Supporting Information

Nucleobase-mediated synthesis of nitrogen-doped carbon nanozymes as efficient peroxidase mimics

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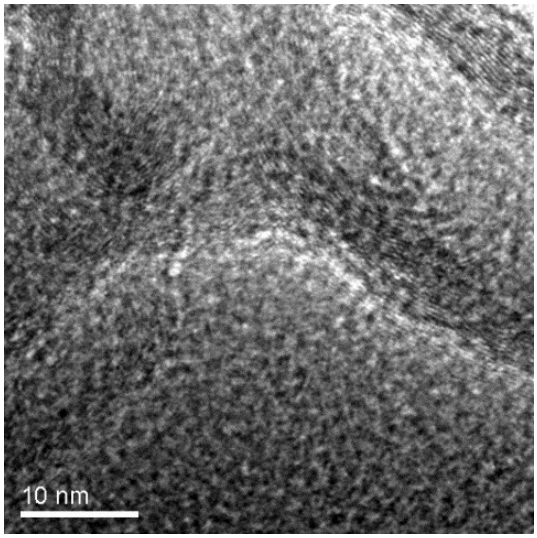

Figure S1. High resolution transmission electron microscopy (HRTEM) image of GNC900.

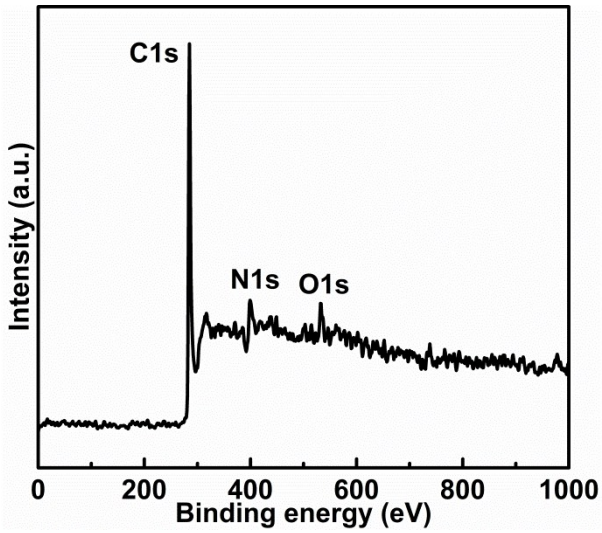

Figure S2. XPS spectrum of GNC900 indicating the presence of C, N, and O elements.

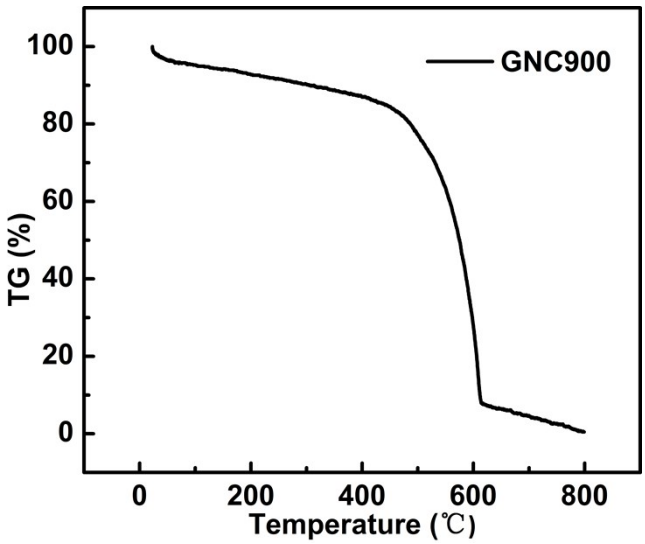

Figure S3. Thermal gravimetric analysis of GNC900 at a heating rate of 10 ℃/min.

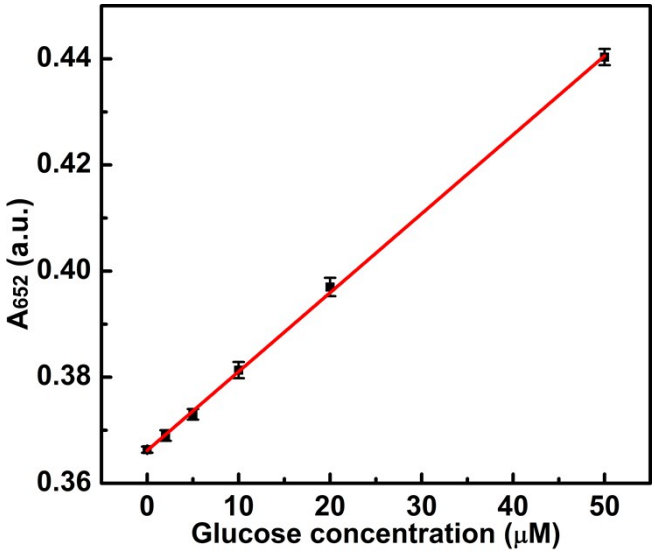

Figure S4. Linear calibration plot of A_{652} against glucose concentration. Error bars represent at least three independent measurements.

