Supporting Information

Mechanofluorochromic Carbon Dots under Grinding Stimulation

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1. Experimental section

1.1. Materials

All the reagents were used as received without further purification. 1,3,6,8-Tetra(4-carboxylphenyl) pyrene (TBAPy) was bought from Beijing HWRK Chemical Co., Ltd. Ethylenediamine was obtained from Tianjin Fengchuan Chemical Reagent Technology Co., Ltd. Dimethyl formamide (DMF) was purchased from Tianjin Concord Technology Co., Ltd. The manufacturer of acetic acid is Fuchen (Tianjin) Chemical Reagent Co., Ltd. Ammonia was purchased from Shanghai Aladdin Technology Co., Ltd. The water used in the experiment is double distilled water.

1.2. Instruments

The fluorescence characterization of the CDs was performed on a fluorescence spectrometer (FS920P, Edinburgh Instruments). Fourier transform infrared (FT-IR) spectroscopy of TBAPy and CDs was performed with a Bruker Vector 22 spectrophotometer. The UV-visible spectra of the CDs were recorded by an Agilent Carry 100 UV-vis spectrometer, with a test range from 200 nm to 800 nm. The morphological characterization of the CDs was performed using a JEOL JEM-2100 high-resolution transmission electron microscope (TEM). X-ray photoelectron spectroscopy (XPS) data were obtained with a Thermo SCIENTIFIC ESCALAB250 Xi. X-ray powder diffraction (Bruker D8 Focus) was used to investigate the XRD pattern of the CDs.

1.3. Synthesis of MFC-CDs

The MFC-CDs were prepared based on a solvothermal reaction between 1,3,6,8-Tetra(4-carboxylphenyl) pyrene (TBAPy) and ethylenediamine. Briefly, 171 mg of TBAPy (0.25 mmol) and 150 μL of ethylenediamine were dissolved into a 10 mL of solution of DMF and water (v/v 1:1), and sonicated until the solution was clear and transparent. The mixture solution was transferred into a polytetrafluoroethylene (Teflon)-lined autoclave (30 mL) at 180 ℃ for 6 h. After cooling to room temperature, the reaction solution was dialyzed against water for 24 h, and the supernatant was remained by centrifugation. It was then dried at 60 ℃ to obtain the yellow solid of as-prepared MFC-CDs.

1.4. Grinding treatment

Take about 20 mg of carbon dots in an agate mortar, lightly grind for 1 min, 5 min, 10 min, 30 min, and measure the emission spectrum.

1.5. Acid fumed treatment and ammonia fumed treatment

First, take 5 mg of the ground carbon dots and lay them flat on the weighing paper; then, take 4 mL of acetic acid/ammonia in an open small glass bottle. Finally, put the above prepared sample into a 500 mL beaker and seal it to form a closed environment for acid fumigation/ammonia fumigation.

2. Water solubility of MFC-CDs

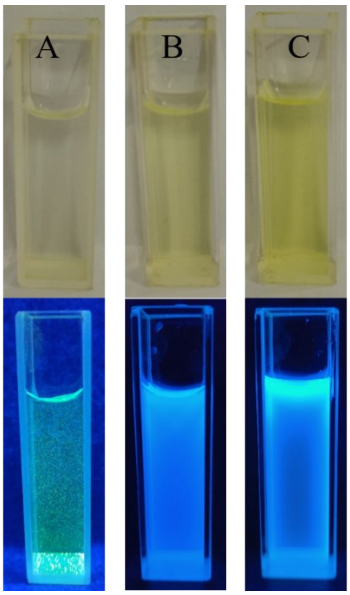

Figure S1 The bright and fluorescent images of (A) TBAPy, (B) as-prepared MFC-CDs, and (C) ground MFC-CDs.

