Electrical Supplementary Information

FeS_2/carbon hybrids on carbon cloth: a highly efficient and stable counter electrode for dye-sensitized solar cell

Li Li,[a] Pin Ma,[b] Sabir Hussain,[c] Lianjun Jia,[a,b] Di Lin,[a] Xiong Yin,*[a] Yuan Lin,[b] Zhihai Cheng,[d] and Leyu Wang *[a]

[a] State Key Laboratory of Chemical Resource Engineering, Beijing Advanced Innovation Center for Soft Matter Science and Engineering, School of Chemistry, Beijing University of Chemical Technology, Beijing 100029, P. R. China.

E-mails: yinxiong@mail.buct.edu.cn; lywang@mail.buct.edu.cn.

[b] Beijing National Laboratory for Molecular Sciences, Key Laboratory of Photochemistry, CAS Research/Education Center for Excellence in Molecular Sciences, Institute of Chemistry, Chinese Academy of Sciences, Beijing 100190, P. R. China.

[c] CAS Key Laboratory of Standardization and Measurement for Nanotechnology, CAS Center for Excellence in Nanoscience, National Center for Nanoscience and Technology (NCNST), Beijing 100190, P. R. China

[d] Beijing Key Laboratory of Optoelectronic Functional Materials & Micro-nano devices, Department of Physics, Renmin University of China, Beijing 100872, P. R. China.

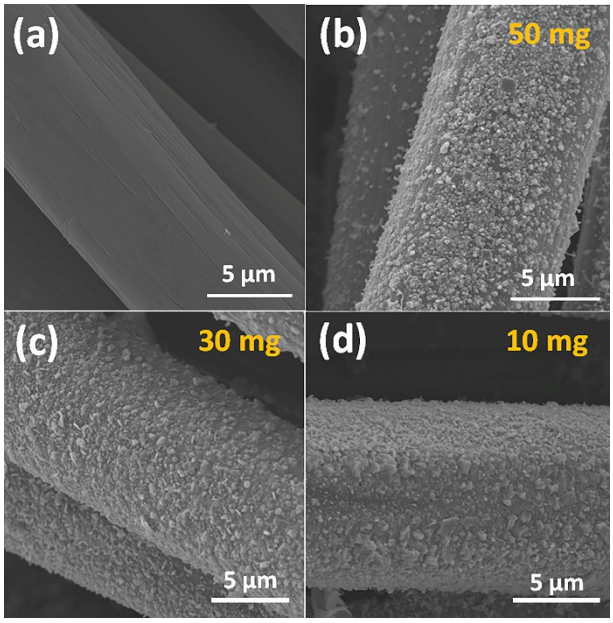

Figure S1. SEM images of bare carbon cloth (a), FeS_2/C@CC sample (b), and (c, d) Fe_2O_3/C@CC sample sulfurized with different amounts of S powder.

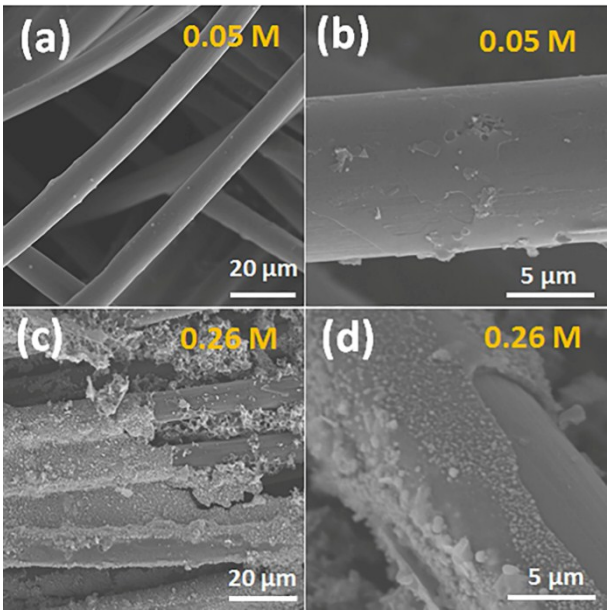

Figure S2. SEM images with different magnifications of FeS_2/C@CC samples prepared with different concentrations of FeOL precursors: (a, b) 0.05 M and (c, d) 0.26 M.

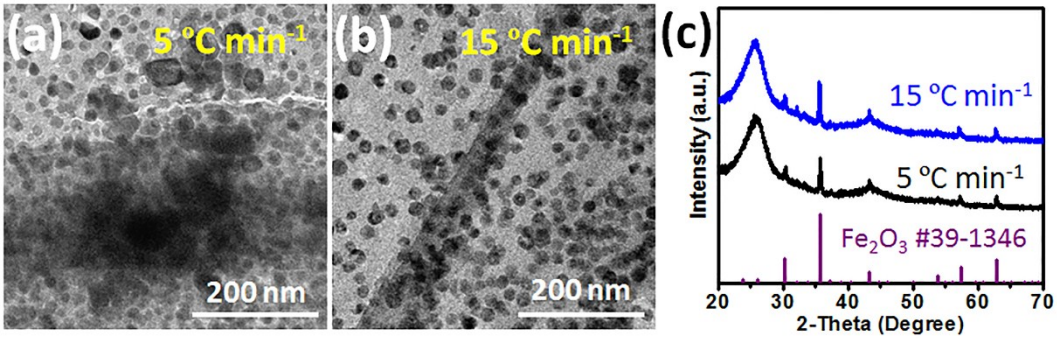

Figure S3. (a, b) TEM images and (c) XRD patterns for Fe_2O_3/C nanoparticles prepared at different heating rates.

