Electronic Supplementary Information

Super-resolution fluorescent imaging of PEDOT:PSS films

Jun-Dan Huang[a], *Li-Jun Mei*[a], *Weibing Kuang*[a], *Feng-Yu Zhu*[a], *Rui Tian*[a], *Wanxia Wei*[a], *Chong Li*[a], *Ya-Long Wang*[b], *Yinhua Zhou*[a*], *Ming-Qiang Zhu*[*a,b]

[a] Wuhan National Laboratory for Optoelectronics, School of Optical and Electronic Information, Huazhong University of Science and Technology, Wuhan, Hubei 430074, China.

[b] Key Laboratory of Biomedical Engineering of Hainan Province, School of Biomedical Engineering, Hainan University, Haikou, Hainan 570228, China.

[*]Corresponding author. Email: mqzhu@hust.edu.cn, yh_zhou@hust.edu.cn.

Materials: All commercially available starting materials, reagents and solvents were purchased, unless otherwise stated, from Energy, Aladdin, J&K, Sigma Aldrich and Sinopharm Chemical Reagent Co. Ltd.

Preparation of PEDOT:PSS films with different concentrations: The mass concentration of the purchased PEDOT:PSS stock solution (Clevios PH1000, PEDOT:PSS weight ratio 1:2.5) was 1.3×10^{-2} g/L. The PEDOT:PSS stock solution was diluted into aqueous solution with different concentrations (1.3×10^{-5} g/L -1.3×10^{-2} g/L). Then each solution was filtered using the hydrophilic syringe filter (0.45 μm) to remove any large-size particles, respectively. The filtrates were spin-coat on the clean cover glass substrates or the silicon chip at the speed of 2000 rpm for 40 s and then were dried at 120 °C on a hot plate for 15 min to obtain PEDOT:PSS films.

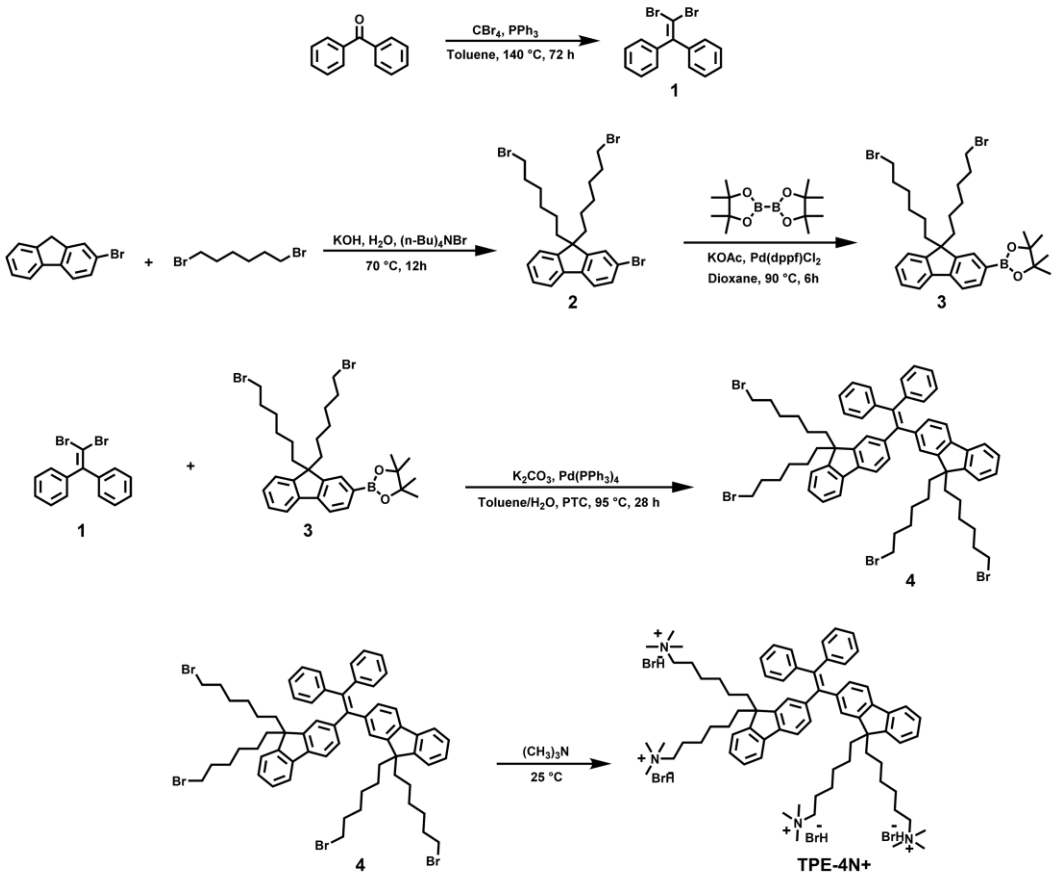
Preparation of PEDOT:PSS films treated with H_2SO_4: PEDOT:PSS films were prepared by spin-coating at the above-mentioned speed and subsequently immersed in H_2SO_4 of different concentrations (20%, 40%, 60%, 80% and 98%, respectively) for 10 min. Then the films were washed in a deionized water bath and dried at 120 °C for 10 min to remove any residual water.

