Electronic Supplementary Material (ESI) for RSC Advances.


# *ESI*

## Enhanced photocatalytic activity of $TiO_2$ activated by doping Zr and modifying Pd

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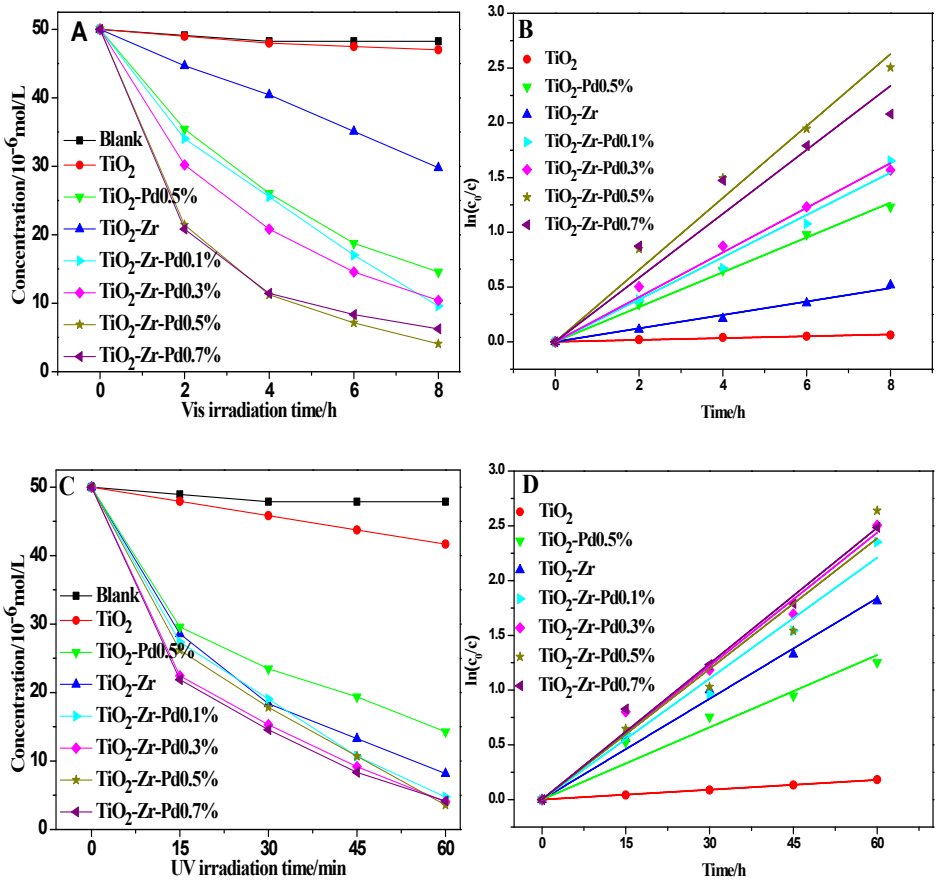


**Figure S1.** Photodegradation of 4-CP (A is under Vis irradiation and C is under UV irradiation) and relationship of ln ($c_0$/c) to reaction time (B is under Vis irradiation and D is under UV irradiation) for $TiO_2$, $TiO_2$-Pd0.5%, $TiO_2$-Zr and $TiO_2$-Zr-Pdx samples.

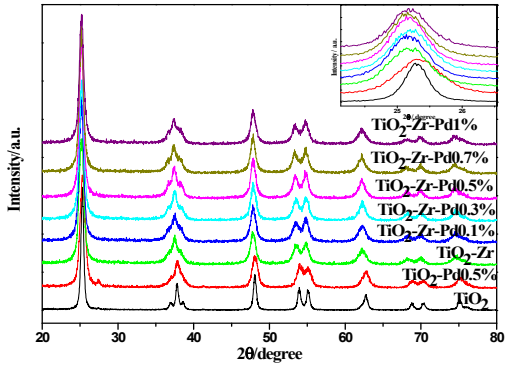


**Figure S2.** XRD patterns of $TiO_2$, $TiO_2$-Pd0.5%, $TiO_2$-Zr and $TiO_2$-Zr-Pdx samples. The inset is the enlargement of the XRD peaks for the (1 0 1) plane.

