1	Electronic	Supplementary	Information
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- 3 Synthesis of Rare Earth Doped TiO₂ Nanorods as Photocatalysts for Lignin
- 4 Degradation
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- Liang Song^{a,b,*}, Xueyuan Zhao^a, Lixin Cao^c, Ji-Won Moon^b, Baohua Gu^b, Wei Wang^{b,c,*}
- 8 a. Key Laboratory of Biofuel, Chinese Academy of Sciences, Qingdao Institute of Bioenergy and Bioprocess Technology, Qingdao,
- 9 Shandong 266101, P.R. China. Email: songliang@qibebt.ac.cn
- 10 b. Environmental Sciences and Biosciences Divisions, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA.
- c. Institute of Materials Science and Engineering, Ocean University of China, Qingdao, Shandong 266100, P.R. China. Email:
 wangw@ouc.edu.cn
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- 14Table of Contents
- 15 Part I. Calculation of energy bandgap of Ti-based oxide photocatalysts
- 16 Part II. Calculation of apparent reaction rate constants
- 17 Part III. Supplementary figures
- 18 Part IV. Supplementary table
- 19 Part V. References
- 20
- 21

1 I. Calculation of bandgap energy of Ti-based oxide photocatalysts

In order to quantify the effect of RE³⁺ ions modification on the bandgap of nanorods, the bandgap energy was calculated by Kubelka–Munk theory. According to the hypothesis of plural scattering, diffuse reflection spectrum can be transformed into a plot of the square root of $F(R)\hbar v$ versus the energy of irradiation light. The Kubelka–Munk function¹ is shown as in Eq. (1).

7
$$F(R) = \frac{(1-R)^2}{2R}$$
 Eq. (1)

8 Here, *R* is the measured reflectance ($R = R_{sample}/R_{reference}$). The use of F(R) as the 9 equivalent of absorbance relies on the assumption that the scattering coefficients are 10 consistent throughout the reference samples². From Yeong Kim's results, the optical 11 absorption behavior of lamellar titanate is consistent with an indirect gap semiconductor³. 12 So, bandgap can be estimated from the plot of the square root of $F(R)\hbar v$ versus photon 13 energy (as shown in Eq. (2)). Here, $\hbar v$ is photon energy, and *Eg* is bandgap energy of 14 semiconductor.

15
$$\sqrt{F(R)hv} = c(hv - E_g)$$
 Eq. (2)

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1 II. Calculation of apparent reaction rate constants

Decrement of MO concentration (*C*) during the treatment time (*t*) was described by the
first order kinetics, as shown in Eq. (3).

$$r = -\frac{d(C)}{dt} = kC^n$$
 Eq. (3)

5 where *r*, *k* and *n* represent the rate of photocatalytic degradion of dye, the apparent 6 reaction rate constant, and reaction order, respectively. To simplify the heterogeneous 7 catalytic process, the initial concentration of the methyl orange substrate C_0 was kept 8 constant. The apparent first order reaction rate constant *k* (s⁻¹) was obtained by fitting the 9 experimental data from Eq. (4).

$$-\ln\left(\frac{C}{C_0}\right) = kt$$
Eq. (4)

11 The *k* values were determined by the slope of the linear curve (plotting $-ln(C/C_0)$ 12 versus time). Consequently, reaction half-times $t_{1/2}$ were calculated using Eq. (5).

$$t_{1/2} = \frac{ln2}{k}$$
 Eq. (5)

14

1 III. Supplementary figures











Fig. S4 UV-Vis reflectance spectra of TiO₂ nanorods and RE ions doped TiO₂
photocatalysts. (a) undoped TiO₂ nanorods, (b) La-TiO₂ nanorods, (c) Ce-TiO₂ nanorods,
(d) Pr-TiO₂ nanorods, (e) Sm-TiO₂ nanorods, (f) Eu-TiO₂ nanorods, (g) Tb-TiO₂
nanorods, and (h) Er-TiO₂ nanorods.



Fig. S5 Photodegradation of MO in aqueous solution. Initial concentration of dye was 20
mg L⁻¹ and concentration of catalysts was 1 g L⁻¹. Data symbols stand for:
∞photodegradation of MO without catalysts, photocatalytic degradation of MO with
catalyst OP25 TiO₂, OTiO₂ nanorods, □La doped TiO₂ nanorods, ⊕Ce doped TiO₂
nanorods, *Pr doped TiO₂ nanorods, □Sm doped TiO₂ nanorods, □Eu doped TiO₂
nanorods, * Tb doped TiO₂ nanorods, and SEr doped TiO₂ nanorods.





Fig. S7 UV-Vis absorption spectra of lignin solution before irradiation and after 3h UV
irradiation. Reaction condition: 100mL lignin aqueous solution with a concentration of

- 4 250 mg L⁻¹ was illuminated under 100 W near-ultraviolet light (UVA) without catalyst.
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1 IV. Supplementary table

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Table S1 Assigned IR peaks of lignin

Wavenumber (cm ⁻¹)	Assigned chemical structure
1596	C=C stretching in aromatic lignin ⁴
1504	C=C vibrations of the aromatic lignin ^{4, 7-9}
1464	C-H deformations in methyl, methylene and
1404	methoxyl groups in lignin ^{4, 5}
1425	C-H deformations in methyl, methylene and
1425	methoxyl groups in lignin ^{4, 5}
1335	C-O vibration in syringyl derivatives ⁴
1228	Aromatic ring vibrations of syringl and
1328	guaiacyl ¹⁰
1262	C-O stretching in lignin ⁴
1225	C-O stretching ⁹

3

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