Characterization of PEDOT:PSS films: The fluorescence of probe TPE-4N+ in aqueous solution of PEDOT:PSS with different concentrations (1.3×10^{-5} g/L-1.3×10^{-2} g/L) and PEDOT:PSS solid films (1.3×10^{-2} g/L) treated with sulfuric acid were measured by Hitachi Fluorescence Spectrophotometer (F-4600). The DLS mean particle size of PEDOT:PSS aqueous solution (1.3×10^{-5} g/L) was measured by BeNano 180 Zeta nanoparticles and Zeta potential analyzer (Figure S1). The SEM images were taken with Nova Nano SEM 450 FP2053/45 from FEI. PEDOT:PSS aqueous solution of different concentrations (1.3×10^{-5} g/L-1.3×10^{-2} g/L) was drop-coated on silicon substrates to characterize the morphology by SEM (Figure 2). The same concentration (1.3×10^{-2}

g/L) of PEDOT:PSS aqueous solution were spin-coated on silicon substrates, and the morphology was characterized by SEM after treated with different concentrations of sulfuric acid (Figure S2). The AFM images were taken with SPM9700 from Shimadzu. The same concentration (1.3×10^{-2} g/L) of PEDOT:PSS aqueous solution was spin-coated on 1.7×1.7 cm^2 glasses. The morphology of PEDOT:PSS film after treated with different concentrations of sulfuric acid was characterized by AFM in the tapping mode. (Figure S3). The TEM images were taken with Tecnai G2 20 from FEI. PEDOT:PSS aqueous solution with the same concentration (1.3×10^{-2} g/L) was spin-coated on silicon substrates and treated with sulfuric acid of different concentrations. The silicon substrates were ultrasound in deionized water to characterize the morphology by TEM (Figure S4). The sheet resistance of PEDOT:PSS films treated with different concentrations of sulfuric acid was measured by the four-point probe (RTS-8). The thickness of PEDOT:PSS films treated with different concentrations of sulfuric acid was measured using a surface profiler (Veeco Dektak 150). The purchased PEDOT:PSS aqueous solution was spin-coated on 0.5×0.5 cm^2 glasses to compare the changes in elemental content of XPS before and after with sulfuric acid treatment by AXIS SUPRA+ from Kratos. Raman spectra of PEDOT:PSS films before and after sulfuric acid treatment were measured by LabRAM HR800 from Horiba JobinYvon. To obtain clear XRD patterns, the PEDOT:PSS films were prepared by drop-casting a filtered PEDOT:PSS aqueous solution onto silicon substrates. But the details of the process conditions were adjusted as follows: the sulfuric acid immersion time increased to 3 h, and the drying condition was adjusted to 60-80 °C for one hour, followed by 120 °C for 30 min.[1] XRD patterns were obtained using x'pert3 powder from PANalytical B.V. in a conventional theta/2theta geometry.

Scheme S1 The Synthesis of TPE-4N+.

