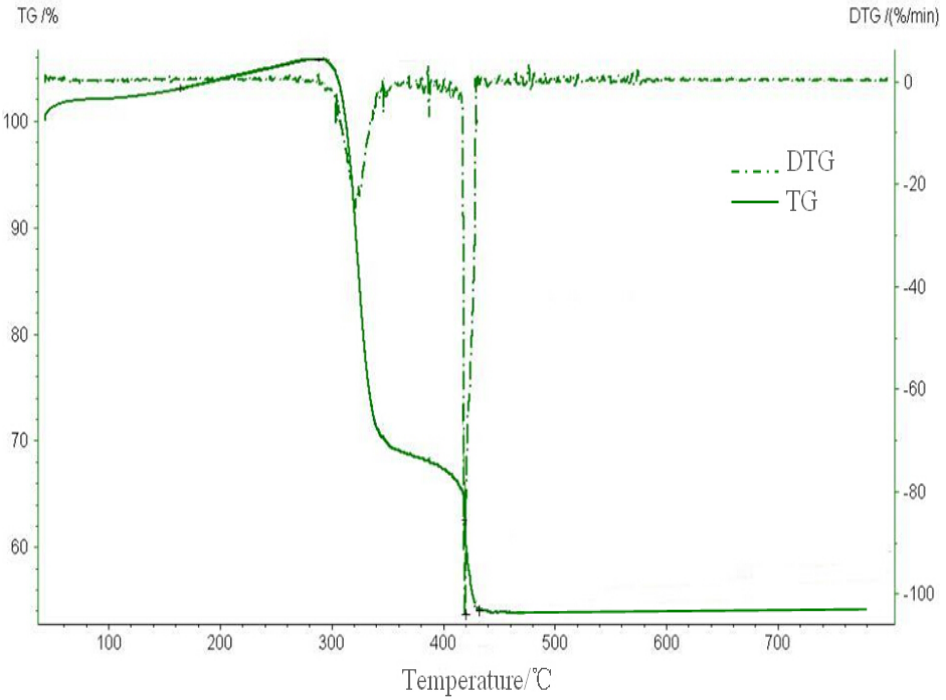



**Figure S2.** TG and DTG images of $TiO_2$@PS

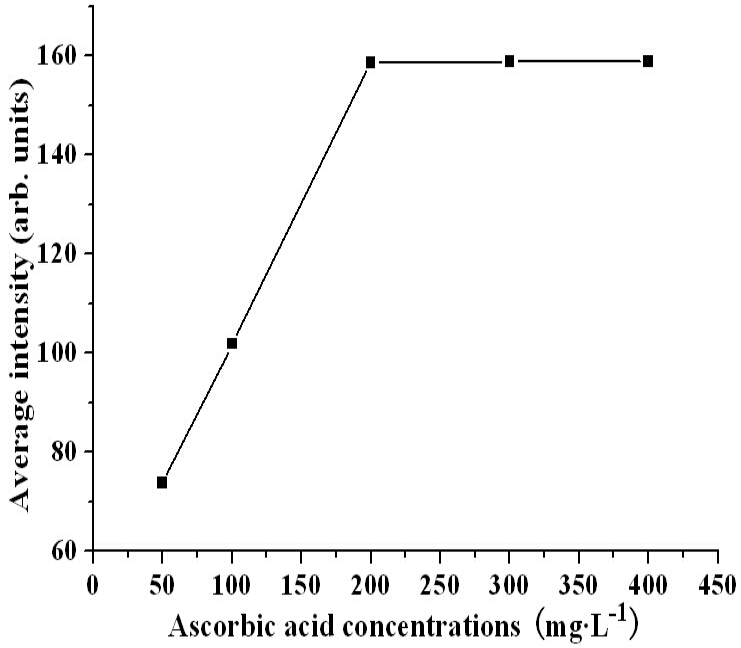



**Figure S3**. Effect of ascorbic acid concentration on the gray scale intensity

The time-dependent photodegradation curves for OPs were shown in **Figure S4**. The concentration of OPs was 3.0 $\mu$mol P·L$^{-1}$ and the photocatalyst used was 1.0 g·L$^{-1}$.

