Electronic Supplementary Material (ESI) for Nanoscale.

Electronic Supporting Information

Ozone-mediated synthesis of ceria nanoparticles

Anuja Bhalkikar,[a] Tai-Sing Wu,[b] Chris M. Marin,[a] Tamra. J. Fisher,[a] Meiyu Wang,[c] Isaac H. Wells,[a] Anandakumar Sarella,[d] Yun-Liang Soo,[b, e] and Chin Li Cheung[a*]

a. Department of Chemistry, University of Nebraska-Lincoln, Lincoln, Nebraska 68588, United States. Email: *ccheung2@unl.edu*
b. National Tsing Hua University, Hsinchu 30013, Taiwan, R.O.C.
c. Department of Mechanical and Materials Engineering, University of Nebraska-Lincoln, Lincoln, Nebraska 68588, United States.
d. Nebraska Center for Materials and Nanoscience, University of Nebraska-Lincoln, Lincoln, Nebraska 68588, United States.
e. National Synchrotron Radiation Research Centre, Hsinchu 30076, Taiwan, R.O.C.

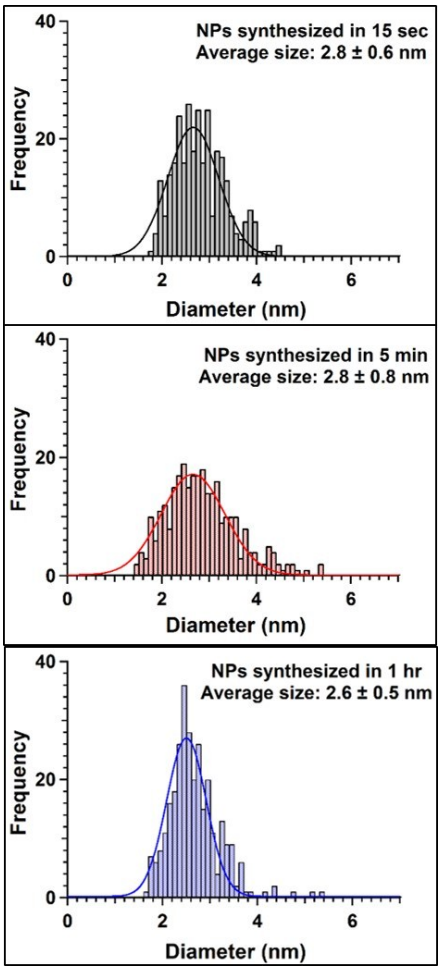

Fig. S1 Average size distributions of ceria NPs synthesized from cerium (III) nitrate in ethanol with different ozonation reaction times (15 sec, 5 min, and 1 h). The sizes of the nanoparticles were estimated from the size of the crystallites in the transmission electron microscopy images.

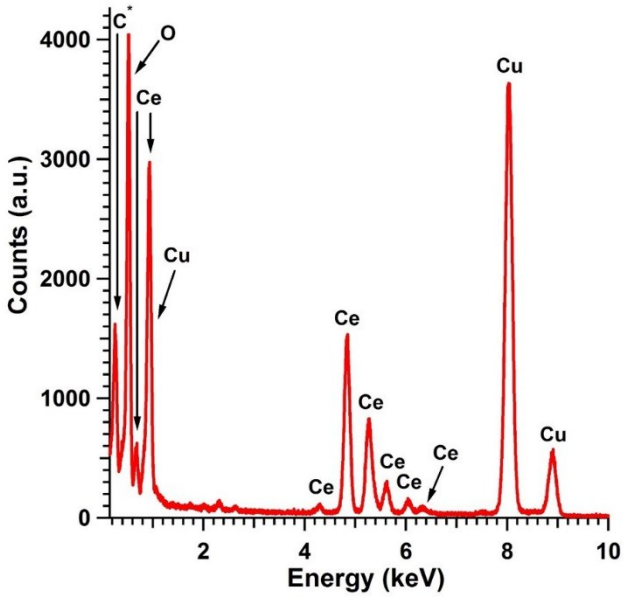

Fig. S2 Energy dispersive X-ray spectrum of ceria NPs synthesized with one hour of ozonation.

