

Supporting Information of

New magnetically assembled electrode consisting of magnetic activated carbon particles and Ti/Sb-SnO₂ for a more flexible and cost-effective electrochemical oxidation wastewater treatment

**Fanxi Zhang^a, Dan Shao^{a*}, Changan Yang^a,
Hao Xu^{b*}, Jin Yang^a, Lei Feng^a, Sizhe Wang^a, Yong Li^a,
Xiaohua Jia^a, Haojie Song^{a*}**

^a School of Materials Science and Engineering, Shaanxi Key Laboratory of Green Preparation and Functionalization for Inorganic Materials, Shaanxi University of Science & Technology, Xi'an, 710021, China

^b Department of Environmental Engineering, Xi'an Jiaotong University, Xi'an, 710049, China

Corresponding Authors

Dan Shao*: shaodan@sust.edu.cn

Hao Xu*: xuhao@mail.xjtu.edu.cn

Haojie Song*: songhaojie@sust.edu.cn

Electrode preparation detail

The AEs (magnetic activated carbon) were prepared by the chemical coprecipitation method from commercial activated carbon granules. The preparation procedure of AEs is divided into two steps:

(1) Pretreatment: the activated carbon was acid-washed with 1 wt % HCl at 98 °C for 30 min, and finally washed thoroughly with deionized water and dried under natural conditions.

(2) The pretreated activated carbon was added into the precipitation liquid mixed with Fe(II) salts ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) and Fe(III) salts ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) ($\text{Fe}^{3+} : \text{Fe}^{2+} = 2 : 1$ (mole ratio)). The mixture was heated to 80 °C, and the pH was adjusted to 9 with NaOH aqueous solution. The mixture was fully reacted and mechanically stirred for 120 min. Finally, after the reaction, let the beaker stand and precipitate, remove the supernatant, and repeatedly rinse with ultra-pure water. Then put the remaining turbid liquid into the oven at 105 °C to dry.

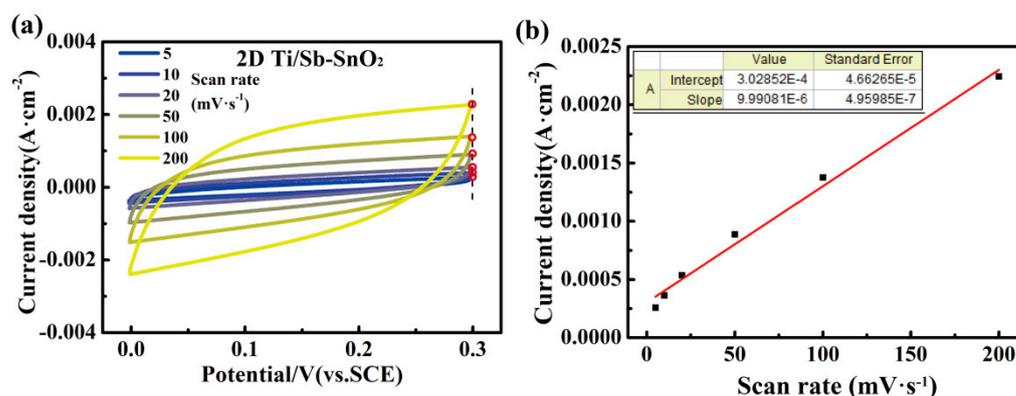
The electrodeposition-thermal oxidation technique described in the prior work (Reference S1) was used to fabricate a 2D Ti/Sb-SnO₂ sheet (ME).

Reference S1

Shao, D.; Yan, W.; Li, X.; Xu, H. Fe₃O₄/Sb-SnO₂ Granules Loaded on Ti/Sb-SnO₂ Electrode Shell by Magnetic Force: Good Recyclability and High Electro-oxidation Performance. *ACS Sustainable Chemistry & Engineering* **2015**, *3*, 1777-1785, doi:10.1021/acssuschemeng.5b00321.

Voltammetric charge calculation

Voltammetric charges (q^*) obtained from narrow cyclic voltammograms (potential range 0-0.3 V (vs. SCE)) at various potential scan rates in 0.5 M Na_2SO_4 solution (Fig.S1) would essentially negate the effect of Faraday reactions and reflect the actual surface area and quantity or quality of active sites. The electrochemical workstation used the integral of the current times the time to calculate the q^* value. The number of total active sites (complete electrochemical active surface) and the number of outer accessible active sites (partial electrochemical active surface) that could easily contact the solution, respectively, are reflected by the q^* values obtained under scan rates of 5 $\text{mV}\cdot\text{s}^{-1}$ and 200 $\text{mV}\cdot\text{s}^{-1}$ in this study. The C_{dl} values were also obtained from the narrow CV curves according to Reference S2, and the calculation process is illustrated as the following example,



Scheme S1. Illustrations of the C_{dl} calculation procedures: (a) Obtaining current density data from the narrow CV curves; (b) Linearly fitting of the current density.

