Electronic Supplementary Information

Design of Fe and N co-decorated Biomass-derived Hierarchical Porous Carbon Frameworks with Boosted Oxidase-like Activity for Hydroquinone Detection

Han Zhang, Xiaodan Qi, Zhifei Wang, Lihua Jin* and Yehua Shen*
Key Laboratory of Synthetic and Natural Functional Molecule Chemistry of the Ministry of Education, College of Chemistry & Materials Science, Northwest University, Xi'an 710069, People's Republic of China

1. Apparatus

The transmission electron microscopy (TEM) was carried out in Talos F200X (Thermo Fisher). The X-ray photoelectron spectroscopy (XPS) spectrum was performed on an Axis Ultra X-ray photoelectron spectrometer (Kratos, UK). The X-ray powder diffraction spectrum (XRD) was performed on the D8 Advance X-ray powder analyzer (Bruker, USA). The N_2 adsorption-desorption with Brunauer Emmett-Teller (BET, ASAP 2460) method and the pore size distributions were measured by the Barrett-Joyner-Halenda (BJH). Electron paramagnetic resonance (EPR) spectroscopy was obtained on Bruker E500-9.5/12. The scanning electron microscope (SEM, Zeiss Sigma) was used to observe the surface morphology of the catalysts. A UV-2550 spectrophotometer (Shimadzu, Japan) was used to record the changes of UV-vis spectrum signal.

2. Optimization experiments and Steady-state dynamics experiments

The effect of pH on the catalytic activity of Fe-N-C composites was obtained in different pH (2, 3, 4, 4.8, 5, 6, 7) of 0.2 M NaAc-HAc buffer solutions. The effect of temperature on the catalytic activity of Fe-N-C composites were carried out at 20℃,

*To whom correspondence should be addressed. Fax: +86-029-88302635. E-mail: jinlihua@nwu.edu.cn.
*To whom correspondence should be addressed. Fax: +86-029-88302635. E-mail: yhshen@nwu.edu.cn.

25℃, 30℃, 37℃, 40℃, 45℃, 50℃ and 60℃, respectively. The influence of reaction time on the catalytic activity of Fe-N-C composites was recorded at 0 min, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min. The effect of material concentration on the catalytic activity of Fe-N-C composites was investigated from 2.5 to 20 μg/mL, and the effect of TMB concentration was varied from 0.1 to 1.0 mM. The absorbance values at 652 nm were recorded. Steady-state kinetic experiments were performed according previous reports in NaAc-HAc buffer (0.2 M, pH 4.0) consisting of 15 μg/mL Fe-N-C composite and different concentrations of TMB at 30℃. All measurements were parallel performed three times, and the values were averaged. The experiment processes are described in detail in the supplementary material.