The synthesis, detail optical properties and other application of the compound TPE-4N+ was reported in other work.[2] The synthesis procedures are shown below:



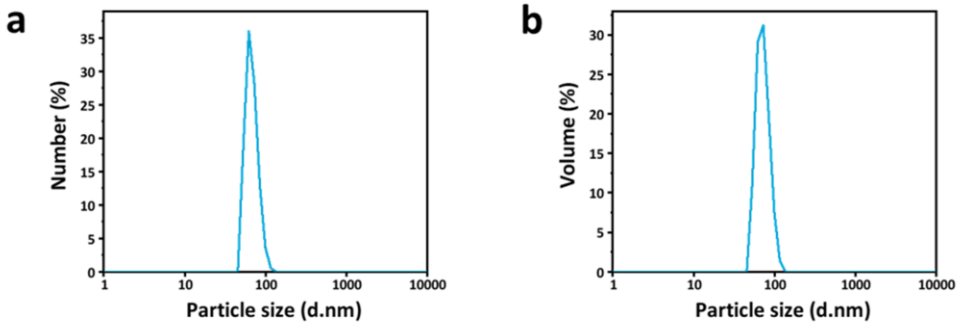


Figure S1 The mean particle size distribution of PEDOT:PSS aqueous solution (1.3×10^{-5} g/L) measured by dynamic light scattering. a) Distribution of number; b) Distribution of volume.

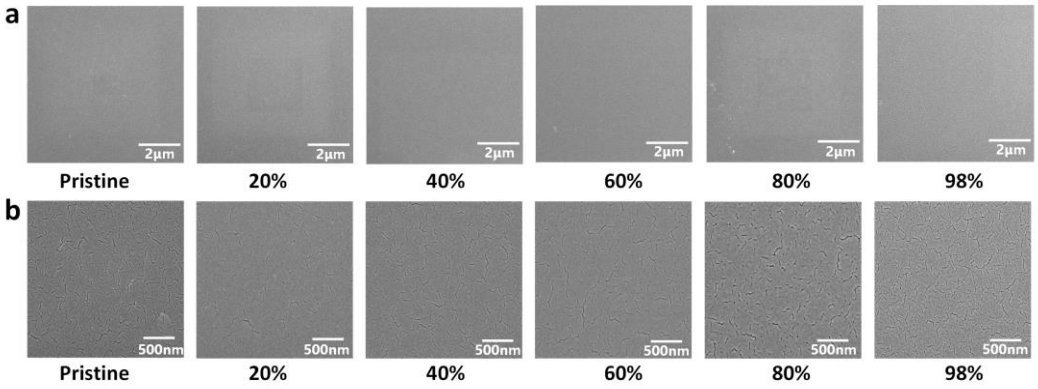


Figure S2 a) The SEM images of PEDOT:PSS films after H_2SO_4 treatment with different concentrations (Pristine, 20%, 40%, 60%, 80% and 98%, respectively); b) The locally enlarged view of each figure in a).

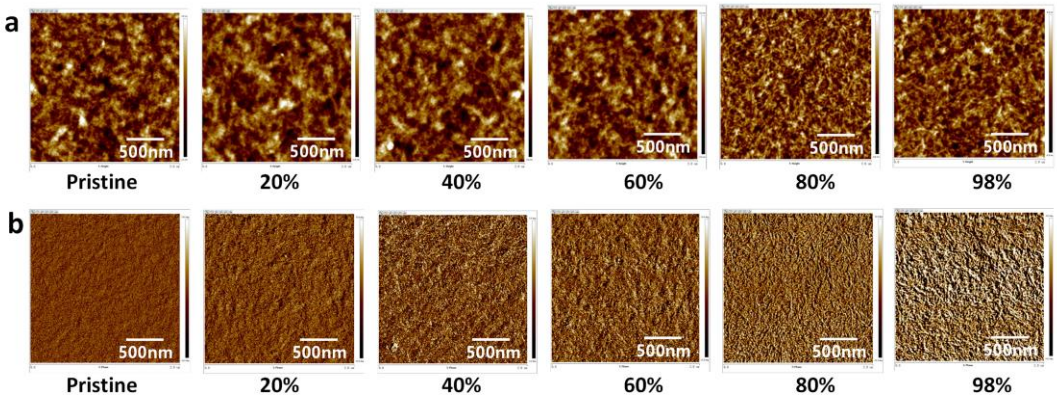


Figure S3 a) The AFM images of PEDOT:PSS films after H_2SO_4 treatment with different concentrations (Pristine, 20%, 40%, 60%, 80% and 98%, respectively); b) The corresponding phase images in a).