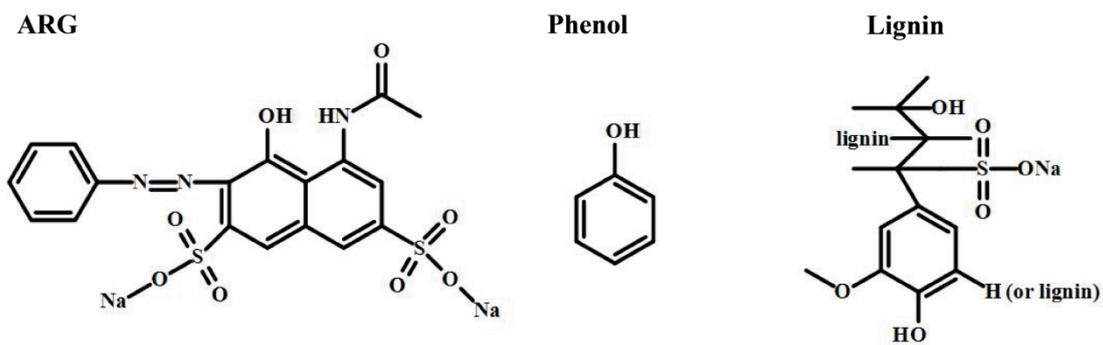
where the calculated C_{dl} value of 2D Ti/Sb-SnO₂ is 9.99 $\text{mF}\cdot\text{cm}^{-2}$.

Reference S2

Montilla, F.; Morallón, E.; De Battisti, A.; Vázquez, J.L. Preparation and Characterization of

Antimony-Doped Tin Dioxide Electrodes. Part 1. Electrochemical Characterization. *The Journal of*

Physical Chemistry B **2004**, *108*, 5036-5043, doi:10.1021/jp037480b.



Scheme S2. Structural formulas of the three pollutants used in this study.

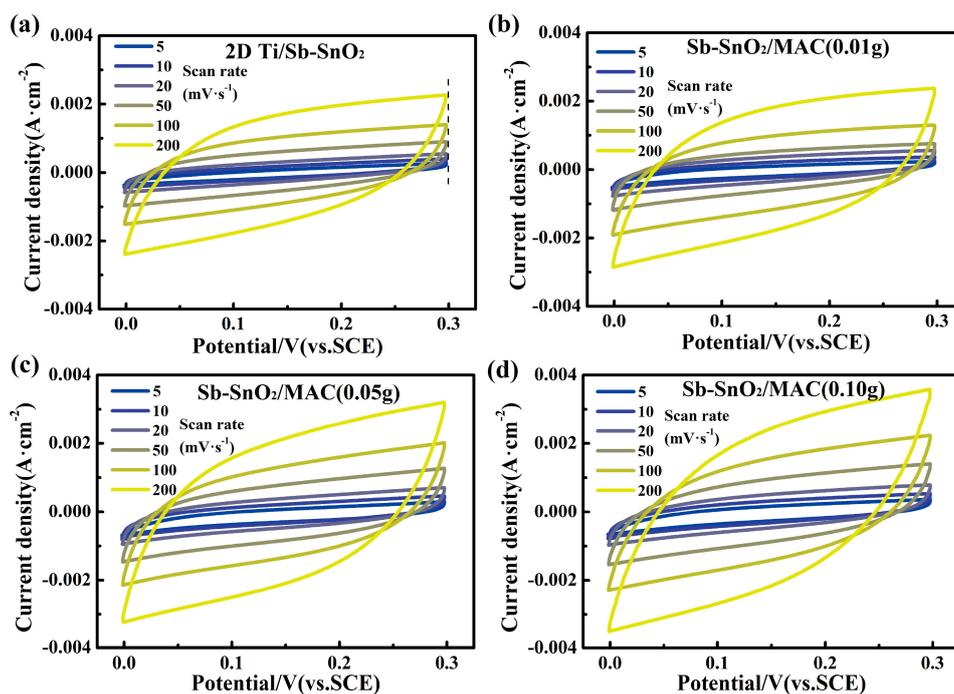


Figure S1. Narrow CV curves at different scan rates in 0.5 M Na₂SO₄ solution: (a) 2D Ti/Sb-SnO₂; (b) Sb-SnO₂/MAC(0.01g); (c) Sb-SnO₂/MAC(0.05g); (d) Sb-SnO₂/MAC(0.10g).