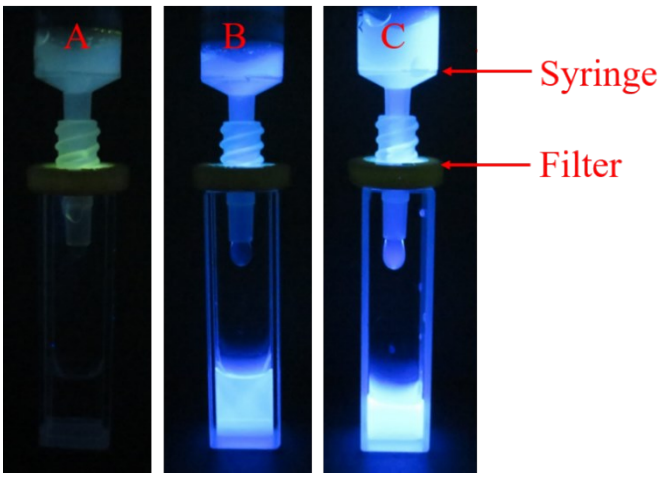

Figure S2 The fluorescent images of (A) TBAPy, (B) as-prepared MFC-CDs, and (C) ground MFC-CDs by filtering.

3. Lattice of MFC-CDs

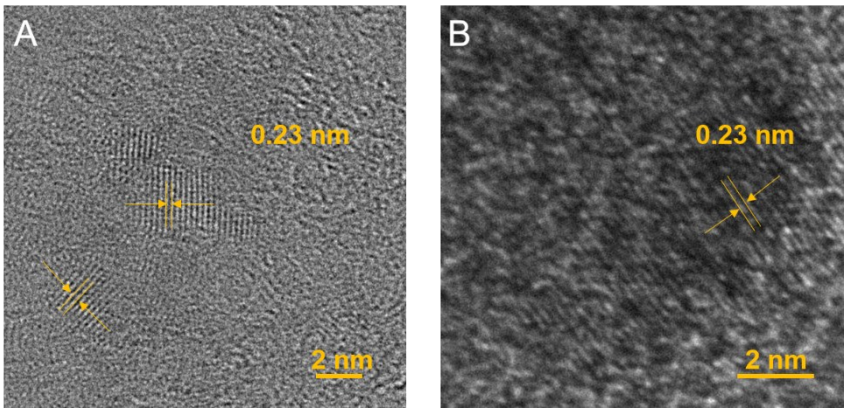

Figure S3 Lattice images of (A) as-prepared MFC-CDs and (B) ground MFC-CDs.

3. FT-IR characterization

The FT-IR spectrum of TBAPy with O-H bond vibration absorption is at 3400-3100 cm^{-1}, and the characteristic absorption peak of C=O is at 1693 cm^{-1}. The peaks in both samples at 1533 and 1604 cm^{-1} are attributed to the N-H bending vibration, stretch and C=C stretch of aromatic hydrocarbons. It is obvious that the vibration band of 3100-3400 cm^{-1} represents O-H/N-H. The peak of the N-H stretching was masked by the large broad peak of the O-H stretching. Compared with TBAPy, the CDs had a clear peak at 1390 cm^{-1}, which is attributed

to the bending vibration of C-N. Only one peak in the range of 3400-3100 cm^{-1} proved to be from a secondary amine. The amide stretch was observed at 1658 cm^{-1} because of the amide condensation reaction between TBAPy and ethylenediamine. Interestingly, the shift of stretch of C=O and C-N bonds can be observed in FT-IR investigation of MFC-CDs and ground MFC-CDs. The displacement of the C=O stretching bonds changed from 1658 cm^{-1} to 1664 cm^{-1}, and C-N bonds changed from 1390 cm^{-1} to 1401 cm^{-1}.