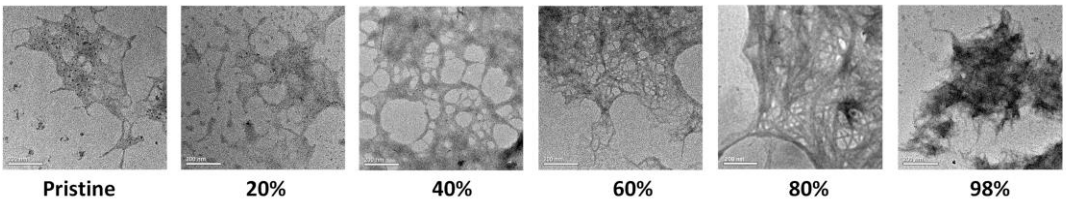


Figure S4 The TEM images of PEDOT:PSS films after H_2SO_4 treatment with different concentrations (Pristine, 20%, 40%, 60%, 80% and 98%, respectively).

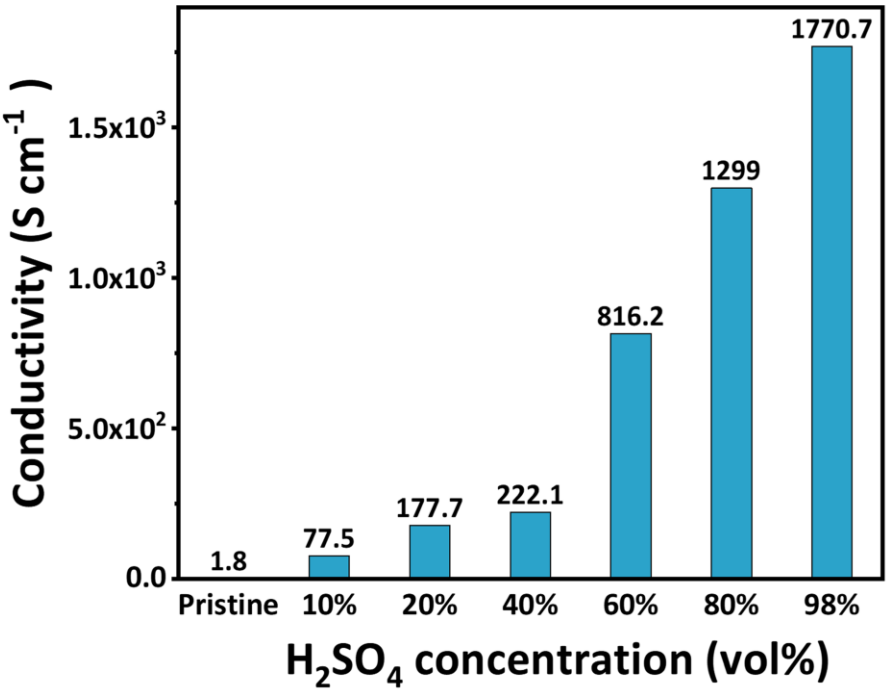


Figure S5 The electrical conductivity of PEDOT:PSS films after H_2SO_4 treatment with different concentrations (Pristine, 10%, 20%, 40%, 60%, 80% and 98%, respectively).

