Electronic Supplementary Material

Detoxification of DON by photocatalytic degradation and quality evaluation of wheat

Shijia Wu,\textsuperscript{abcd} Fang Wang,\textsuperscript{b} Qian Li,\textsuperscript{b} You Zhou,\textsuperscript{b} Chuxian He,\textsuperscript{b} Nuo Duan*\textsuperscript{abcd}

\textsuperscript{a} State Key Laboratory of Food Science and Technology, Jiangnan University, Wuxi 214122, China

\textsuperscript{b} School of Food Science and Technology, Jiangnan University, Wuxi 214122, China

\textsuperscript{c} International Joint Laboratory on Food Safety, Jiangnan University, Wuxi 214122, China

\textsuperscript{d} Collaborative innovation center of food safety and quality control in Jiangsu Province, China

*Corresponding author. Fax: +86 510 85917023.
E-mail address: duannuo@jiangnan.edu.cn.
Preparation of NaYF₄:Yb,Tm@TiO₂

Typically, YCl₃•6H₂O, YbCl₃•6H₂O and TmCl₃•6H₂O with a stoichiometric ratio of 79.5: 20: 0.5 were dissolved in 6 mL oleic acid along with 15 mL 1-octadecene. Then the solutions were heated to 160 °C under the N₂ atmosphere to form a homogeneous solution. After the obtained solution was cooled to room temperature, 10 mL of a methanol solution containing 4 mmol of NH₄F and 2.5 mmol of NaOH was added dropwise. The solution was stirred and heated to completely evaporate the methanol. Then, the solution was heated to 300 °C and maintained for 1 h under the N₂ atmosphere. After the solution was cooled naturally, the obtained nanoparticles were precipitated by adding ethanol and were separated by centrifugation. The final precipitation was dispersed in cyclohexane to obtain 0.1 M NaYF₄:Yb,Tm nanomaterial dispersion. 0.05 g of cetyltrimethyl ammonium bromide (CTAB) and 1 mL of cyclohexane with prepared nanoparticles were added to 20 mL of deionized water stirring until it formed a milky solution. The obtained solutions were heated to 80 °C to evaporate the cyclohexane until the milky solution became transparent. After the mixture cooled to room temperature, the product was collected by centrifugation, washed with deionized water two times, and finally re-dispersed in 10 mL of isopropanol. Then 10 mL isopropanol containing 36 µL TDAA was slowly added to the above solution. The solution was stirred continuously for 12 h at room temperature. The TiO₂ coated NaYF₄:Yb³⁺,Tm³⁺ nanoparticles were collected by centrifugation, washed with deionized water and ethanol several times, and then dried at 70 °C in air. To finally obtain a crystalline anatase TiO₂ shell, the products were annealed at 500 °C for 3 h in an oven under an atmosphere of air.
UPLC -TQD-MS detection conditions

UPLC was performed on a Waters Acquity UPLC system equipped with an ultraviolet detector. Chromatography separation was achieved using a Waters Acquity UPLC BEH C18 column (2.1 mm × 50 mm). The column temperature was 35°C, the injection volume was 5 μL and the flow rate was 0.3 mL/min. The mobile phase comprised (A) acetonitrile and (B) 0.1% formic acid aqueous solution. The total operation time was 10 min.

Mass spectrometry was performed on a Waters Synapt Q-TOF system fitted with an electron spray ionization source. The ESI source operated in the positive ionization mode. The optimum conditions were set as follows: capillary voltage to 2.5 kV, cone voltage to 30 kV, source temperature to 120°C, and desolvation temperature to 350°C. The gas flow rate for cone and desolvation were 50 L/h and 600 L/h, respectively. The mass spectrometry was operated in a scan range from 200 m/z to 1000 m/z.

Recyclability of photocatalyst

The photocatalytic activity of photocatalyst was measured in five consecutive DON degradation reactions. As shown in Fig. S2, the degradation rate decreased from 100% to 92% after five cycle tests. Considering the inevitable loss in the recycling
process (such as the centrifuge, washing with distilled water and drying). UCNP@TiO$_2$ has good stability and can be used as a recyclable photocatalyst.

![Graph showing the recyclability of UCNP@TiO$_2$ nanoparticles for DON degradation](Image)

**Fig. S2.** The recyclability of the UCNP@TiO$_2$ nanoparticles for the degradation of DON (the UCNP@TiO$_2$ nanoparticles was 6 mg·mL$^{-1}$, DON 10 µg·mL$^{-1}$)

