Supplementary Information

Large-sized and highly crystalline ceria nanorods with abundant Ce^{3+} species achieve efficient intracellular ROS scavenging

Trung Hieu Vu, †[a] Ha-Rim An, †[b] Phuong Thy Nguyen[a], Jiwon Seo[b] Chang Yeon Kim[b], Ji-In Park[b], Byoungchul Son[b], Hyeran Kim[b], Hyun Uk Lee*[b] and Moon Il Kim*

[a] Department of BioNano Technology, Gachon University, 1342 Seongnamdae-ro, Sujeong-gu, Seongnam, Gyeonggi 13120, Republic of Korea

[b] Division of Material Analysis and Research, Korea Basic Science Institute, Gwahak-ro, Yuseong-gu, Daejeon 34133, Republic of Korea

[1]These authors contributed equally to this work.

*To whom correspondence should be addressed.

Tel.: +82-31-750-8563; Fax: +82-31-750-4748. E-mail: moonil@gachon.ac.kr (M.I. Kim)

Tel.: +82-42-865-3637; Fax: +82-42-865-3640. E-mail: leeho@kbsi.re.kr (H.U. Lee)

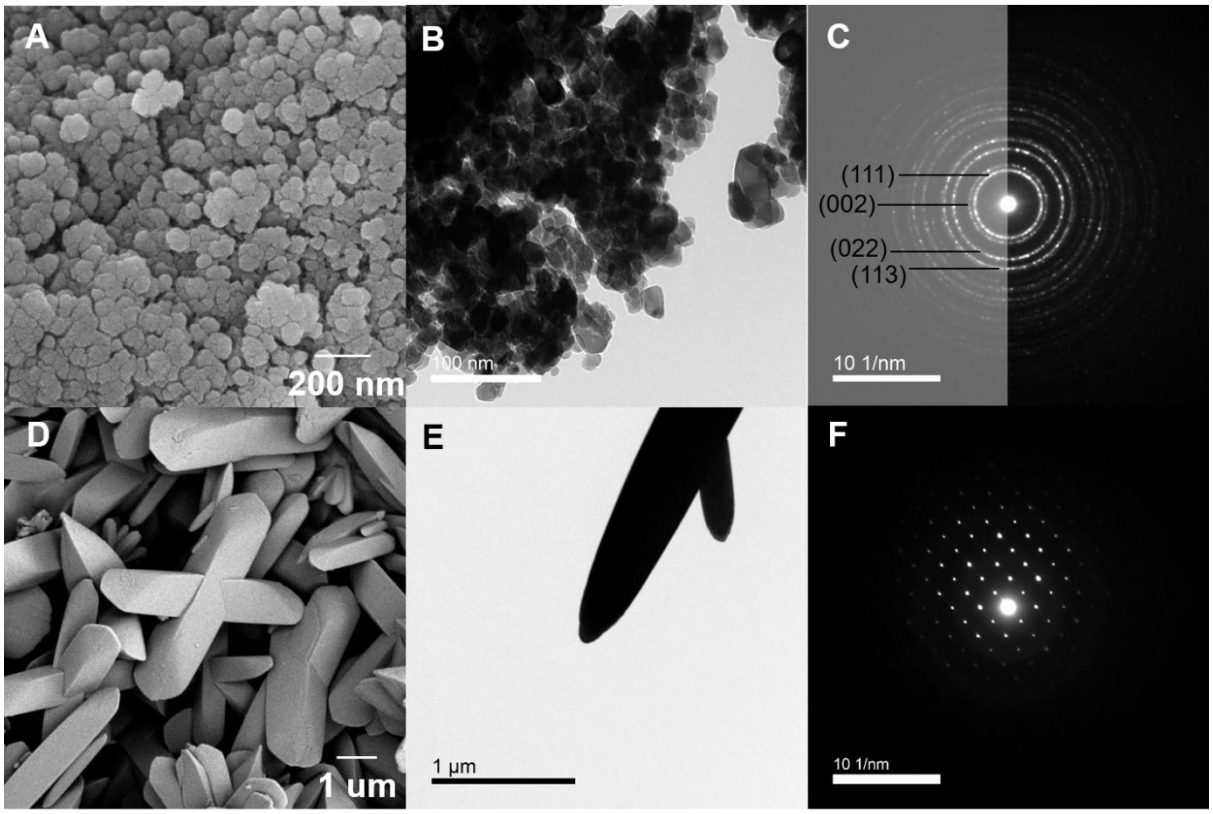

Fig. S1. SEM, TEM, and SAED images of (A-C) commercial CeNPs and (D-F) BHT-CeNRs.