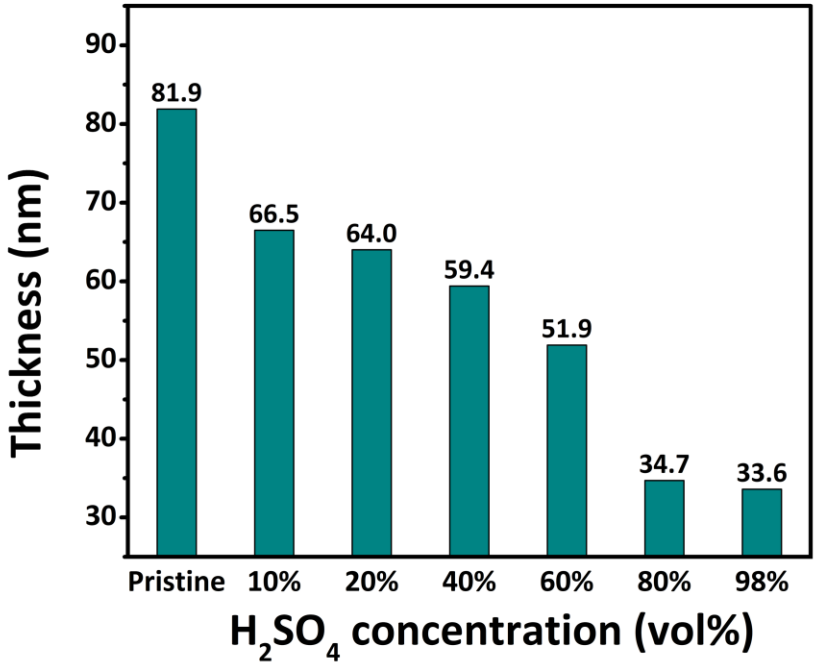


Figure S6 The thickness of PEDOT:PSS films after H_2SO_4 treatment with different concentrations (Pristine, 10%, 20%, 40%, 60%, 80% and 98%, respectively).

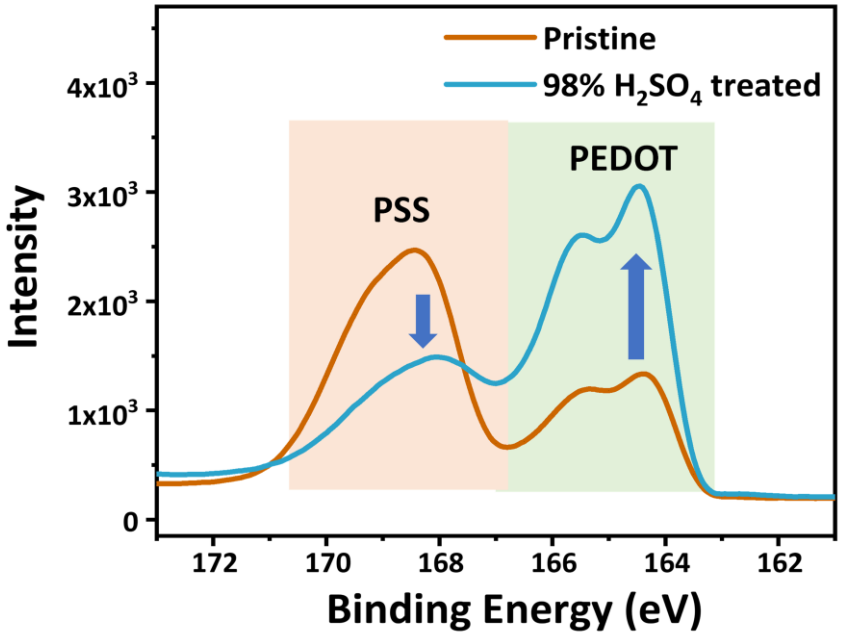


Figure S7 The XPS spectra of PEDOT:PSS films before and after H_2SO_4 treatment.