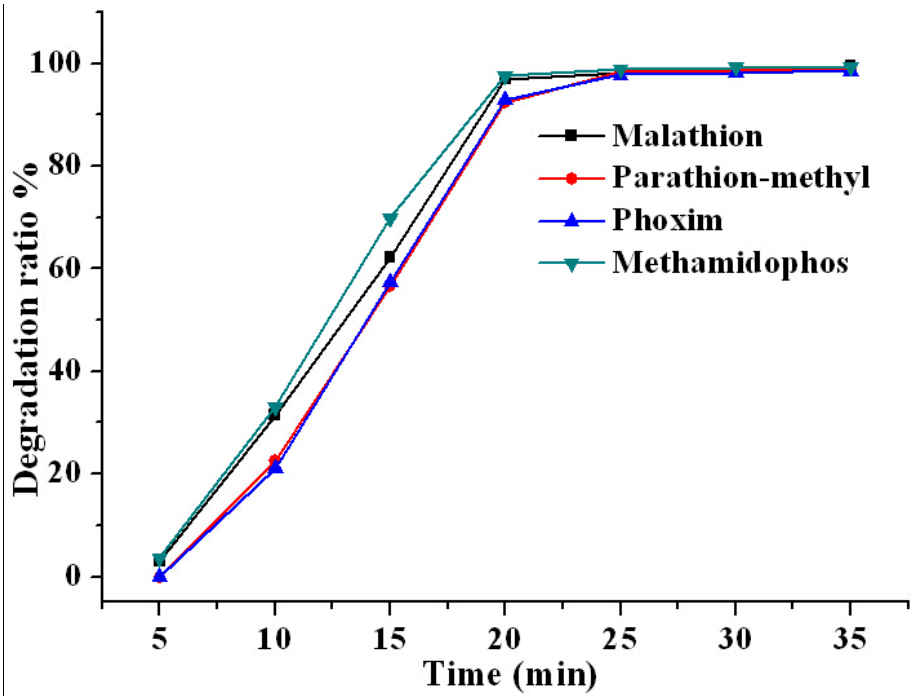



**Figure S4.** Photodegradation ratio of OPs by AA-$TiO_2$@PS under visible light

**Table S1.** The name, structure, and molecular weight of organophosphorus pesticides.

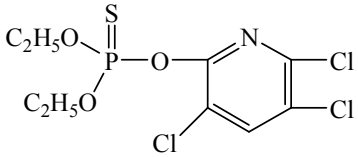
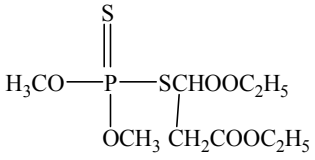
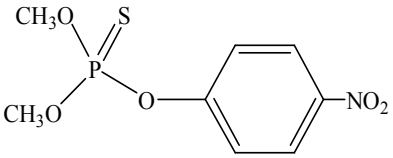
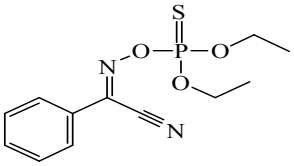
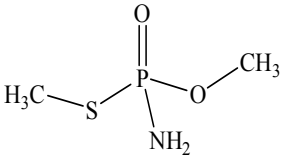
| Name | Structure | Molecular weight |
|---|---|---|
| Chlopyrifos |  | 350.5 |
| Malathion |  | 330.36 |
| Parathion-methyl |  | 263.21 |
| Phoxim |  | 298.18 |
| Methamidophos |  | 141.14 |

**Table S2.** $R_f$ values of OPs on different mobile phase.

| OPs | $R_f$ value | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 |
| Chlopyrifos | 0.86 | 0.79 | 0.88 | 0.82 | 0.71 | 0.77 | 0.92 | — |
| Malathion | 0.79 | 0.80 | 0.81 | 0.69 | — | 0.28 | — | 0.88 |
| Parathion-methyl | 0.49 | 0.4 | 0.54 | 0.43 | 0.34 | 0.41 | 0.51 | — |
| Phoxim | 0.69 | 0.42 | 0.79 | 0.70 | 0.76 | 0.43 | 0.76 | 0.42 |
| Methamidophos | 0.90 | 0.75 | — | 0.81 | — | — | 0.19 | 0.31 |

***Note:*** M1 (hexane: acetone: methanol: water =5: 2: 1.5: 1.5); M2 (hexane: dichloromethane: methanol =5: 3: 2); M3 (hexane: dichloromethane: acetone = 4.5: 3:2.5); M4 (hexane: acetone: methanol =6.5: 2 : 1.5); M5 (hexane: acetone =7: 3); M6 (hexane: dichloromethane =5: 5); M7(chloroform: benzene=1: 9); M8 (acetonitrile: benzene =2: 8)

**Table S3.** Adsorption kinetics of OPs on AA-$TiO_2$@PS

| OPs | pseudo first-order model | | pseudo-second-order model | |
|---|---|---|---|---|
| | Equation | $R^2$ | Equation | $R^2$ |
| Chlopyrifos | y = -0.0603x + 3.7868 | 0.9707 | y = 0.3699x - 0.228 | 0.8763 |
| Malathion | y = -0.0537x + 3.6577 | 0.9748 | y = 0.3554x - 0.9013 | 0.8801 |
| Parathion-methyl | y = -0.0754x + 4.0827 | 0.9482 | y = 0.3559x - 1.6327 | 0.8871 |
| Phoxim | y = -0.0598x + 3.8102 | 0.9543 | y = 0.3663x - 1.456 | 0.8907 |
| Methamidophos | y = -0.051x + 3.527 | 0.9302 | y = 0.4489x - 3.473 | 0.9112 |

**Table S4.** Conversion ratio of phosphate in OPs into $PO_4^{3-}$ by the photodegradation of AA-$TiO_2$@PS under visible light irradiation for 25 min

| OPs | Concentration of OPs | | Concentration of $PO_4^{3-}$ | Conversion ratio |
|---|---|---|---|---|
| | ($mg \cdot L^{-1}$) | ($\mu mol\ P \cdot L^{-1}$) | ($\mu mol\ P \cdot L^{-1}$) | |
| Chlopyrifos | 1.05 | 3.0 | 2.90 | 96.7 % |
| Malathion | 1.0 | 3.0 | 2.94 | 98.0 % |
| Parathion-methyl | 0.79 | 3.0 | 2.96 | 98.7 % |
| Phoxim | 0.89 | 3.0 | 2.93 | 97.7 % |
| Methamidophos | 0.42 | 3.0 | 2.96 | 98.7 % |