4. XPS characterization

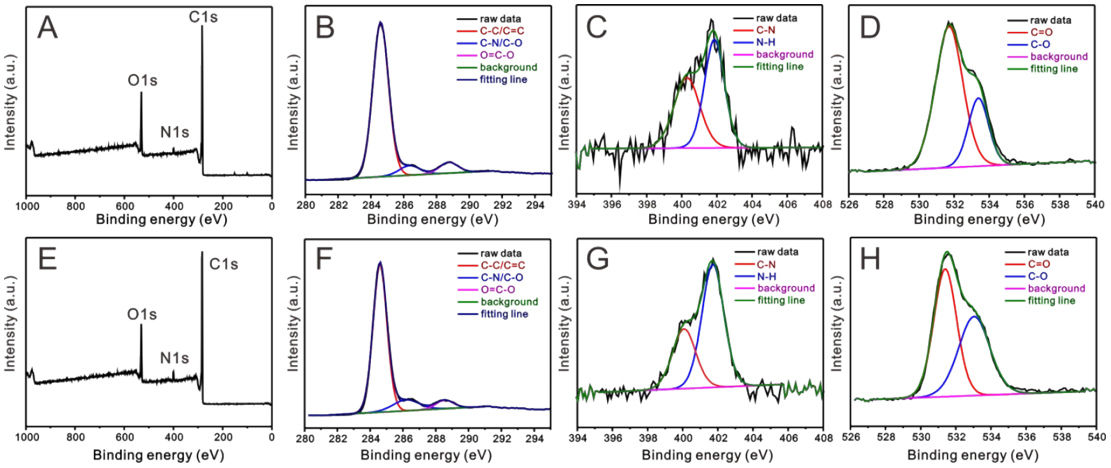

Figure S4 XPS spectra of MFC-CDs (A-D) before and (E-H) after grinding.

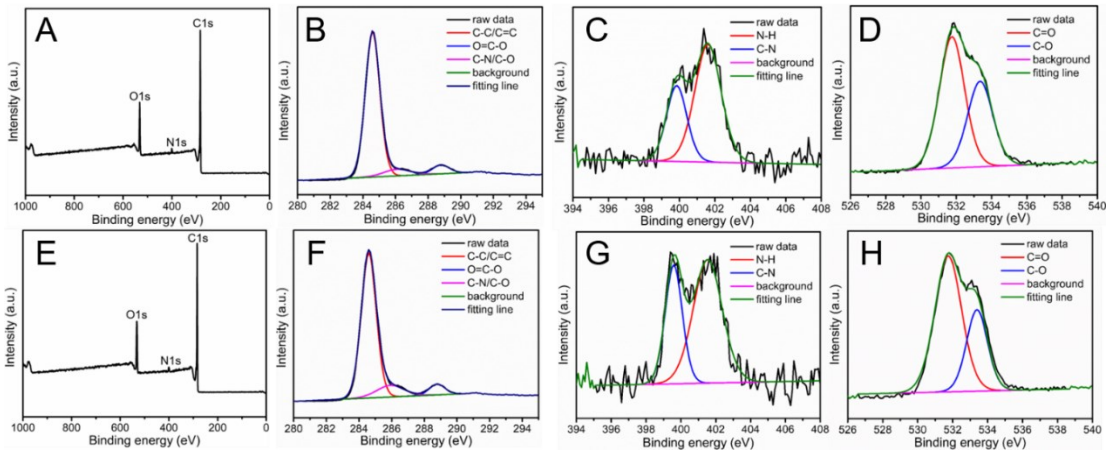

Figure S5 XPS spectra of (A-D) MFC-CDs after acid fumed and (E-H) then with grinding treatment again.

Table S1 Ratio of C1s, N1s and O1s of as-prepared after grinding, after acid fumed and after grind again.

	C1s	N1s	O1s
As-prepared	80.3%	3.4%	16.4%
After grinding	81.3%	4.4%	14.3%
After acid fumed	82.5%	2.4%	15.1%
After grinding again	82.4%	3.0%	14.6%

Table S2 Ratio of each C1s functional group of as-prepared after grinding, after acid fumed and after grind again.

	C1s		
	C-C/C=O	C-N/C-O	O=C-O
As-prepared	85.7%	7.1%	7.2%
After grinding	82.4%	11.6%	6.0%
After acid fumed	86.4%	7.3%	6.3%
After grinding again	81.5%	12.1%	6.4%

Table S3 Ratio of each O1s functional group of as-prepared after grinding, after acid fumed and after grind again.

	O1s	
	C=O	C-O
As-prepared	73.6%	26.4%
After grinding	54.1%	45.9%
After acid fumed	59.6%	40.4%
After grinding again	61.2%	38.8%

5. Fluorescence characterization

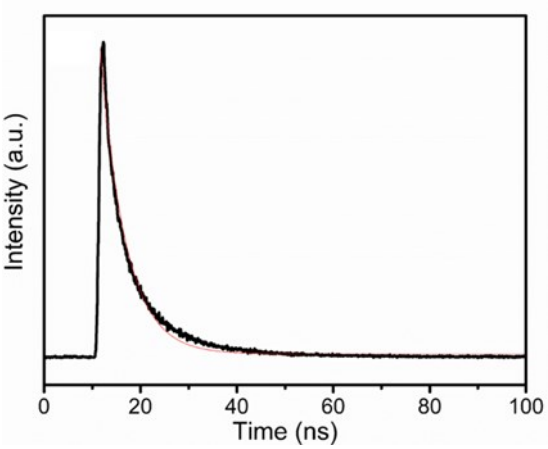

Figure S6 Fluorescence lifespan spectrum of MFC-CDs.