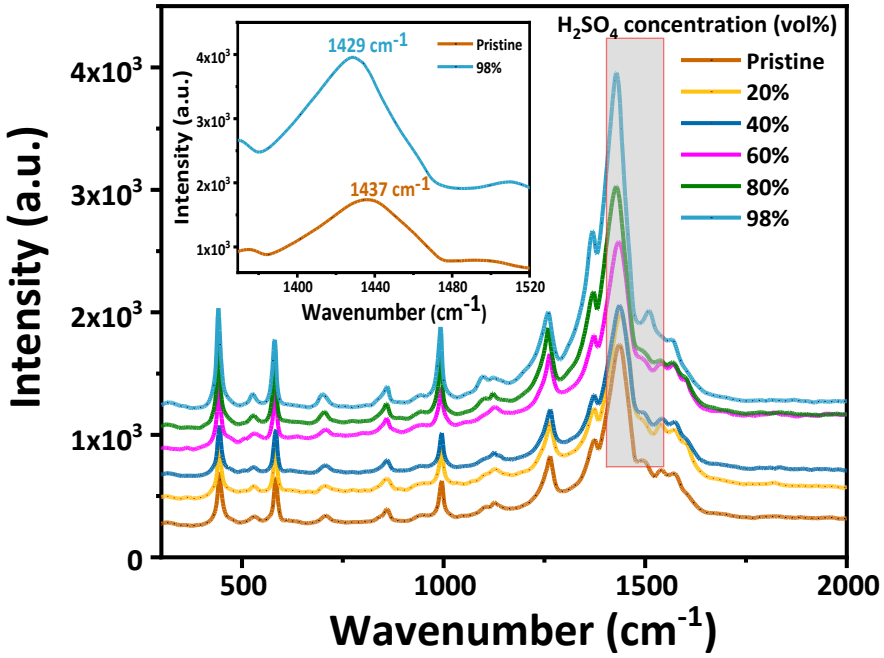


Figure S8 The Raman spectra of PEDOT:PSS films after H_2SO_4 treatment with different concentrations (Pristine, 20%, 40%, 60%, 80% and 98%, respectively).

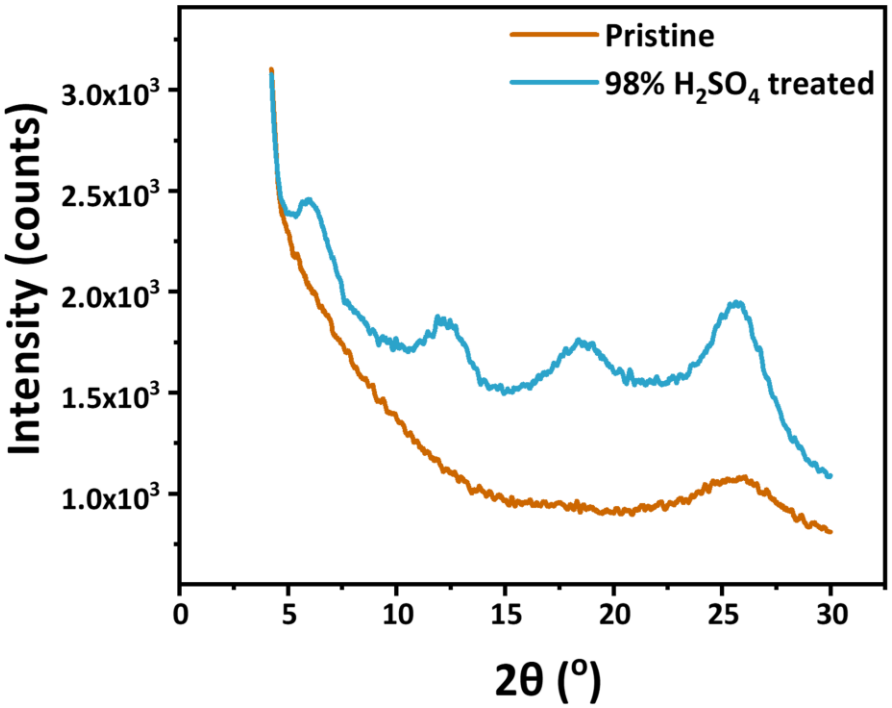


Figure S9 The XRD pattern of PEDOT:PSS films before and after H_2SO_4 treatment.

References

1 N. Kim, S. Kee, S. H. Lee, B. H. Lee, Y. H. Kahng, Y.-R. Jo, B.-J. Kim and K. Lee, *Adv. Mater.*, 2014, **26**, 2268.

2 L.-J. Mei, C. Fan, C.-R. Xu, Q. Yu, C. Li, Y.-L. Wang and M.-Q. Zhu, *Chem. Eng. J.*, 2023, **451**, 139027.