

Electronic Supplementary Information (ESI)

Biomass-derived activated carbon as high-performance non-precious electrocatalyst for oxygen reduction

Keliang Wang,^a Hui Wang,^a Shan Ji,^{*b} Hanqing Feng,^c Vladimir Linkov,^b Rongfang Wang,^a

^a *Key Laboratory of Eco-Environment-Related Polymer Materials, Ministry of Education of China, College of Chemistry and Chemical Engineering, Northwest Normal University, Lanzhou, 730070, China, Fax/ Tel: +86 931 7971533;*

E-mail: wrf38745779@126.com

^b *South African Institute for Advanced Materials Chemistry, University of the Western Cape, Cape Town, 7535, South Africa*

^c *College of Life Science, Northwest Normal University, Lanzhou 730070, China*

Experimental Section

Material synthesis

Carbonized egg white (CEW) was synthesized by a novel method with common egg white as the sources of carbon. In a typical experiment, a couple of eggs purchased from local super market were boiled firstly. Subsequently, EW was separated and cut into pieces as the boiled eggs got cool, and then it was dried in an air-circulating oven at 80 °C for 10 h. After that, the as-prepared sample was collected, followed by thermal treatment at 800 °C for 2 h in N₂ gas with a rate of 20 mL min⁻¹. Once the oven (Anhui BEQ Equipment Technology Co., Ltd. BTF-1200C) cooled down under N₂ flow, the black samples was transferred into a milling tank and grinded on a planetary ball mill (Nanjing Chishun Science & Technology Co., Ltd. PM) for 6 h at 250 rpm, then the CEW was obtained.

Fe doped carbonized egg white (Fe-CEW) was synthesized by the similar synthetic procedure of CEW in participation of FeCl₃·6H₂O which obtained from Yantai Shuangshuang Chemical Co., Ltd. Typically, EW separated from several eggs was weighed prior to dispersing into a beaker, and then FeCl₃·6H₂O (the mass of FeCl₃·6H₂O equals tenth of EW) was introduced into a beaker under magnetically stirred violently for half an hour. Afterwards, the beaker was shifted into boiling water and boiled until the sample turned into flocculent under stirring, and then it was dried in an air-circulating oven at 80 °C for 10 h. To obtain homogeneous Fe-CEW nanoparticles, the dried sample was grinded for 6 h at 250 rpm in a milling tank. Subsequently, the doping reaction was carried out under protection of N₂ flow at 800

°C for 2 h till cooled down, then the as-obtained samples was grinded in the same condition above mentioned. After separation, Fe-CEW was synthesized.

Physical characterization

X-ray diffraction (XRD) patterns on a Shimadzu XD-3A (Japan), using filtered Cu-K α radiation (40 kV, 30 mA). All XRD patterns were analyzed using Jade 7.5 of Material Data, Inc. (MDI): peak profiles of individual reflections were obtained by a nonlinear least-square fit of the Cu-K α corrected data. X-ray photoelectron spectra (XPS) was acquired with a VG Escalab210 spectrometer fitted with Mg 300 W X-ray source. Scanning electron microscopy (SEM) images were conducted on Carl Zeiss Ultra Plus. Accurate binding energies are determined by referencing to the C 1s peak at 285.0 eV. The Fourier-Transform infrared (FT-IR) spectra of KBr pellets are recorded in the 4000–400 cm⁻¹ region on a Perkin-Elmer FT-IR M-1700 2B spectrophotometer. Raman spectrum was obtained on a Ft-Raman spectroscopy (RFS 100, BRU-KER) employing Nd: YAG laser wavelength of 1064 nm. The thermal gravimetric analysis (TGA) was performed with a TGA/DSC-1 instrument system (Mettler Toledo, Swiss) at a scan rate of 10 °C min⁻¹ up to 800 °C under protection N₂ flow. Elemental Analysis was measured by organic elemental analyzer (Thermo Flash2000).