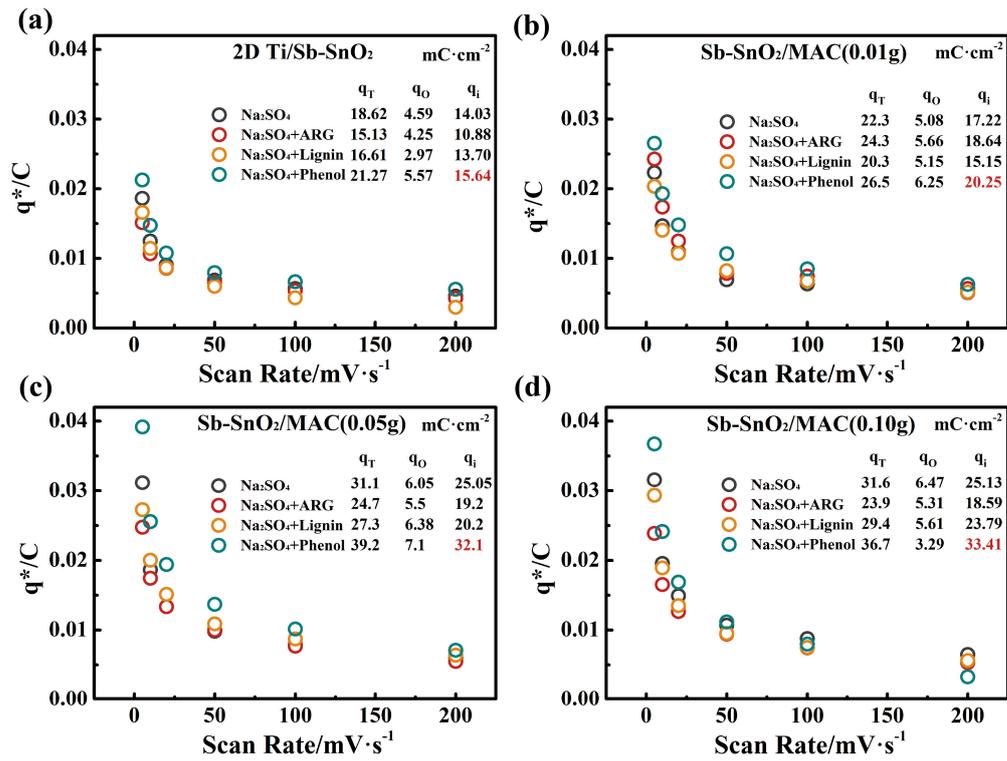


Figure S2. Voltammetric charges obtained from the narrow CV curves (from 0 to 0.3 V (vs. SCE)) at different scan rates in 0.5 M Na₂SO₄ solution and 0.5 M Na₂SO₄ solution with 2000 ppm of ARG, lignin or phenol: (a) 2D Ti/Sb-SnO₂; (b) Sb-SnO₂/MAC(0.01g); (c) Sb-SnO₂/MAC(0.05g); (d) Sb-SnO₂/MAC(0.10g).