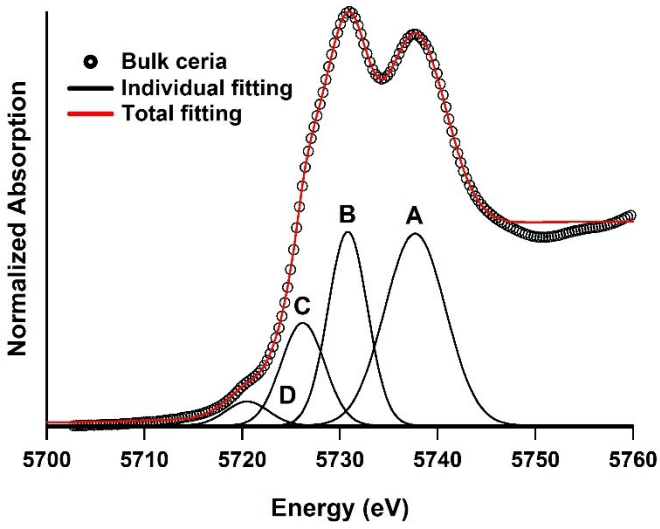

Fig. S3 Ce L_3-edge XANES spectrum of commercial bulk ceria. Peaks A and B were attributed to the Ce^{4+} state. Peak C was ascribed to the Ce^{3+} state. Peak D was due to the final states of 2p4f*. Note: 2p denotes the hole produced in $2p^{3/2}$ and 4f* indicates the presence of an excited electron in the 4f band.

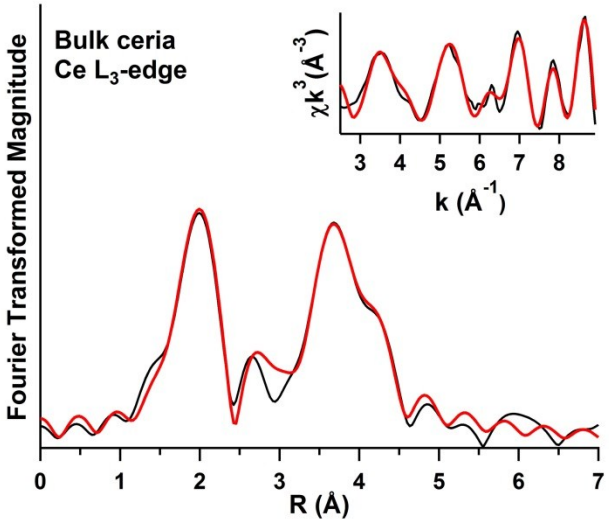

Fig. S4 Fourier transformed Ce L_3-edge EXAFS spectrum of commercial bulk ceria. (inset) Normalized data in *k*-space. (Black: data; red: fitting)

Sample	Atom	*N*	R (Å)	σ^2 (10^{-3} Å^2)
Commercial bulk ceria	O	7.9 ± 0.8	2.35 ± 0.01	6.2 ± 3.9
	Ce	12.0 ± 0.4	3.85 ± 0.01	3.2 ± 1.6
	O	23.6 ± 3.0	4.45 ± 0.01	14.0 ± 5.2

Table S1 Fitted structural parameters of the Ce L_3-edge EXAFS analysis for commercial bulk ceria. *N* is the coordination number. R is the average bond distance. σ^2 is the Debye-Waller factor. Underlined parameters are fixed in the fitting analysis. The fitting model for commercial bulk ceria was based on the fluorite-like CeO_2 crystal structure.

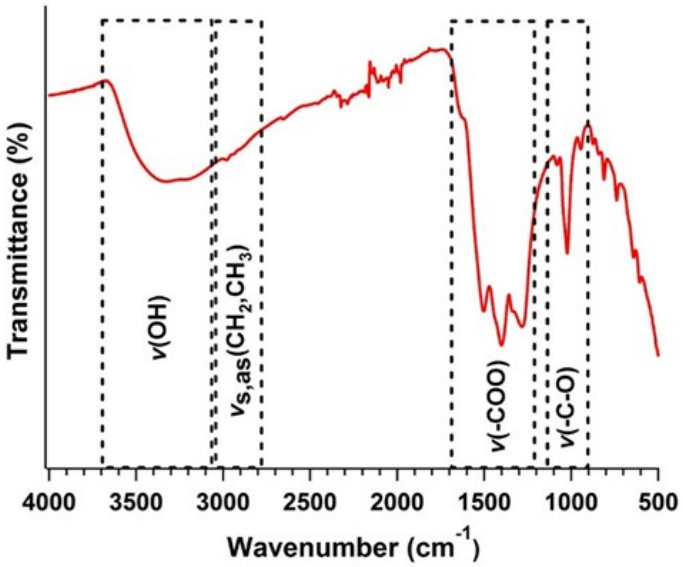

Fig. S5 FT-IR spectrum of ceria nanoparticles synthesized with one hour of ozonation