Electrochemical characterization

The electrochemical measurements were performed using an Autolab electrochemical workstation (Netherlands, Autolab, PGSTAT128N). A common three-electrode

electrochemical cell was used for the measurements. The counter and reference electrode were a platinum wire and an Ag/AgCl (saturated KCl solution) electrode, respectively. The working electrode was a glassy carbon disk (5 mm in diameter). The thin-film electrode was prepared as follows: 5 mg of catalyst was dispersed ultrasonically in 1 mL Nafion/ethanol (0.25% Nafion) for 15 min. 8 μ L of the dispersion was transferred onto the glassy carbon disk using a pipette, and then dried in the air. All the experiments were conducted at 30 °C which controlled by a electro-thermostatic water cabinet, and the commercial Pt/C (20 wt.%, J.M. Corp.) was compared with the as-prepared samples under the same condition.

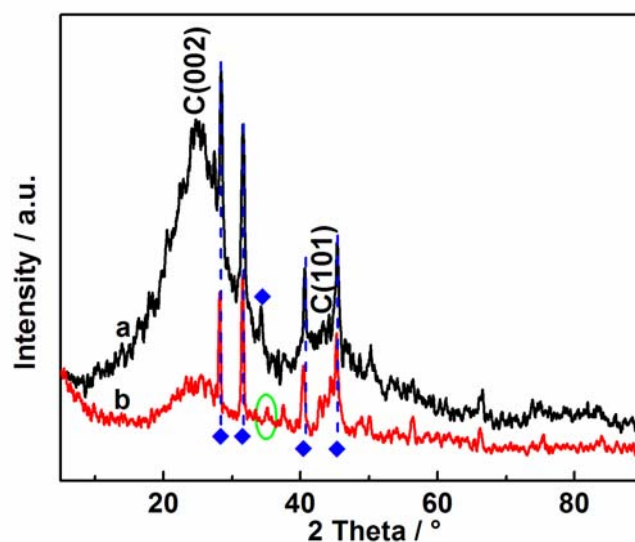


Figure S1. XRD patterns of (a) CEW and (b) Fe-CEW.

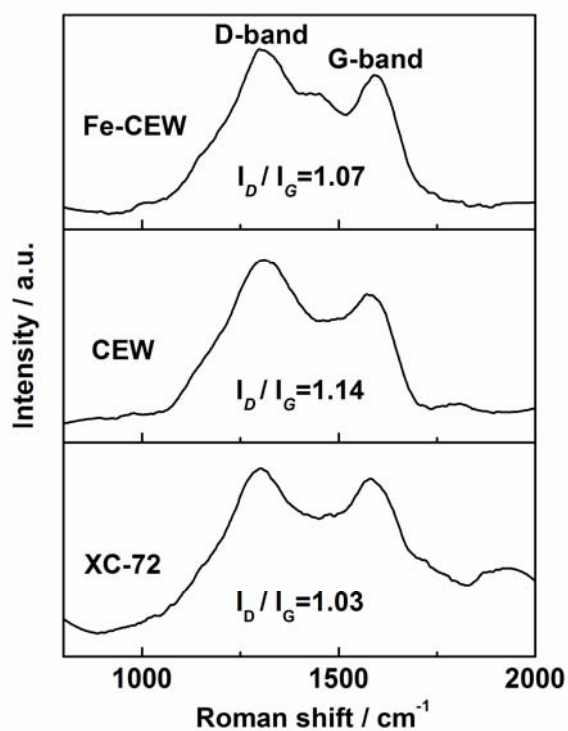


Figure S2. Raman spectra of XC-72, CEW and Fe-CEW.

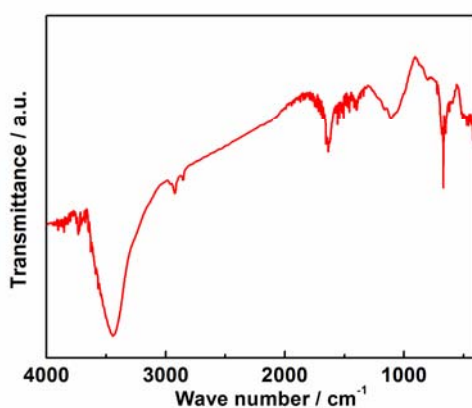


Figure S3. FT-IR spectrum of Fe-CEW.