The size of the final samples on CC substrate could be tuned by changing the heating rate and temperature during the carbonization step. When the heating rate was over 10 ºC min^{-1}, the size of the Fe_2O_3 nanoparticles was about 30 nm with a small size distribution (Figure 2a, Figure S3b). When the heating rate decreased to 5 ºC min^{-1}, the size distribution of the nanoparticles became broadened, containing lots of large size of particles (Figure S3a). Thus, the heating rate was set to be 10 ºC min^{-1} in the study. Furthermore, the heating rate did not affect the components of the final samples, as revealed by the corresponding XRD patterns (Figure S3c).

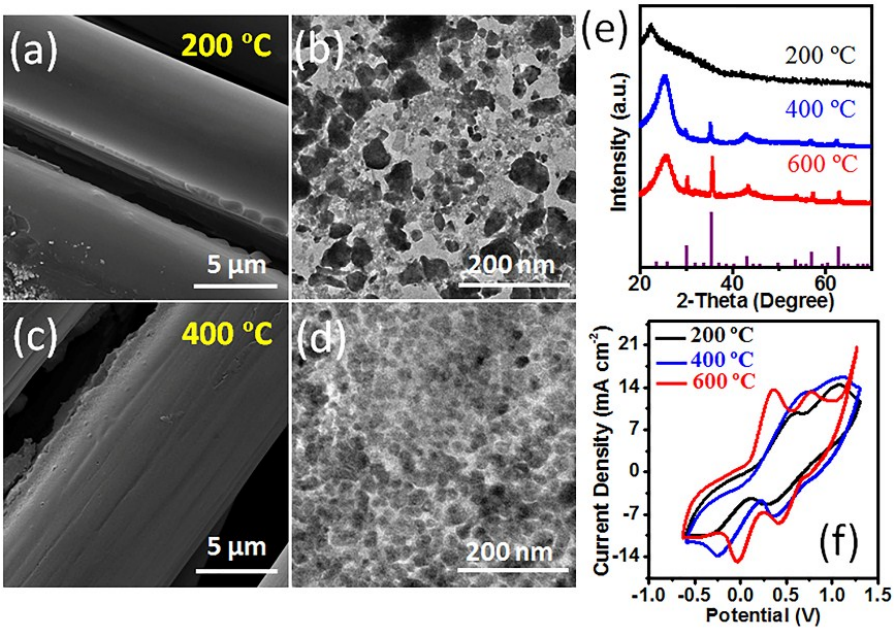

Figure S4. SEM (a, c) and TEM (b, d) images of samples prepared at 200 and 400 ºC; XRD patterns (e) and CV curves of samples prepared at different temperatures, including 200, 400 and 600 ºC.

In addition, the size of Fe_2O_3 nanoparticles was also affected by the heating temperature. The samples prepared under 200 and 400 ºC were also prepared. The corresponding SEM and TEM images, XRD patterns as well as CV curves are shown

in Figure S4. Obviously, the size of the nanoparticles was affected by the heating temperature. According to SEM analysis (Figure S4a,c), no obvious particles were observed on CC substrate when heating temperature was lower than 600 ºC, compared with those prepared at 600 ºC (Figure 1a). Considering that carbonization of organic precursors usually takes place at temperatures higher than 400 °C, it is likely that Fe_2O_3 NPs were formed and assembled on the CC as the temperature was increased from 200 to 400 °C. The XRD pattern peaks for Fe_2O_3 became strong as the temperature was increased from 200 to 600 ºC (Figure S4e). After the following sulfurization treatment at temperature of 500 ºC, different sizes of nanocrystals were obtained (Figure S4b, 4d). In the CV test, the sample prepared at 600 ºC presented the highest catalytic performance toward I_3^- reduction (Figure S4f). This could be attributed to its good distribution and suitable size of as-obtained nanoparticles. Therefore, the optimized temperature of carbonization was 600 ºC in the study.

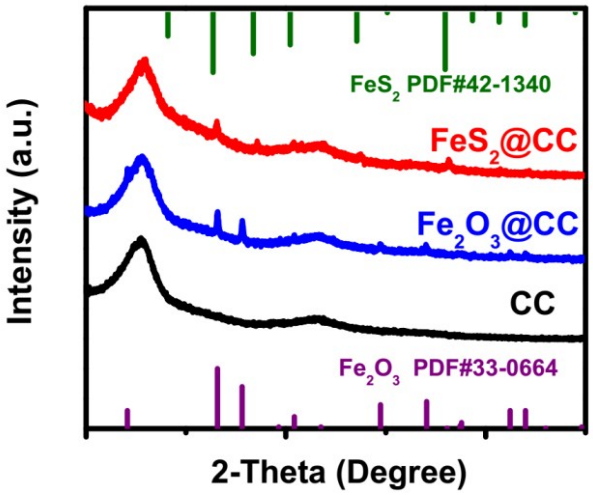

Figure S5. XRD patterns of Fe_2O_3@CC sample before and after sulfurization process.