3. Figure and Table

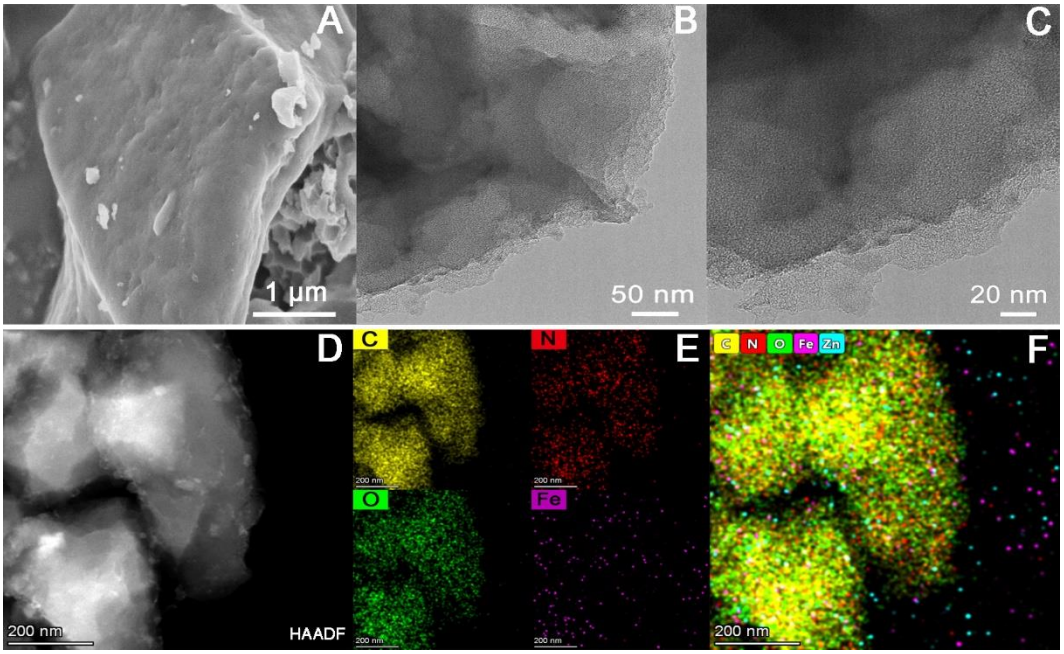

Figure S1. SEM image (**A**) and TEM image of the prepared Fe- C (**B-C**); EDS element mapping spectra (**D-F**) of the prepared Fe-C.

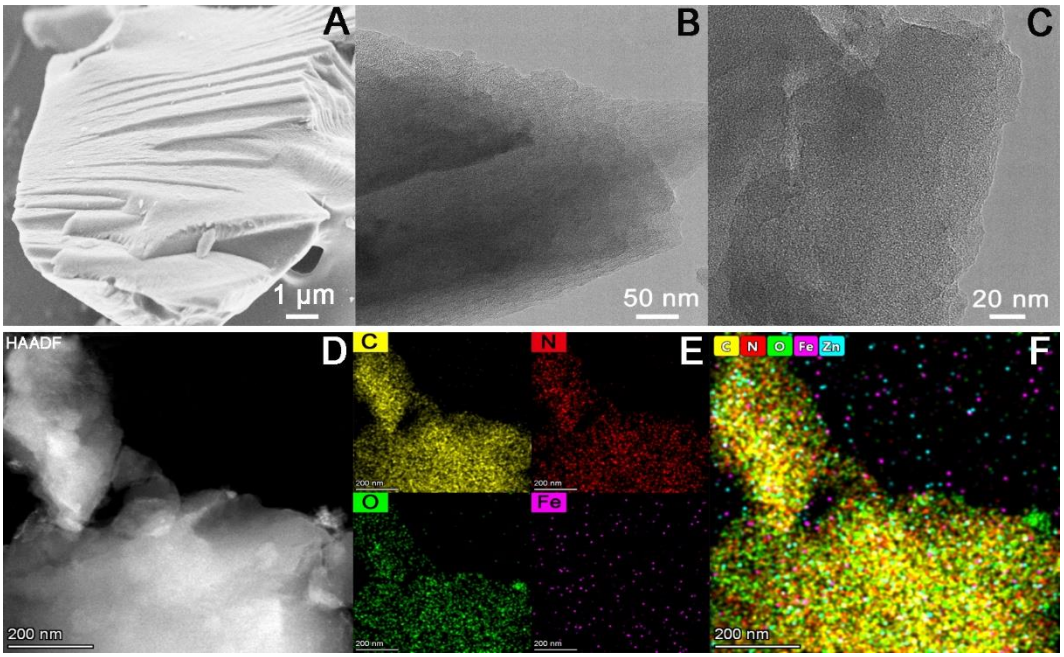

Figure S2. SEM image (**A**) and TEM image of the prepared N-C (**B-C**); EDS element mapping spectra (**D-F**) of the prepared N-C.