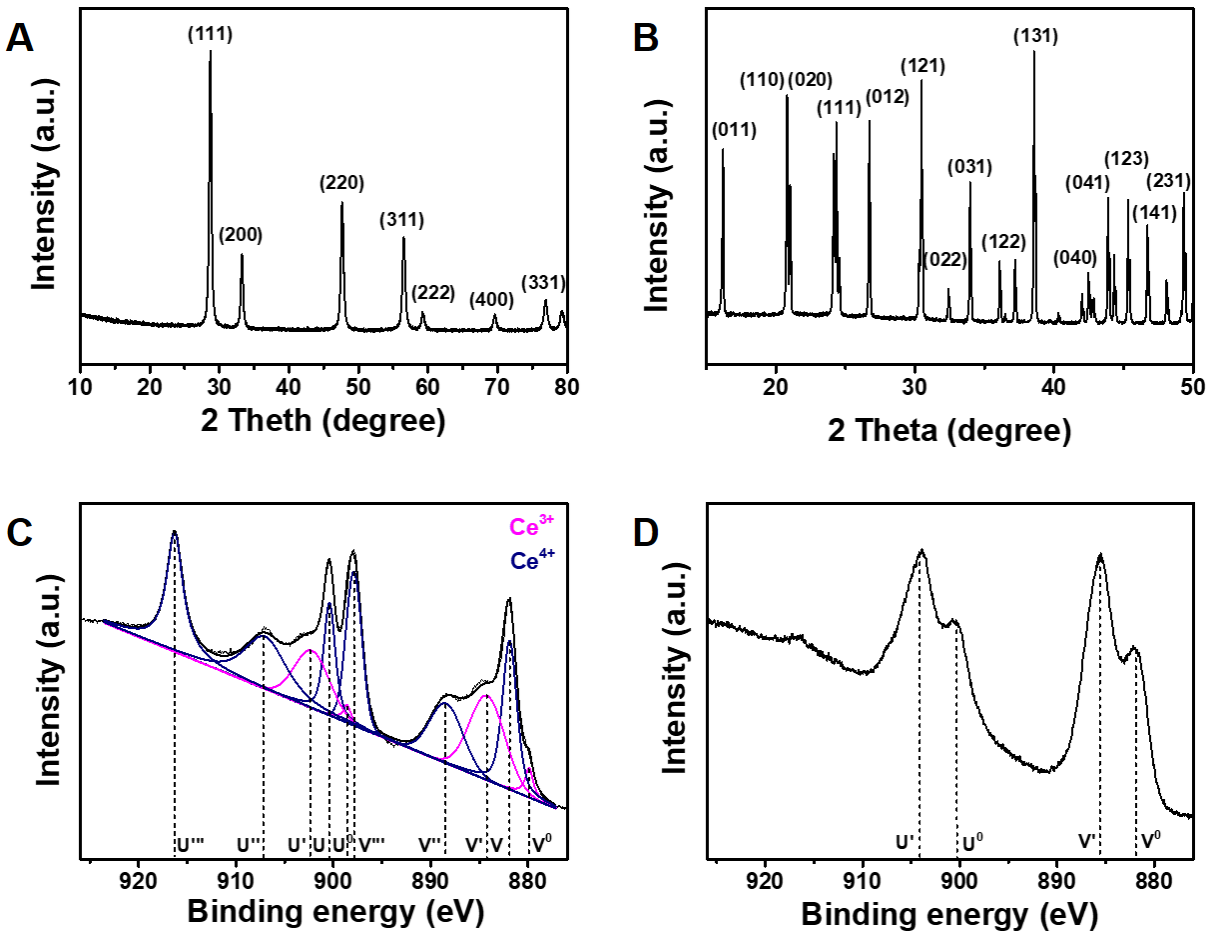

Fig. S2. XRD patterns of (A) commercial CeNPs, (B) BHT-CeNRs, XPS spectra of (C) commercial CeNPs, and (D) BHT-CeNRs.