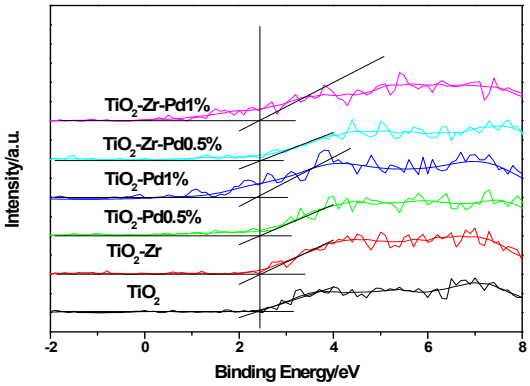


**Figure S3.** XPS valence band spectra for $TiO_2$, $TiO_2$-Zr, $TiO_2$-Pd0.5%, $TiO_2$-Pd1%, $TiO_2$-Zr-Pd0.5% and $TiO_2$-Zr-Pd1% samples.

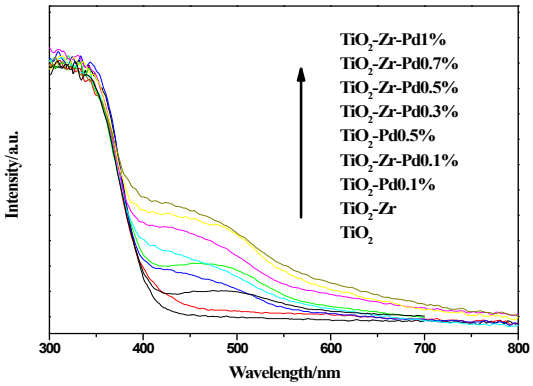


**Figure S4.** Diffuse reflectance UV-vis absorption spectra for $TiO_2$, $TiO_2$-Pd0.1%, $TiO_2$-Pd0.5%, $TiO_2$-Zr and $TiO_2$-Zr-Pdx samples.