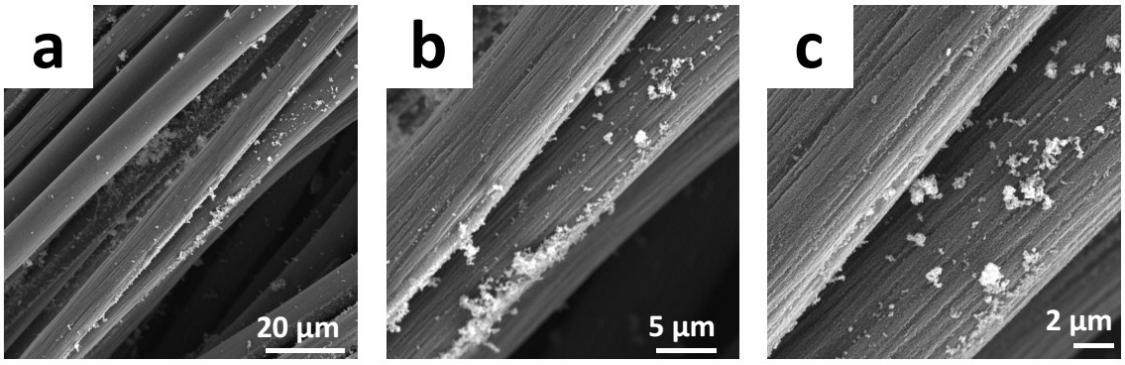

Figure S6. Typical SEM images of FeS_2@CC sample prepared using $FeCl_3$ as the Fe^{3+} ions source.

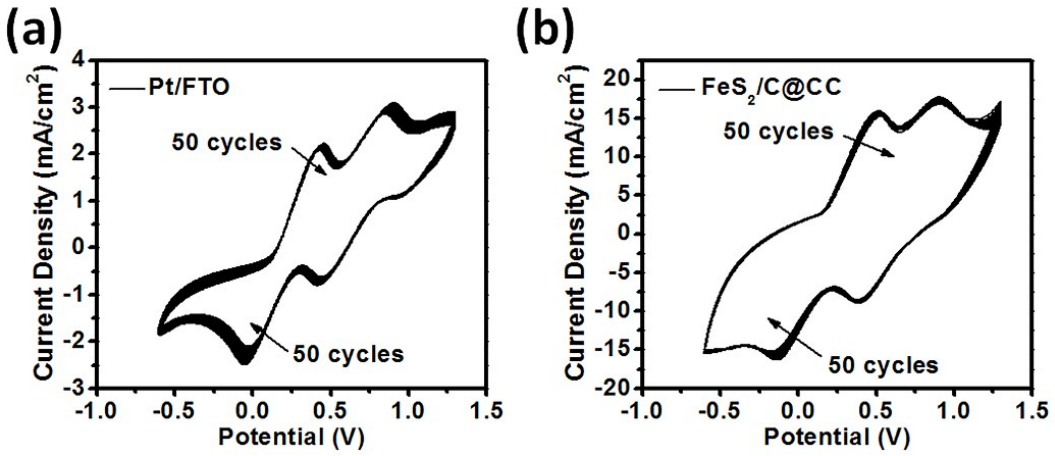

Figure S7. CV curves with 50 cycles obtained by testing the (a) Pt and (b) FeS_2/C@CC electrodes, respectively.

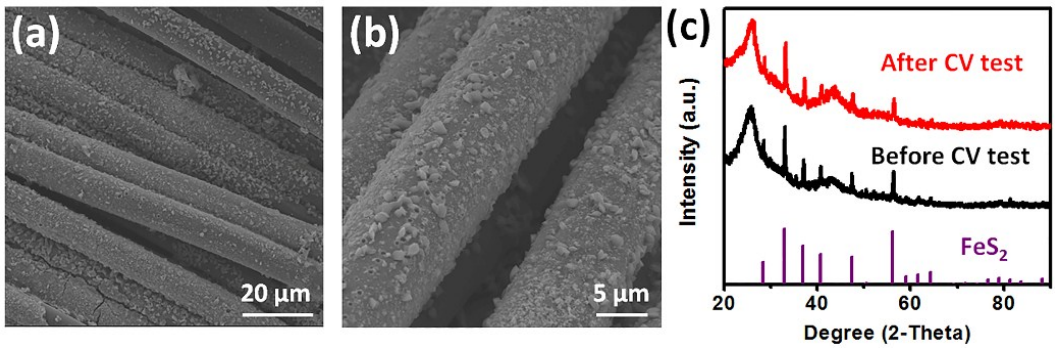

Figure S8. (a, b) SEM images and (c) corresponding XRD patterns of FeS_2/C@CC electrode after 50 cycles in CV test. XRD patterns of FeS_2/C@CC sample before CV test as reference.