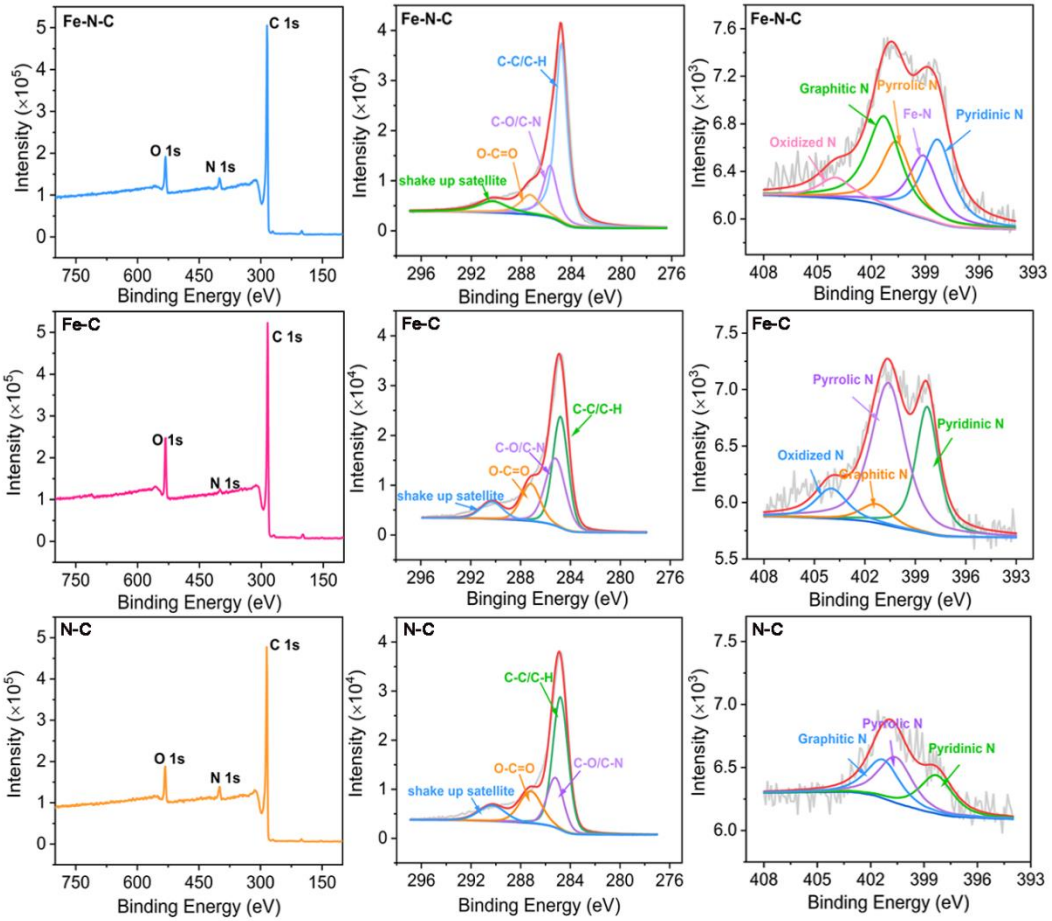

Figure S3. XPS spectra of **(A)**Fe-N-C, **(D)**Fe-C and **(G)**N-C; High resolution C1s spectra of **(B)**Fe-N-C, **(E)**Fe-C and **(H)**N-C; High resolution N1s spectra of **(E)**Fe-N-C, **(F)**Fe-C and **(G)**N-C.