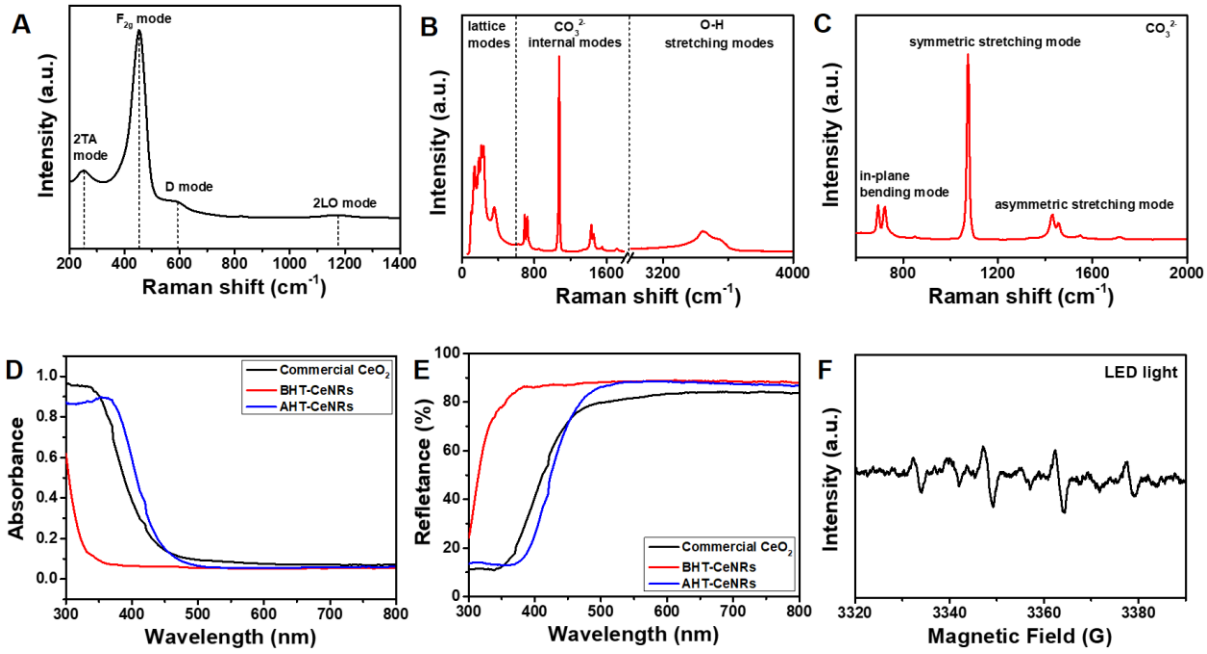

Fig. S3. Raman shift of (A) commercial CeNPs, (B-C) BHT-CeNRs, (D) UV-visible absorbance, (E) reflectance, and (F) EPR spectra under UV light irradiation of AHT-CeNRs with DMPO adduct.

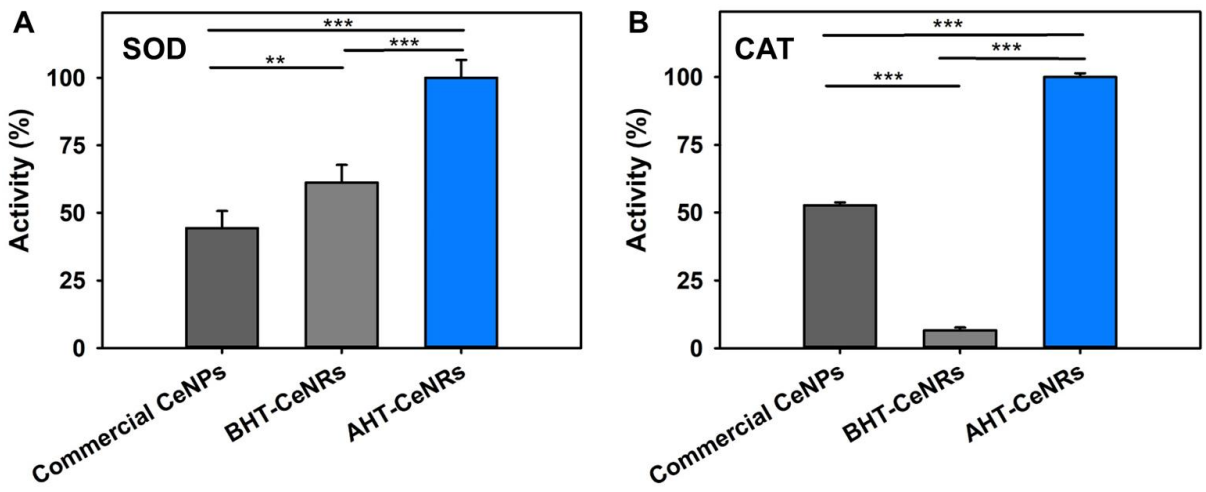

Fig. S4. Comparison of (A) SOD-like and (B) CAT-like activities of commercial CeNPs, BHT- and AHT-CeNRs. Data are represented as mean ± standard deviation. *** $p < 0.001$ when compared to control groups, n = 3.