### Free radical capture experiments

Generally, the reactive oxygen species, including •OH, h$^+$ and •O$_2^-$, is produced in the photocatalytic reaction. tBuOH was used for trapping the hydroxyl radical •OH, EDTA-2Na as an h$^+$ scavenger, and N$_2$ as a detective molecular to•O$_2^-$ . Three captured agents were added to the reaction system respectively under the same reaction conditions. The results (Fig. S3) showed that the degradation rate of DON was decreased slightly with N$_2$ blowing, indicating that •O$_2^-$ is not the main effect. The degradation rate decreased both with EDTA-2Na and tBuOH, but the latter was much higher than the former. Based on the above analysis, it can be concluded that •OH, with its strong oxidation ability, is mainly responsible for the degradation of DON in the photocatalytic process.
Fig. S3. Photodegradation rate curves of DON with the addition of h+ and •OH scavengers and N₂ under the irradiation of simulated sunlight.
| Amino acids (g/100g) | 0     | 30    | 60    | 90    |
|----------------------|-------|-------|-------|-------|
| Asp                  | 0.575 | 0.497 | 0.503 | 0.532 |
| Glu                  | 3.236 | 3.585 | 3.268 | 3.442 |
| Ser                  | 0.396 | 0.360 | 0.353 | 0.365 |
| His                  | 0.246 | 0.203 | 0.192 | 0.227 |
| Gly                  | 0.438 | 0.439 | 0.403 | 0.421 |
| Thr                  | 0.313 | 0.270 | 0.274 | 0.287 |
| Arg                  | 0.457 | 0.457 | 0.443 | 0.442 |
| Ala                  | 0.398 | 0.366 | 0.366 | 0.378 |
| Tyr                  | 0.192 | 0.186 | 0.181 | 0.161 |
| Sys-S                | 0.119 | 0.112 | 0.071 | 0.069 |
| Val                  | 0.511 | 0.493 | 0.469 | 0.493 |
| Met                  | 0.158 | 0.121 | 0.125 | 0.122 |
| Phe                  | 0.505 | 0.501 | 0.475 | 0.497 |
| Ile                  | 0.435 | 0.419 | 0.401 | 0.421 |
| Leu                  | 0.743 | 0.717 | 0.678 | 0.708 |
| Lys                  | 0.277 | 0.233 | 0.245 | 0.251 |
| Pro                  | 1.737 | 1.504 | 1.689 | 1.349 |
| EAA                  | 3.032 | 2.844 | 2.757 | 2.869 |
| TAA                  | 10.736| 10.463| 10.136| 10.166|
| EAA/TAA              | 0.282 | 0.272 | 0.272 | 0.282 |
### Table S2 Effect of photocatalytic technology on amino acids content in wheat

| Amino acids | (g/100g) | 0   | 30  | 60  | 90  |
|-------------|----------|-----|-----|-----|-----|
| Asp         |          | 0.559 | 0.509 | 0.510 | 0.507 |
| Glu         |          | 3.250 | 3.597 | 3.342 | 3.479 |
| Ser         |          | 0.410 | 0.372 | 0.355 | 0.375 |
| His         |          | 0.260 | 0.215 | 0.216 | 0.202 |
| Gly         |          | 0.452 | 0.451 | 0.411 | 0.419 |
| Thr         |          | 0.327 | 0.282 | 0.275 | 0.279 |
| Arg         |          | 0.471 | 0.469 | 0.435 | 0.449 |
| Ala         |          | 0.412 | 0.378 | 0.374 | 0.365 |
| Tyr         |          | 0.206 | 0.198 | 0.166 | 0.179 |
| Sys-S       |          | 0.133 | 0.814 | 0.071 | 0.072 |
| Val         |          | 0.525 | 0.505 | 0.481 | 0.491 |
| Met         |          | 0.172 | 0.133 | 0.129 | 0.117 |
| Phe         |          | 0.519 | 0.513 | 0.483 | 0.499 |
| Ile         |          | 0.449 | 0.431 | 0.408 | 0.419 |
| Leu         |          | 0.717 | 0.729 | 0.691 | 0.718 |
| Lys         |          | 0.291 | 0.245 | 0.241 | 0.244 |
| Pro         |          | 1.751 | 1.316 | 1.550 | 2.006 |
| EAA         |          | 3.090 | 2.928 | 2.798 | 2.857 |
| TAA         |          | 10.904 | 10.426 | 10.165 | 10.821 |
| EAA/TAA     |          | 0.283 | 0.281 | 0.275 | 0.264 |
Table S3 Comparison of the developed method with previous methods for degradation DON in wheat

| Reagents            | Dosage      | Initial DON   | Reaction time | Removal rate | Reference                  |
|---------------------|-------------|---------------|---------------|--------------|-----------------------------|
| miling              | 20 μg·mL⁻¹ |               |               | 19%          | Bullerman et al., 2007      |
| thermal             | 250 °C      | 3 μg·mL⁻¹     | 15 min        | 31.8%        | Numanoglu et al., 2012      |
| electron beam       | 55.8 kGy   | 5 μg·mL⁻¹     |               | 17.6%        | Stepanik et al., 2007       |
| sodium carbonate    | 0.1 M       | 3mg·kg⁻¹      | 24 h          | 89.7%        | Trenholm et al., 1992       |
| aqueous ozone       | 80 mg·mL⁻¹ | 10 μg·mL⁻¹    | 7 min         | 83%          | Sun et al., 2016            |
| strain S. cerevisiae| 100 μg·mL⁻¹|               | 24 h          | 33%          | Chlebicz et al., 2019       |
| strain WSN05-2      | 1000 μg·mL⁻¹|              | 7 d           | 90%          | Ikunaga et al., 2011        |
| dendritic-Like α-Fe₂O₃ | 0.1 mg·mL⁻¹ | 4 μg·mL⁻¹    | 2 h           | 90.3%        | Wang et al., 2019           |
| UCNP@TiO₂           | 6 mg·mL⁻¹  | 10 μg·mL⁻¹    | 60 min        | 100%         | This study                  |

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