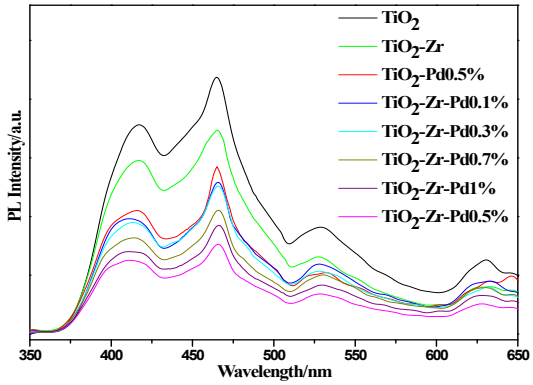


**Figure S5.** Photoluminescence spectra for $TiO_2$, $TiO_2$-Pd0.5%, $TiO_2$-Zr and $TiO_2$-Zr-Pdx samples.

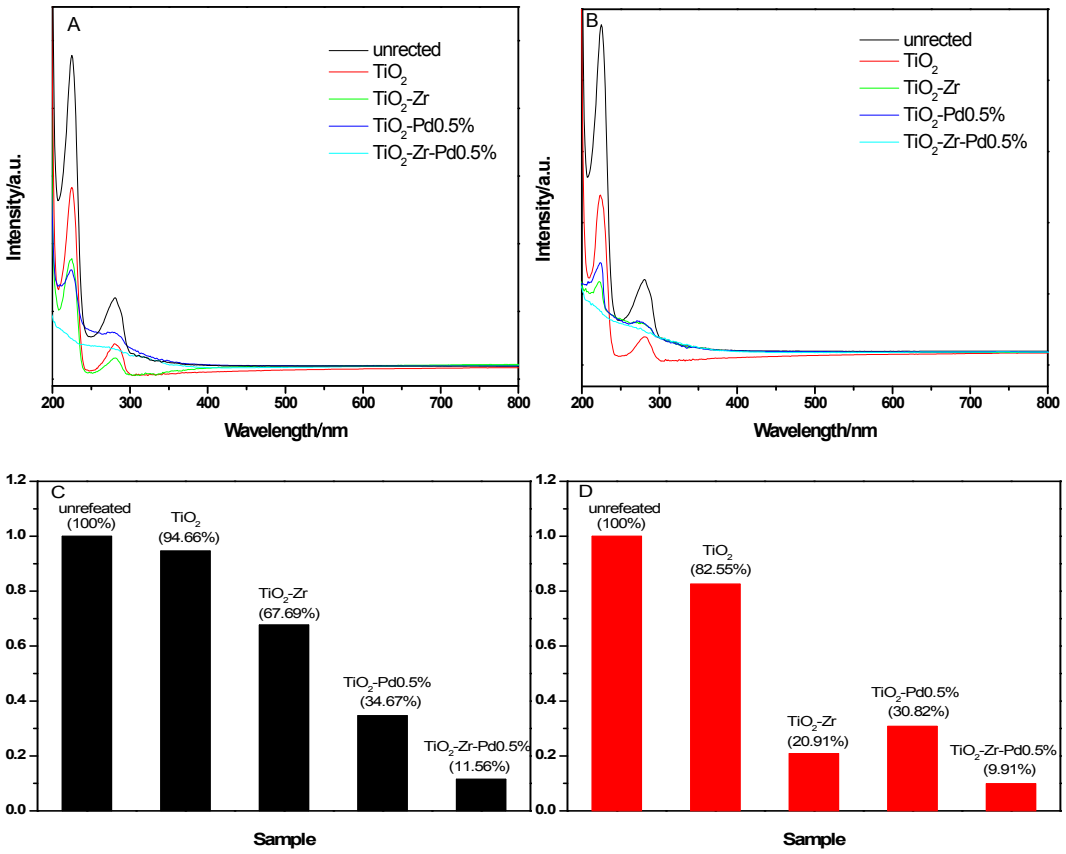


**Figure S6.** UV-Vis absorption spectra of the resultant reaction product under Vis irradiation (A) and UV irradiation (B) and the corresponding peak area of the absorption spectra (C is under Vis irradiation and D is UV irradiation) for $TiO_2$, $TiO_2$-Pd0.5%, $TiO_2$-Zr and $TiO_2$-Zr-Pdx samples.

The resultant reaction product can be measured by the UV-Vis absorption spectra after the irradiation. The absorption corresponding to the benzene ring (230 nm) decreases in the order of $TiO_2$ < $TiO_2$-Zr < $TiO_2$-Pd0.5% < $TiO_2$-Zr-Pd0.5% under Vis irradiation. Moreover, we use the peak areas of absorption spectra to represent the resultant amount of organic pollutants. It is found the fewest organic pollutants are detected for $TiO_2$-Zr-Pd0.5%, which is consistent with the discussion above (Figure 1).

**Table S1.** Lattice parameters, Cell volume, Crystal size and Specific surface area for $TiO_2$, $TiO_2$-Pd0.5%, $TiO_2$-Zr and $TiO_2$-Zr-Pdx samples.

| Sample | Lattice parameters | | Cell | Crystal size/nm | Specific |
|---|---|---|---|---|---|
| | a,b/Å | c/Å | volume/Å$^3$ | | Surface Area |
| $TiO_2$ | 3.783 | 9.501 | 136.0 | 13.0 | 63.8 |
| $TiO_2$-Pd0.5% | 3.781 | 9.499 | 135.8 | 12.6 | 75.4 |
| $TiO_2$-Zr | 3.802 | 9.540 | 137.9 | 11.3 | 85.1 |
| $TiO_2$-Zr-Pd0.1% | 3.802 | 9.554 | 138.1 | 11.8 | 83.3 |
| $TiO_2$-Zr-Pd0.3% | 3.803 | 9.542 | 138.0 | 11.1 | 87.0 |
| $TiO_2$-Zr-Pd0.5% | 3.804 | 9.551 | 138.2 | 12.3 | 81.0 |
| $TiO_2$-Zr-Pd0.7% | 3.803 | 9.562 | 138.3 | 12.0 | 83.1 |
| $TiO_2$-Zr-Pd1% | 3.801 | 9.573 | 138.3 | 11.5 | 84.4 |

**Table S2.** Eg for all the samples.

| sample | TiO$_2$ | $TiO_2$-Zr | $TiO_2$-Pd0.1% | $TiO_2$Pd0.5 % | $TiO_2$-Zr-Pd0.1% | $TiO_2$-Zr-Pd0.3% | $TiO_2$-Zr-Pd0.5% | $TiO_2$-Zr-Pd0.7% | TiO2-Zr-Pd1% |
|---|---|---|---|---|---|---|---|---|---|
| Eg (eV) | 3.10 | 3.08 | 3.08 | 3.10 | 3.08 | 3.08 | 3.08 | 3.06 | 3.04 |

**Table S3.** The lattice parameters and cell volume of $TiO_2$-Zr5%-Pd0.5%, $TiO_2$-Zr10%-Pd0.5% and $TiO_2$-Zr15%-Pd0.5%.

| Sample | Lattice parameters | | Cell volume /Å$^3$ |
|---|---|---|---|
| | a,b/ Å | c/Å | |
| $TiO_2$-Zr5%-Pd0.5% | 3.805 | 9.532 | 138.0 |
| $TiO_2$-Zr10%-Pd0.5% | 3.804 | 9.551 | 138.2 |
| $TiO_2$-Zr15%-Pd0.5% | 3.819 | 9.784 | 142.7 |

We have calculated the lattice parameters and cell volume of $TiO_2$-Zr5%-Pd0.5% and $TiO_2$-Zr15%-Pd0.5%. And it is clear that the lattice parameters and cell volume increase with the Zr content.