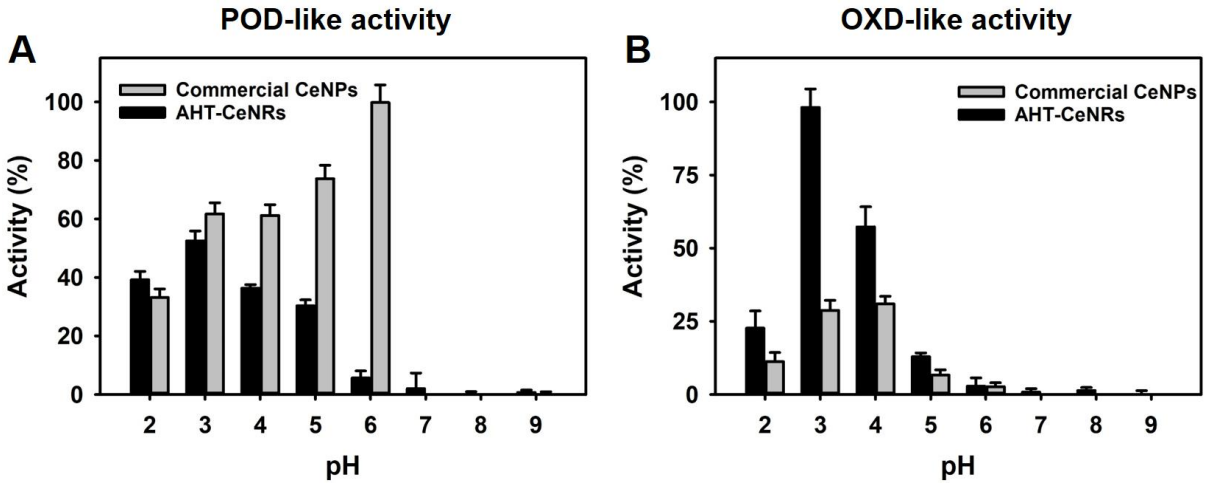

Fig. S5. (A) POD- and (B) OXD-like activities of commercial CeNPs and AHT-CeNRs.