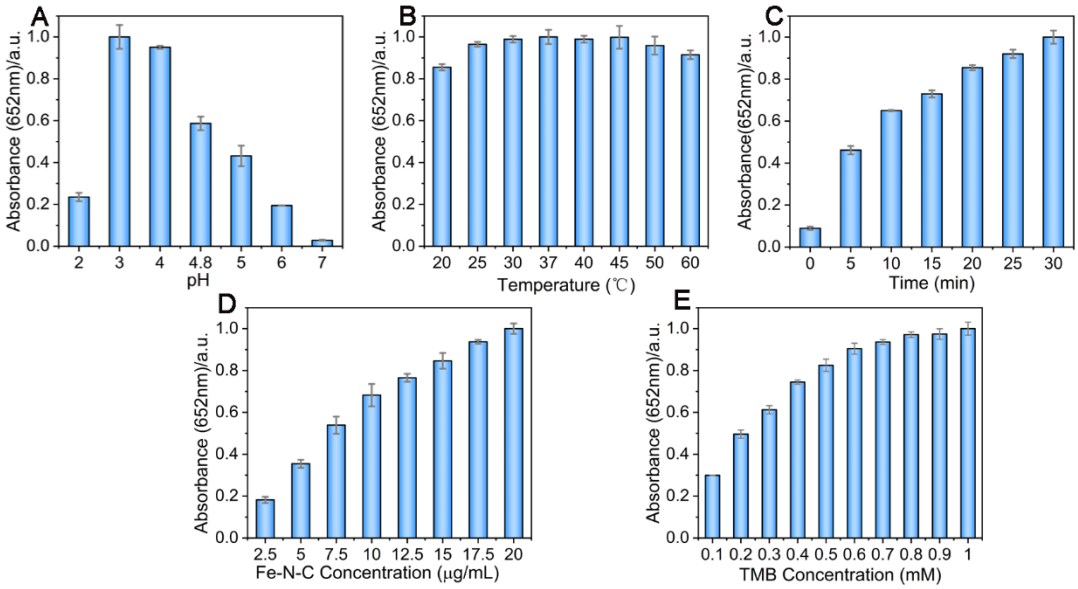

Figure S4 The effects of reaction condition on the oxidase-like activity of Fe-N-C nanozyme **(A)** pH, **(B)** temperature, **(C)** reaction time, **(D)** the concentration of Fe-N-C, **(E)** the concentration of TMB.

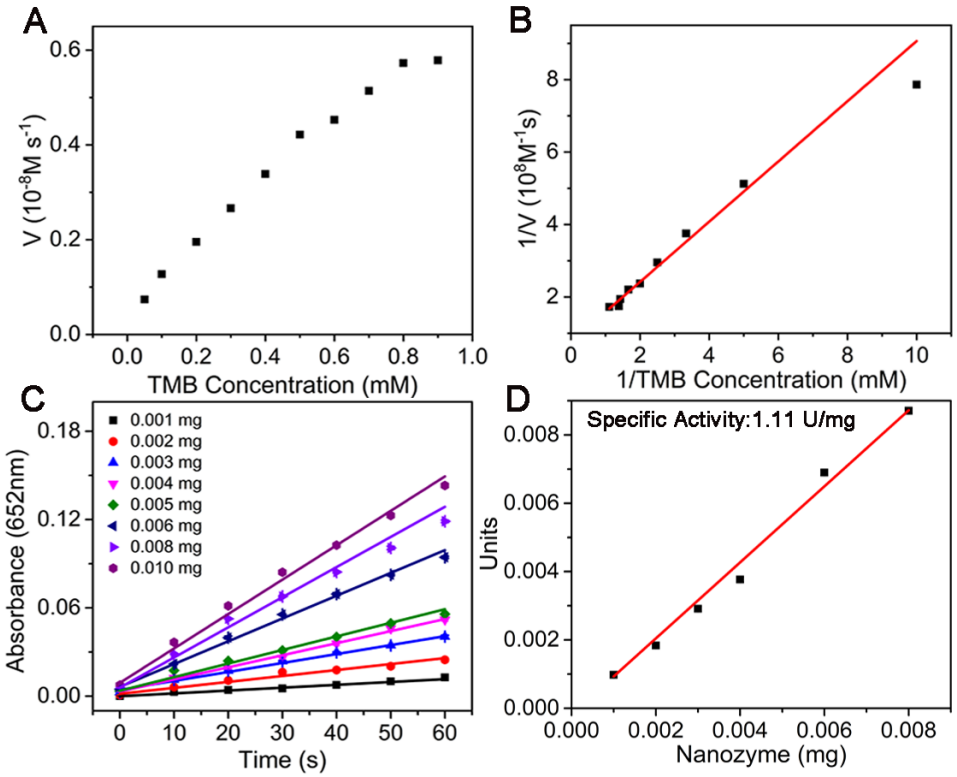

Figure S5. Steady-state kinetic assay of Fe-N-C nanozyme: **(A)** the trend graph of the initial rate with the TMB concentration; **(B)** the double reciprocal curve; **(C)** Absorbance-time curve of TMB colorimetric reaction catalyzed by the Fe-N-C with different amount; **(D)** Relationship between the enzyme-like activity of the Fe-N-C amount.