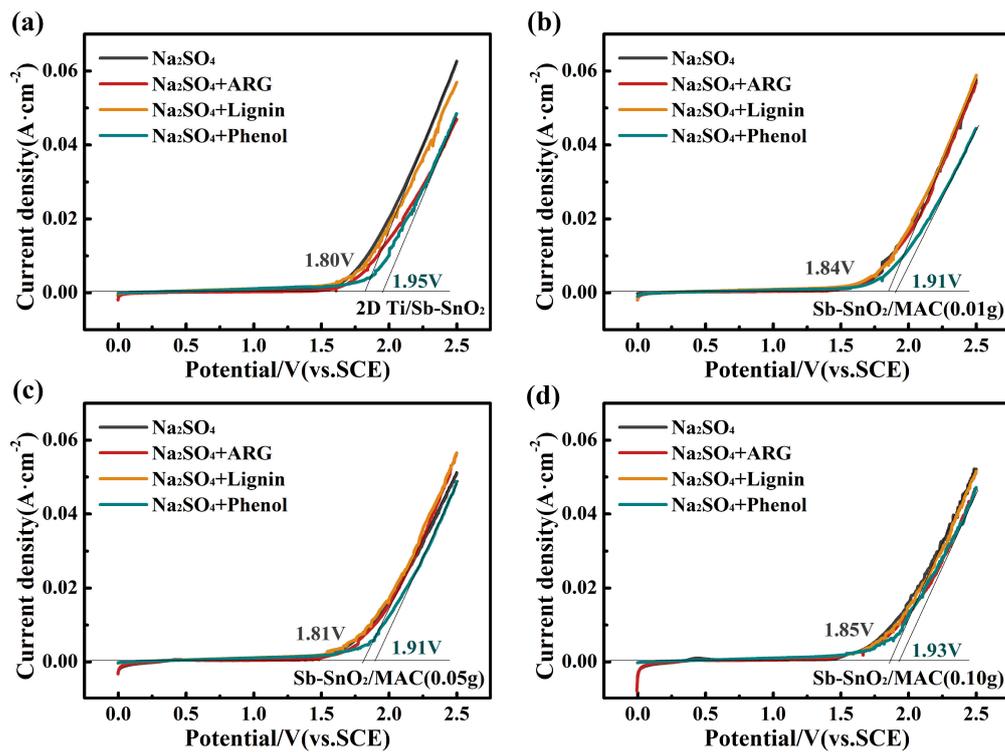


Figure S3. LSV curves of the electrodes (0 to 2.5 V (vs. SCE); scan rate: $0.001 \text{ V} \cdot \text{s}^{-1}$) in 0.5 M Na_2SO_4 solution and 0.5 M Na_2SO_4 solution with 2000 ppm of ARG, lignin or phenol: (a) 2D Ti/Sb-SnO₂; (b) Sb-SnO₂/MAC(0.01g); (c) Sb-SnO₂/MAC(0.05g); (d) Sb-SnO₂/MAC(0.10g).

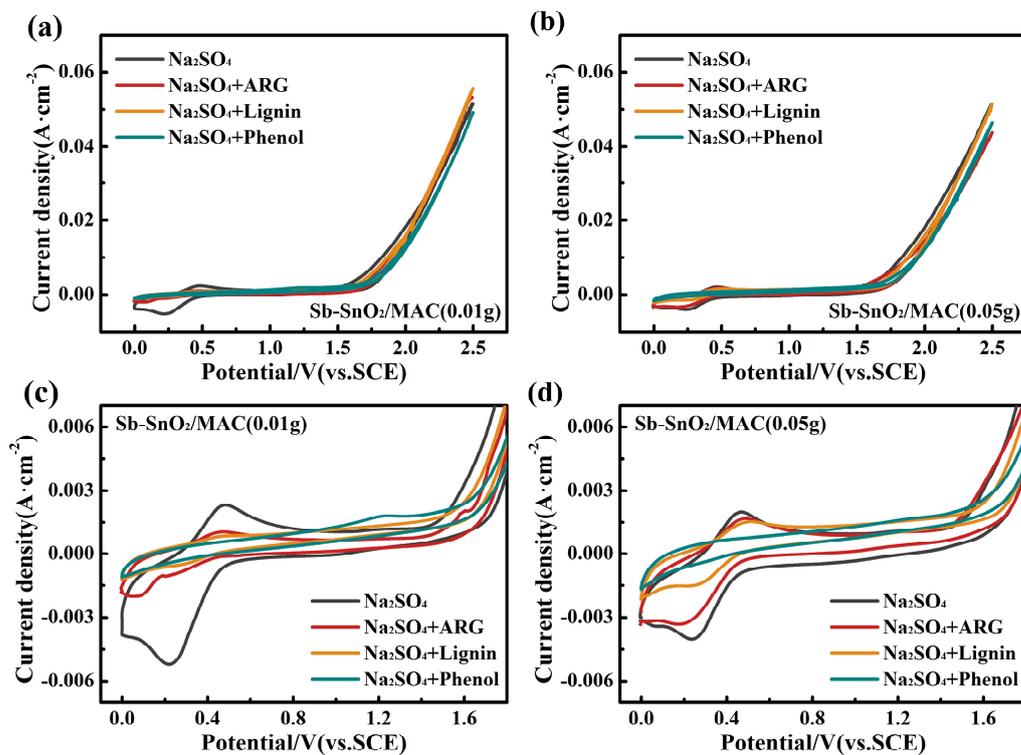


Figure S4. Normal CV curves of the electrodes (0-2.5 V (vs. SCE); scan rate: $0.01 \text{ V} \cdot \text{s}^{-1}$) in $0.5 \text{ M Na}_2\text{SO}_4$ solution and $0.5 \text{ M Na}_2\text{SO}_4$ solution with 2000 ppm of ARG, lignin or phenol: (a) $\text{Sb-SnO}_2/\text{MAC}(0.01\text{g})$, (b) $\text{Sb-SnO}_2/\text{MAC}(0.05\text{g})$, (c) Partial enlarged view of $\text{Sb-SnO}_2/\text{MAC}(0.01\text{g})$, (d) Partial enlarged view of $\text{Sb-SnO}_2/\text{MAC}(0.05\text{g})$.

