Supporting information

The stabilization and utilization of pyrite under light irradiation: the discussion of photocorrosion resistance

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**Figure S2.** XRD pattern of GO and pyrite and GO-pyrite

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Tables

Table S1. The fitting results\(^a\) of fluorescence lifetime curves of pyrite and GO-pyrite samples

| Samples  | Lifetime (ns) | Pre-exponential Factors B | Average lifetime (ns) |
|----------|---------------|----------------------------|-----------------------|
| pyrite   | \(\tau_1=0.60\) | \(B_1=10799.89\)          | 0.78                  |
|          | \(\tau_2=2.58\) | \(B_2=1173.79\)           |                       |
| GO-pyrite| \(\tau_1=12.94\) | \(B_1=82.05\)             | 0.94                  |
|          | \(\tau_2=0.85\) | \(B_2=10886.02\)          |                       |

\(^a\)\(y(t) = B_1 e^{-x/\tau_1} + B_2 e^{-x/\tau_2} + y_0\), \(x\)-time, ns; \(y\)-intensity(a.u.); \(B\)-Pre-exponential factors; \(\tau\)-lifetime, ns
Table S2. The $E_F$, CB, VB energy level and bandgaps of pyrite and GO-pyrite.

| sample     | Fermi Level (E$_F$, vs vacuum level)$^a$ | Fermi Level (E$_F$, vs RHE)$^b$ | Valance band maximum (E$_{VB}$, vs RHE)$^c$ | Conduction band minimum (E$_{CB}$, vs RHE)$^d$ | Band gap (eV)$^e$ |
|------------|-----------------------------------------|----------------------------------|---------------------------------------------|-----------------------------------------------|------------------|
| Pyrite     | -4.31                                   | -0.19                            | 0.15                                        | -0.73                                         | 0.88             |
| GO-pyrite  | -4.61                                   | 0.11                             | 0.45                                        | -0.32                                         | 0.77             |

$^a$ Determined from the intersection point of the secondary electron cutoff shown in Figure S6 b, d;

$^b$ According to conversion of energy level of vacuum (-4.5 eV) to energy level vs RHE (0.0 V)$^3$, $E_F$ (vs RHE) = -4.5 - $E_F$ (vs vacuum level);

$^c$ $E_{VB}$ is calculated from valence band edge determined by SR-PES spectra shown in Figure S6 a, c;

$E_{VB}$ = |the value below fermi level| + $E_F$;

$^d$ $E_{CB}$ = Bandgap - |$E_{VB}$|;

$^e$ Bandgap is estimated from $[h\nu F(r)]^2$ versus $h\nu$ curve shown in Supplementary Figure S5;

Table S3. The BET results of pyrite and GO-pyrite.

| Samples     | $S_{BET}(m^2\cdot g^{-1})$ |
|-------------|-----------------------------|
| Pyrite      | 0.883                       |
| GO-pyrite   | 10.116                      |
Experiments

Preparation of GO-pyrite. The pyrite was ground with an agate mortar, and then, it was sieved through a 100-mesh sieve. After it was rinsed 6 times with ultrapure water, the pyrite was dried using a freeze dryer and was stored in a closed brown glass vial until used. A GO solution with a concentration of 12 mg·mL$^{-1}$ was dispersed using an ultrasonic cleaning instrument for 30 min until the GO dissolved. One milliliter of 12 mg·mL$^{-1}$ GO dispersion solution and 0.2 g of 100 mesh natural pyrite were ground for 5 min in the agate mortar. Then, the mixture was placed in the fume hood and left to dry naturally. Finally, the dry samples (GO-pyrite) were sealed and stored in the dark until used.

Characterization. The microstructure was analyzed using SEM (JSM-7900F, Japan). The crystal structure of the catalysts was determined using XRD (X’pert Powder, Holland). The FTIR spectra was recorded using a Thermo Nicolet 6700 FTIR apparatus. The Raman spectrum was recorded using a LabRAM Aramis microscope (HJY, France). The XPS was performed on a Perkin-Elmer PHI 1600ESCA X-ray photoelectron spectroscope. The BET surface area measurement was performed using an ASAP2000 (Micromeritics, USA) surface area analyzer. A UV-Vis NIR (ultraviolet-visible near-infrared) (lambda 750, USA) instrument was used to measure the light absorbance of the sample. The separation efficiency of the photogenerated electrons and holes was determined using a fluorescence spectrometer (PL, F98, China). The excitation wavelength was 320 nm. The SRPES (NSRL, Hefei, China) was used to
study the valence band energy level of the sample. The CV curves, EIS and I-T curves were measured using a quartz cell with a three-electrode system at the electrochemical workstation (CHI 660e, Chenhua Instrument Company Corporation, Ltd., China). The work electrode was pyrite or GO-pyrite. The counter electrode was platinum, and the reference electrode was saturated calomel. The electrolyte was 0.1 M NaSO$_4$ solution. The preparation method for the working electrode was as follows: 0.05 g of ethyl cellulose and 3 mL of anhydrous ethanol were added to a beaker, and then, the mixture was ultrasonically dispersed for 30 min to obtain an ethyl cellulose solution. The work electrode was made by sticking pyrite or GO-pyrite to fluorine-doped conducting glass (FTO) with the ethyl cellulose solution.

**Stability measurement.** Iron ion leaching directly reflects the corrosion of pyrite. Ten milliliters of hydrochloric acid with pH = 3 and 0.2 g of GO-pyrite were placed in a 50 mL glass beaker. The mixture was allowed to react for 0–10 h in the dark and in light irradiation conditions. The light source was a high-pressure xenon long-arc lamp (500 W). The spectral range of the light source (the high-pressure xenon long-arc lamp) was 300–800 nm. The control experiments were conducted using the same procedures with certain amounts of pyrite without GO coating. The samples were withdrawn from the beaker at regular time intervals using a syringe and were passed through a 0.45 μm polytetrafluoroethylene filter. Then, the dissolved ferrous ions were determined using 1, 10-phenanthroline spectrophotometry. The total dissolved iron ions were quantified after adding hydroxylamine hydrochloride to the filtered solution. The samples were
analyzed using a UV-vis spectrophotometer (UV-2550, Shimadzu, Japan) at a maximum wavelength of 510 nm.

**Photocatalytic measurement.** The photocatalytic reaction was initiated using a high-pressure xenon long-arc lamp (500 W) with the spectral range of 300–800 nm. The RhB (100 mg·L⁻¹) stock solution was prepared and storing in the dark to avoid any photochemical degradation. The initial pH value of the RhB solution was 6.2. All of the photo-degradation experiments were conducted in 50 mL conical flasks covered with aluminum foil. The reaction suspension was prepared by adding 0.03 g of GO-pyrite to 20 mL of RhB (30 mg·L⁻¹). The suspension in the conical flasks was mixed with a magnetic stirrer at room temperature. The suspensions were stirred for 2 h in the dark to maintain the equilibrium of sorption-desorption balance. The first sample was obtained at that moment the light was turned on. Other samples were withdrawn from the conical flasks at regular time intervals using a syringe and were passed through a 0.45 μm membrane filter. Then, the concentration of the RhB in the samples was determined using a UV-vis spectrophotometer (UV-2550, Shimadzu, Japan) at a maximum wavelength of 554 nm.