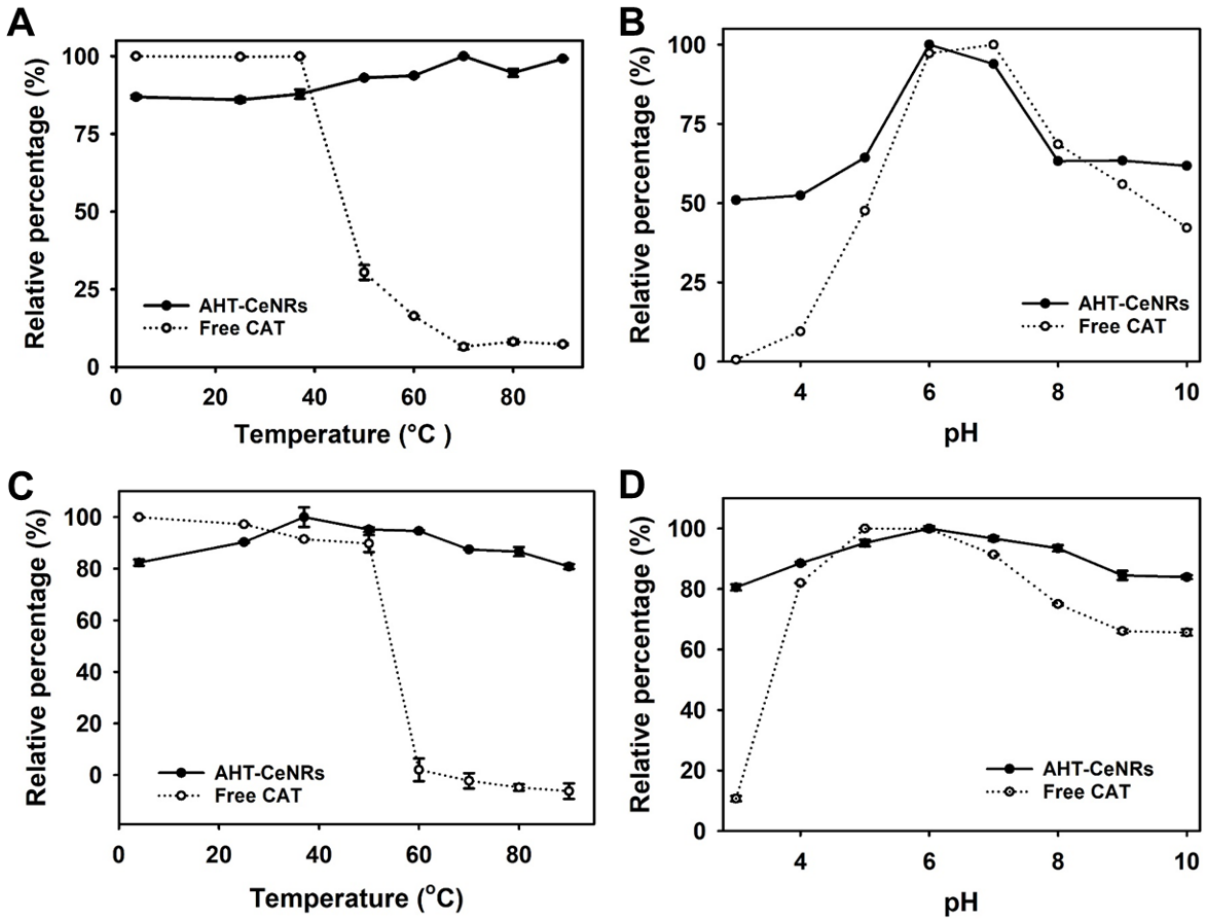

Fig. S6. Effects of (A) temperature and (B) pH on the CAT-like activities of AHT-CeNRs and natural CAT. Stabilities in ranges of (C) temperature and (D) pH for CAT-like AHT-CeNRs and natural CAT.

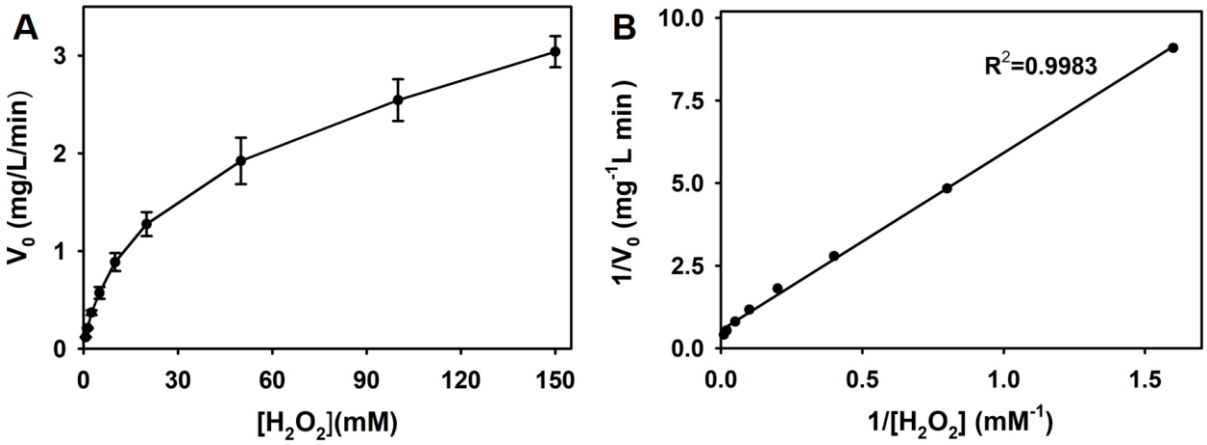

Fig. S7. (A) Michaelis–Menten curves for the CAT-like activity of AHT-CeNRs in the presence of H_2O_2, and (B) the corresponding Lineweaver–Burk plots. Error bars represent the standard deviation (n = 3).