The band at 3448 cm⁻¹ can be ascribed to O-H stretching¹. The band at 2926, 1633 and 1418 cm⁻¹ reflects C-H stretching, C=C stretching and C-N stretching, respectively^{1,2}. While the band at 1338 cm⁻¹ is assigned to an *sp*³ C-C bond or disordered *sp*² graphitic domains, bands below 940 cm⁻¹ are assigned to the graphitic

sp^2 domains³.

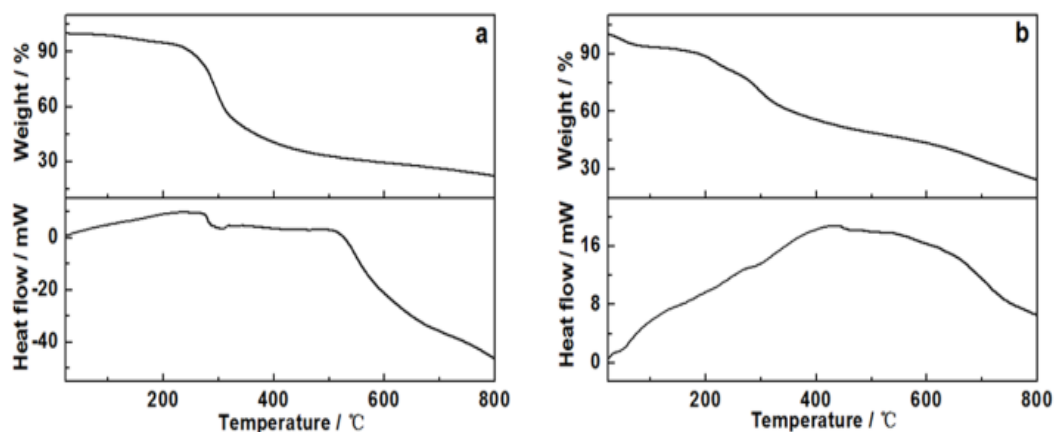


Figure S4. The diagrams for TGA and DTG curves of (a) EW and (b) Fe-EW.

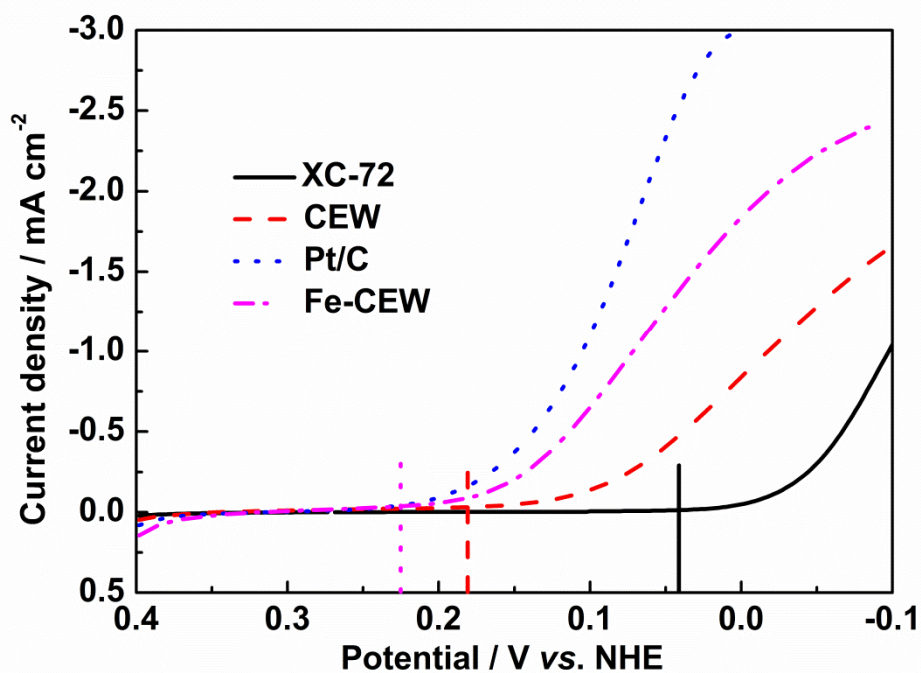


Figure S5. The corresponding enlargement image from LSV curves, where the onset potentials are marked by short lines.

References

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