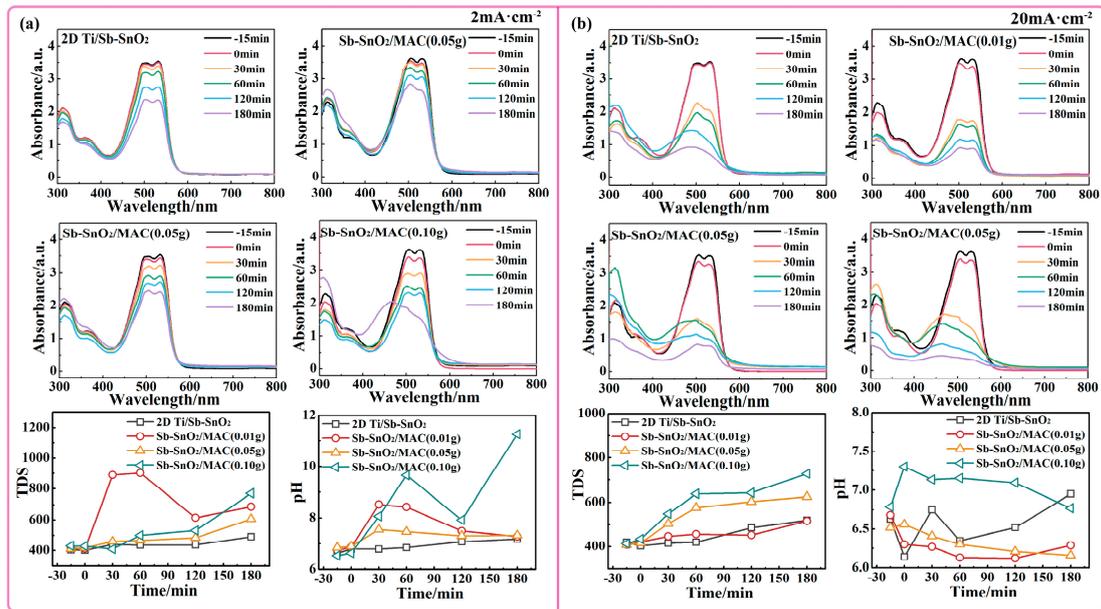


Figure S5. (a) Other details of ARG degradation (initial ARG concentration of 200 ppm, anode area of 9 cm^2 , solution volume of 250 mL, supporting electrolyte of 125 ppm of Na_2SO_4 , room temperature): (a) Variations of UV-Vis spectra, TDS and pH values of solution at low current density of $2 \text{ mA} \cdot \text{cm}^{-2}$; (b) Variations of UV-Vis spectra, TDS and pH values of solution at higher current density of $20 \text{ mA} \cdot \text{cm}^{-2}$.