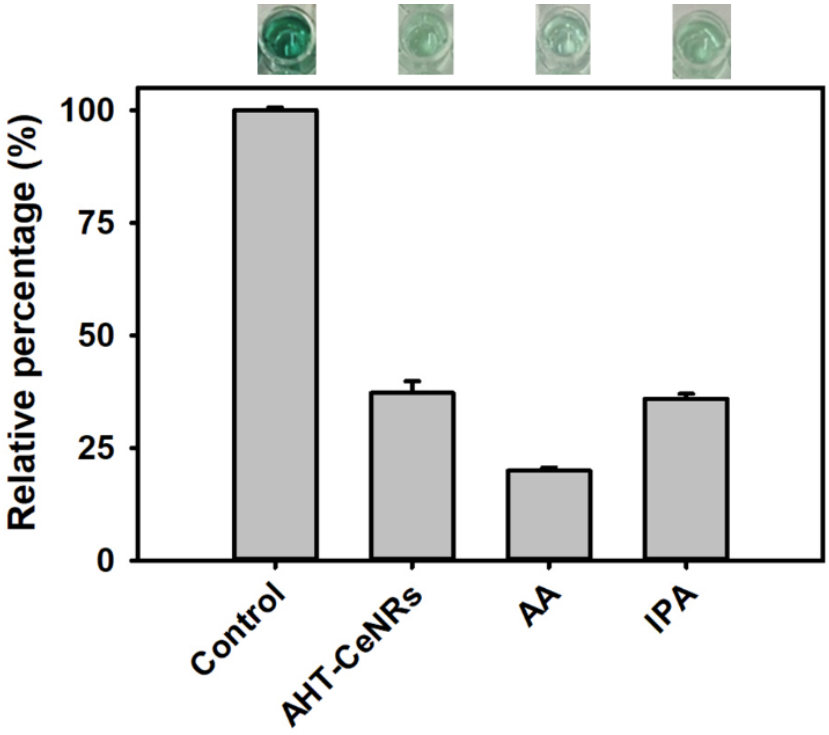

Fig. S8. Comparison of relative absorbance at 417 nm with or without radical scavengers (AA, IPA, and AHT-CeNRs) in the ABTS assay. The green color in control was produced by the reaction including 0.2 μg/mL HRP, 100 mM H_2O_2, and 6 mM ABTS.