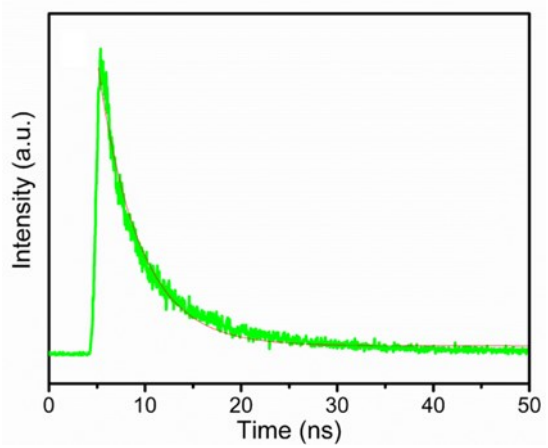

Figure S7 Fluorescence lifespan spectrum of ground MFC-CDs.

6. Reversible mechanochromism investigation

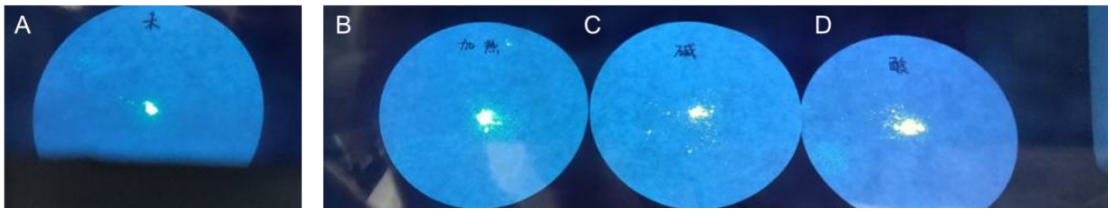

Figure S8 Fluorescence images of ground MFC-CDs (A) without any treatment, (B) with annealed treatment, (C) with base fuming, and (D) with acid fuming.

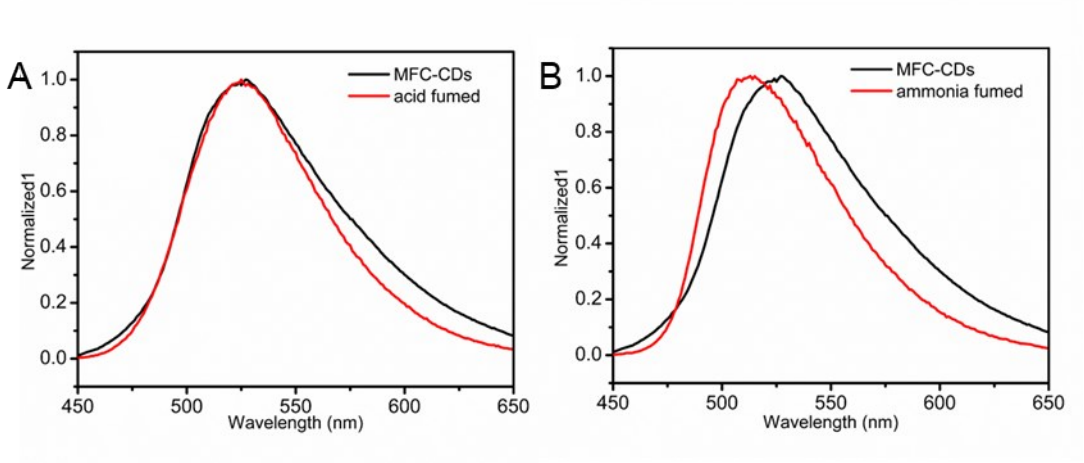

Figure S9 Fluorescence spectrum of MFC-CDs and ground MFC-CDs with (A) acid fumed treatment, and (B) ammonia fumed treatment.