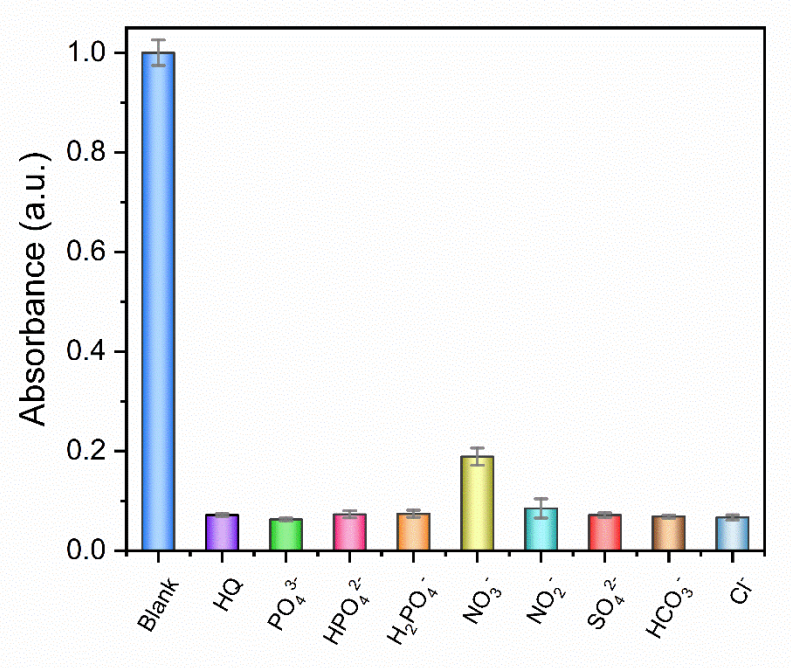

Figure S6. Effect of possible interference ions to the detection system

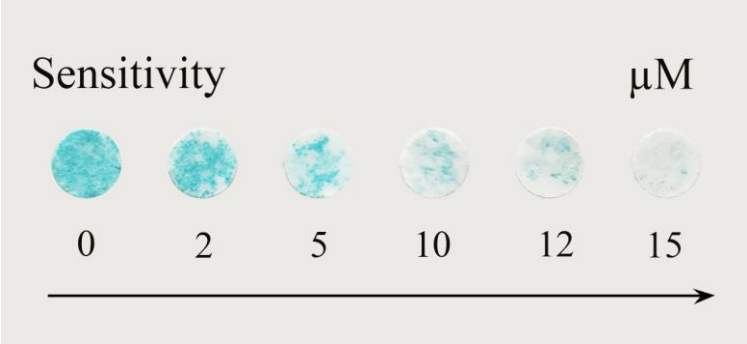

Figure S7. Responses of the color of the Fe-N-C nanozyme test paper to HQ concentration

Table S1. The SSA, porosity parameters and average particle size of Fe-N-C, Fe-C and N-C.

Catalyst	BET (m^2/g)	Total pore volume V_{total} (cm^3/g)	micropore volume V_{mic}(cm^3/g)	V_{mic}/ V_{total} (%)	Average Pore size (nm)
N-C	824.93	0.44	0.32	72.72	2.15
Fe-C	1709.95	0.91	0.21	23.08	2.13
Fe-N-C	1077.81	0.58	0.35	60.34	2.15

Table S2. Comparison of Fe-N-C based system with other reported HQ sensors.

Materials	**Methods**	**Linear range**	**LOD**	**Ref.**
Ce-MOF/carbon nanotube composite	Electrochemistry	10 - 100 μM	5.3 μM	[1]
g-CNQDs	Fluorometry	0.5 - 11.6 μM	0.04 μM	[2]
Si nanoparticles	Fluorometry	2.5 - 27 μM	0.68 μM	[3]
$NiCo_2O4@MnO_2$	Colorimetry	0 - 24 μM	0.042 μM	[4]
P-FM JMMs	Colorimetry	0 - 100 μM	0.0923 μM	[5]
$ZIF-8@MnO_2$	Colorimetry	0.1 - 15 μM	0.1 μM	[6]
Au/CuO	Colorimetry	5 - 200 μM	3 μM	[7]
Ni-MOF@NiV	Colorimetry	0.5-70 μM	0.37	[8]
Fe-C-N	Colorimetry	0.5 - 12 μM	0.09 μM	This work

Reference

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