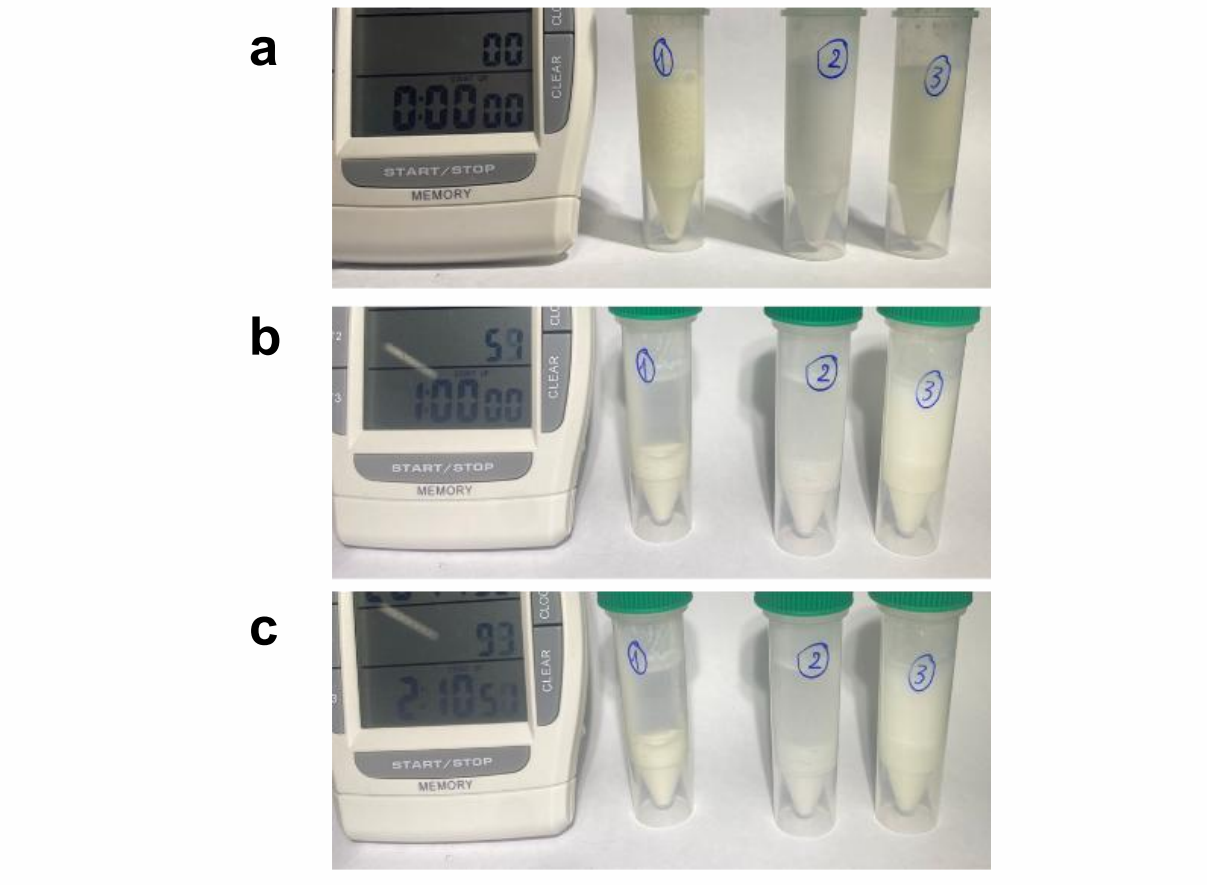

Fig. S9. Water dispersibility of (1) commercial CeNPs, (2) BHT-CeNRs, and (3) AHT-CeNRs (a) after ultrasonication for 5 min and undisturbed settling for (b) 1 h and (c) 2 h.

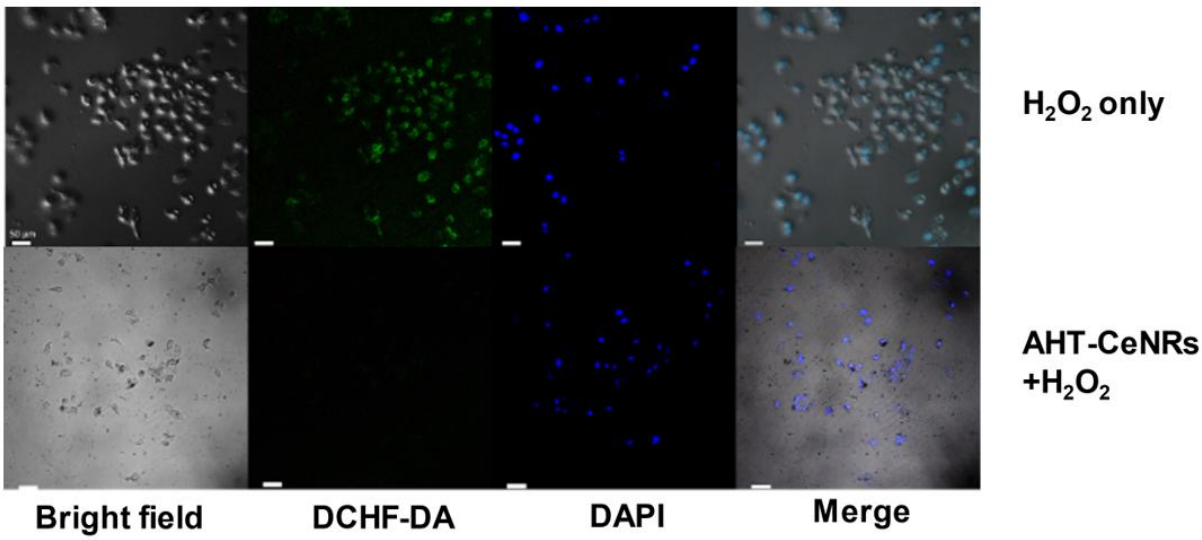

Fig. S10. Fluorescent microscopy images of HaCaT cells treated with H_2O_2 only (5 mM) or H_2O_2 with AHT-CeNRs (scale bar: 50 μm).