As shown in Figure S4, it revealed a linear detection range from 2 μM to 50 μM glucose.

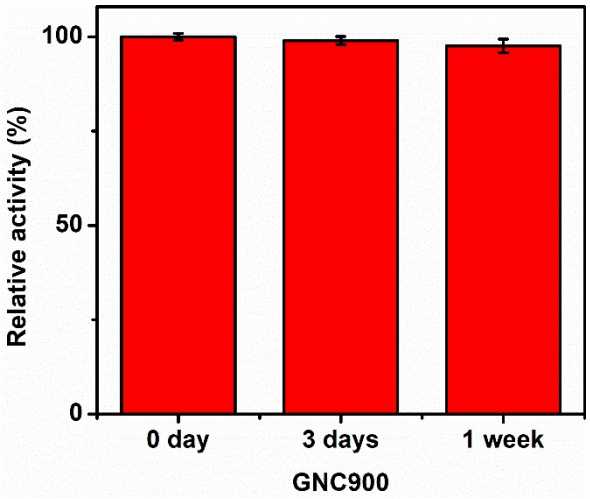

Figure S5. Relative peroxidase-like activity of GNC900 at different storage times. Error bars represent at least three independent measurements.

We have carried out stability test of GNC900. GNC900 dissolved in deionized water with a concentration of 0.4 mg/mL was stored for 3 days and 1 week, respectively. As shown in Figure S5, GNC900 almost maintained the original peroxidase-like activity after 3 days and 1 week. This result demonstrated the high stability of our GNC900.

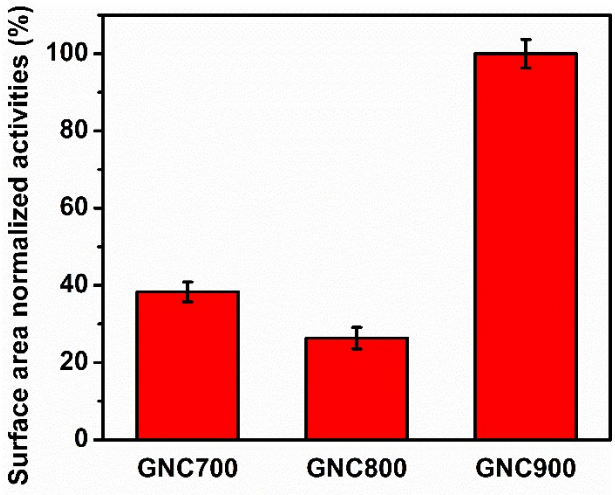

Figure S6. Comparison of the surface area normalized peroxidase-like activities of GNC700, GNC800, and GNC900. Error bars represent at least three independent measurements.

We have measured the surface area of GNC700, GNC800, GNC900, ANC900, CNC900, TNC900, and UNC900. Their BET surface area values are listed in Table R1. It is interesting that guanine-derived N-doped carbon nanozymes exhibited higher surface areas than the ones derived from other nucleobases. Moreover, the obtained GNC maintained a high surface area under a pyrolysis temperature of 900 ℃. For the surface area normalized peroxidase-like activity, GNC900 also showed the highest activity as compared to GNC800 and GNC700 (Figure S6). Together, these results demonstrated that the superior peroxidase-like activity of GNC900 was correlated with its dominant graphitic N species and its high surface area.

Table S1. Comparison of the recent advancements and the current work in N-doped carbon nanomaterial synthesis.