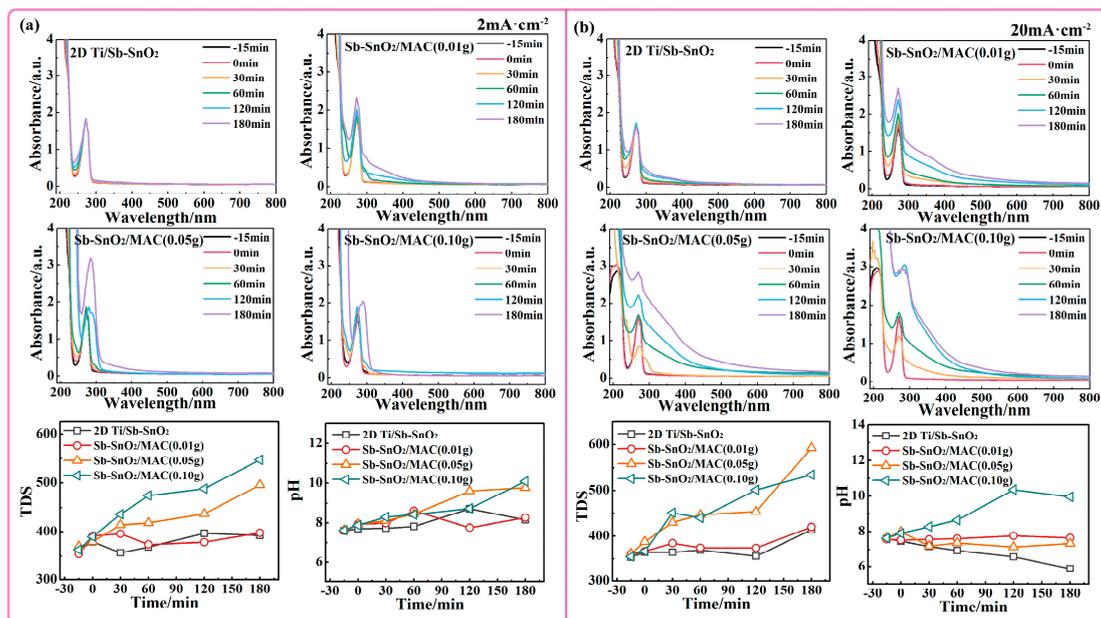


Figure S6. Other details of phenol degradation (initial phenol concentration of 100 ppm, anode area of 9 cm^2 , solution volume of 250 mL, supporting electrolyte of 125 ppm of Na_2SO_4 , room temperature): (a) Variations of UV-Vis spectra, TDS and pH values of solution at low current density of $2 \text{ mA} \cdot \text{cm}^{-2}$; (b) Variations of UV-Vis spectra, TDS and pH values of solution at higher current density of $20 \text{ mA} \cdot \text{cm}^{-2}$.

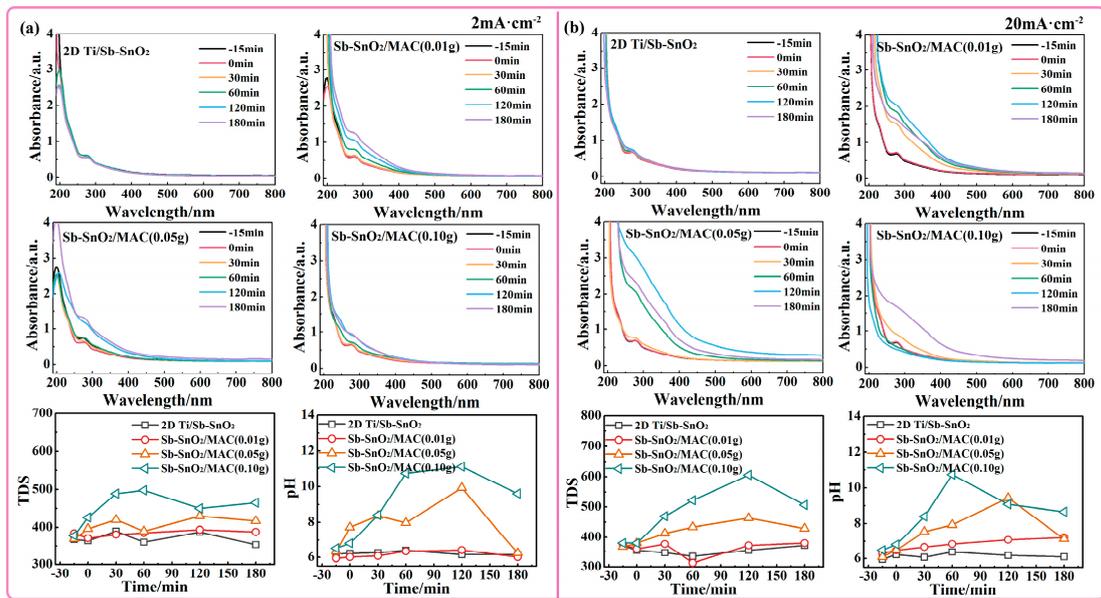


Figure S7. Other details of lignin degradation (initial lignin concentration of 100 ppm, anode area of 9 cm^2 , solution volume of 250 mL, supporting electrolyte of 125 ppm of Na_2SO_4 , room temperature): (a) Variations of UV-Vis spectra, TDS and pH values of solution at low current density of $2 \text{ mA} \cdot \text{cm}^{-2}$; (b) Variations of UV-Vis spectra, TDS and pH values of solution at higher current density of $20 \text{ mA} \cdot \text{cm}^{-2}$.