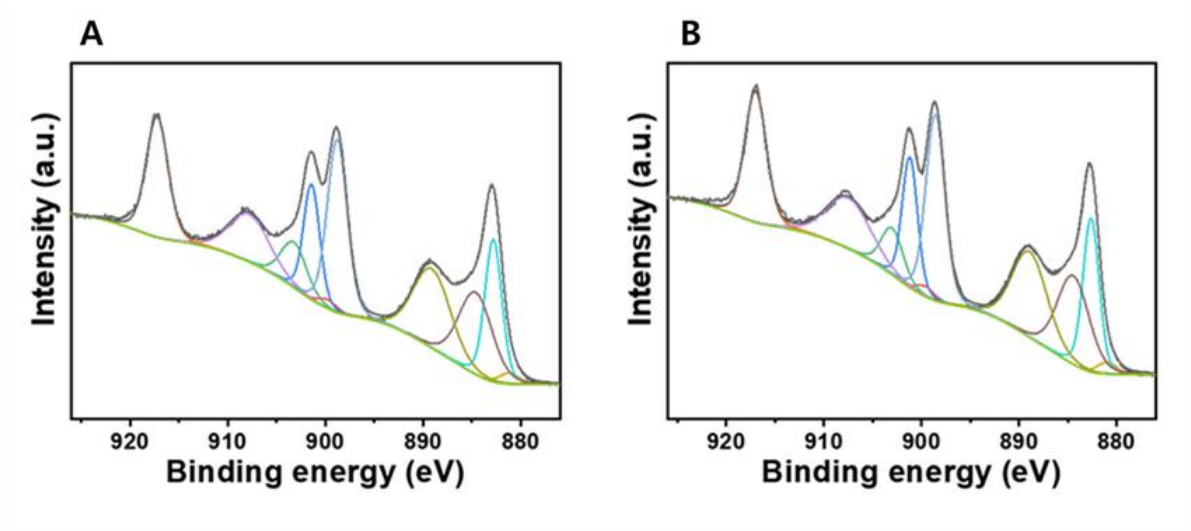

Fig. S11. Ce 3d HR-XPS spectra of AHT-CeNRs treated with (a) 0.1 M and (b) 1 M H_2O_2.

Table S1. Kinetic parameters of CAT-like AHT-CeNRs and reported values for natural CAT and CAT mimics.

Catalyst	K_m (mM)	V_{max} (mM/s)	Reference
Fe-SANzyme	18.80	9.32×10^{-3}	[1]
Natural CAT	52.14	1.274×10^{-2}	
Pt-Ft	420.6	0.84	[2]
Natural CAT	71.60	0.29	
Pd-Ru	31.02	8.78×10^{-3}	[3]
$Au_{24}Ag_1$	222.42	1.15×10^{-3}	[4]
CeO_2 NPs (pH 7.4)	69.48	0.43 (mg L^{-1} min^{-1})	[5]
CeO_2 NPs (pH 6.6)	94.69	0.21 (mg L^{-1} min^{-1})	
CeO_2 NPs	14.96	-	[6]
AHT-CeNRs	9.8	1.89×10^{-2}	This work

References

1 R. Zhang, B. Xue, Y. Tao, H. Zhao, Z. Zhang, X. Wang, X. Zhou, B. Jiang, Z. Yang, X. Yan, K. Fan, *Adv. Mater.*, 2022, **34**, 39, 2205324, DOI: 10.1002/adma.202205324.

2 J. Fan, J. J. Yin, B. Ning, X. Wu, Y. Hu, M. Ferrari, G. J. Anderson, J.Wei, Y. Zhao, G. Nie, *Biomaterials*, 2011, **32,** 6, 1611-1618, DOI: 10.1016/j.biomaterials.2010.11.004.

3 J. Ming, T. Zh, J. Li, Z. Ye, C. Shi, Z. Guo, J. Wang, X. Chen, N. Zheng, *Small*, 2021, **17**, 46, 2103645, DOI: 10.1002/smll.202103645.

4 S. Sun, H. Liu, Q. Xin, K. Chen, H. Ma, S. Liu, X. Mu, W. Hao, S. Liu, Y. Gao, Y. Wang, *Nano Lett.*, 2021, **21**, 6, 2562-2571, DOI: 10.1021/acs.nanolett.0c05148.

5 Q. Weng, H. Sun, C. Fang, F. Xia, H. Liao, J. Lee, J. Wang, A. Xie, J. Ren, X. Guo, F. Li, *Nat. Commun.*, 2021, **12**, 1, 1436, DOI: 10.1038/s41467-021-21714-2.

6 J. K. Sharma, M. Yadav, A. Hazarika, H. S. Yadav, N. Takio, S. Ameen, P. Srivastava, M. S. Akhtar, *Emergent Mater.*, 2022, **5**, 3, 673-682, DOI: 10.1007/s42247-022-00346-2.