Catalyst	Multiple precursors	Template	Complex procedures	Undesired waste	Scalable production	Low cost	Reference
Nucleobases derived N-doped carbon	No	No	No	No	Yes	Yes	This work
Vertically-aligned N-doped carbon nanotube	No	No	No	Yes, NH_3	No	No	*Science*, **2009**, *323*, 760.
N-doped carbon hybrid microfibres	Yes	No	Yes	Yes, HNO_3	Yes	No	*Nat. Nanotechnol.* **2014**, *9*, 555.
N-doped carbon nanotube frameworks	Yes	No	Yes	Yes, H_2SO_4	No	No	*Nat. Energy* **2016**, *1*, 15006.
N-doped nanoporous carbon membranes	Yes	No	Yes	Yes	No	No	*Nat. Commun.* **2017**, *8*, 13592.
N-doped mesoporous carbon	Yes	Yes, SiO_2	Yes	Yes	No	No	*J. Am. Chem. Soc.* **2017**, *139*, 12931.
N-doped carbon dots	No	No	Yes	No	Yes	Yes	*Angew. Chem. Int. Ed.* **2017**, *56*, 6459
N-doped mesoporous carbon spheres	Yes	Yes, polymer	Yes	Yes	No	No	*Angew. Chem. Int. Ed*. **2015**, *54*, 588.
3D hierarchically porous N-doped carbon	Yes	Yes, cellulose ester	Yes	Yes	No	No	*Angew. Chem. Int. Ed*. **2014**, *53*, 9503.
N-doped graphene	No	Yes, mont-morillonite	Yes	Yes, HF	No	Yes	*Angew. Chem. Int. Ed.* **2013**, *52*, 11755.
N-doped carbon nanocages	Yes	Yes, MgO	Yes	Yes, HCl	No	Yes	*Adv. Mater*. **2012**, *24*, 5593.
N-doped graphene	Yes	No	Yes	Yes	No	No	*Chem. Mater.* **2018**, *30*, 6431.

Table S2. Contents of C, N, and O for GNC900 from XPS characterization.

Sample	C wt%	N wt%	O wt%
GNC900	86.28	8.77	4.95

Table S3. Contents of different N species for GNC900 from XPS characterization.

Sample	Pyridinic N at%	Pyrolic N at%	Graphitic N at%	Oxidized N at%
GNC900	18.61	2.80	39.88	38.71

Table S4. Comparison of the kinetic parameters of GNC900 with other reported peroxidase mimics. K_m is the Michaelis-Menten constant, V_{max} is the maximal reaction velocity.

Catalyst	Substrate	K_m (mM)	V_{max} (Ms^{-1})	Ref.
GNC900	TMB	0.23	2.53×10^{-7}	This work
GNC900	H_2O_2	28.3	7.63×10^{-7}	This work
GO-COOH	TMB	0.0237	3.45×10^{-8}	*Adv. Mater*. **2010**, *22*, 2206.
GO-COOH	H_2O_2	3.99	3.85×10^{-8}	*Adv. Mater*. **2010**, *22*, 2206.
Pd-Ir cubes	TMB	0.13	6.5×10^{-8}	*ACS Nano*. **2015**, *9*, 9994.
Pd-Ir cubes	H_2O_2	340	5.1×10^{-8}	*ACS Nano*. **2015**, *9*, 9994.
Fe_3O_4	TMB	0.098	3.44×10^{-8}	*Nat. Nanotechnol*. **2007**, *2*, 577.
Fe_3O_4	H_2O_2	154	9.78×10^{-8}	*Nat. Nanotechnol*. **2007**, *2*, 577.
HRP	TMB	0.434	10×10^{-8}	*Nat. Nanotechnol*. **2007**, *2*, 577.
HRP	H_2O_2	3.7	8.71×10^{-8}	*Nat. Nanotechnol*. **2007**, *2*, 577.

Table S5. Detection of glucose by representative carbon nanozymes based on their intrinsic peroxidase-like activity.

Peroxidase mimics	Catalyst concentration	Detection time	Linear range	Limit of detection	Reference
GNC900	10 μg/mL	30 min + 20 min	2.5-50 μM	1.14 μM	This work
GO-COOH	40 μg/mL	1 h + 10 min	1-20 μM	1 μM	*Adv. Mater.* **2010**, *22*, 2206.
C-Dots	1 μg/mL	30 min + 30 min	1-500 μM	0.4 μM	*Chem. Commun.* **2011**, *47*, 6695.
$C_{60}[C(COOH)_2]_2$	20 μM	30 min + 2 h	1-40 μM	0.5 μM	*Biosens. Bioelectron.* **2013**, *47*, 502
SWCNH-COOH	25 μg/mL	30 min + 15 min	100-2000 μM	100 μM	*Analyst*, **2015**, *140*, 6398.

Table S6. BET surface area of nucleobase-derived carbon nanozymes.

Nanozymes	BET surface area (m^2/g)
GNC700	358.0883
GNC800	659.6481
GNC900	493.7293
ANC900	8.5763
CNC900	16.9208
TNC900	54.2764
UNC900	10.5649