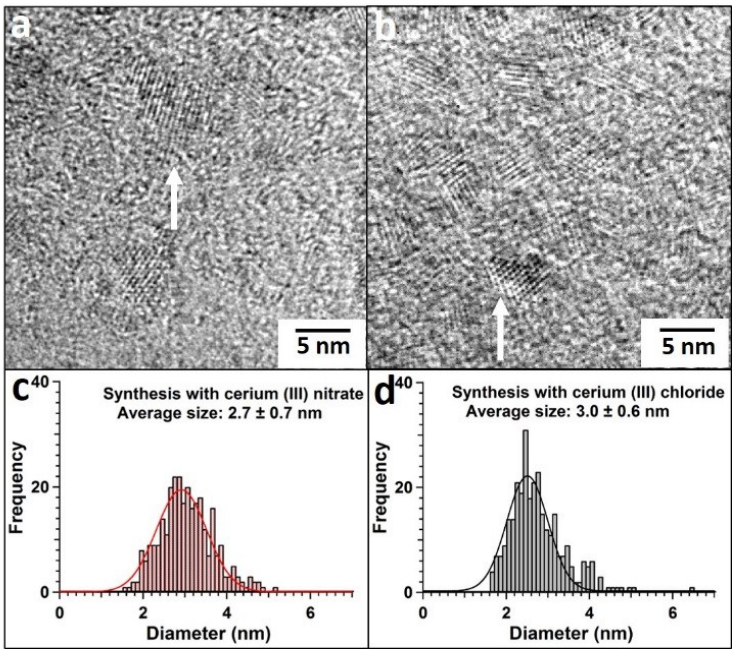

Fig. S6 HRTEM images of ceria NPs synthesized with 30 minutes of ozonation in ethanol using (a) cerium (III) nitrate and (b) cerium (III) chloride. Corresponding size distributions (c & d) are under the images. White arrows indicate the nanoparticles.

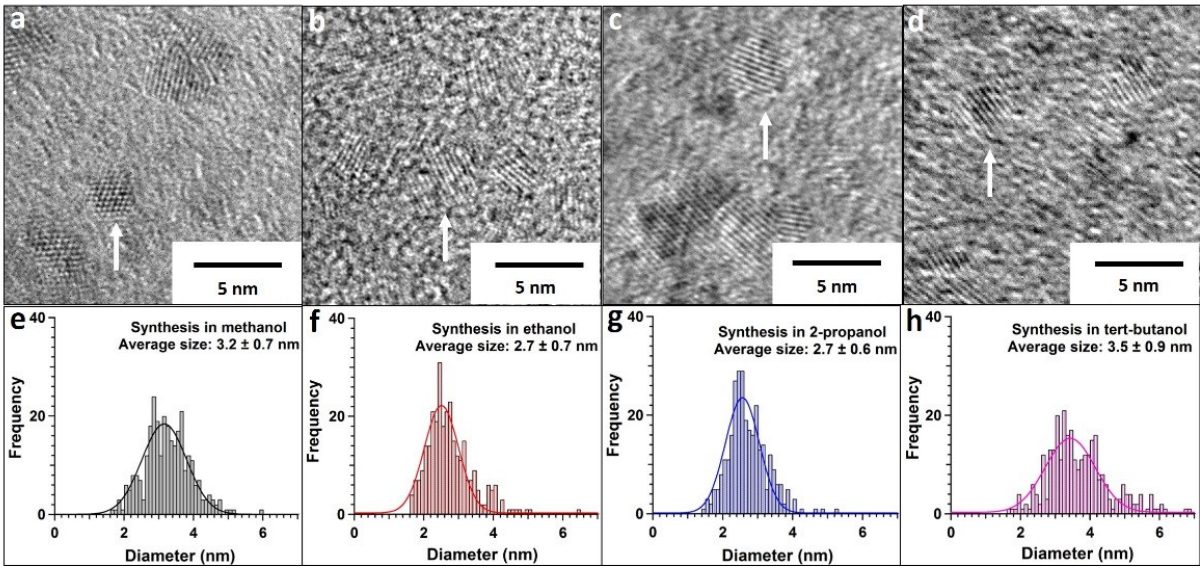

Fig. S7 HRTEM images of ceria NPs synthesized with 30 minutes of ozonation with cerium (III) nitrate using (a) methanol, (b) ethanol, (c) 2-propanol, and (d) tert-butanol. Corresponding size distributions (e, f, g & h) are under the images. Arrows indicate the nanoparticles.

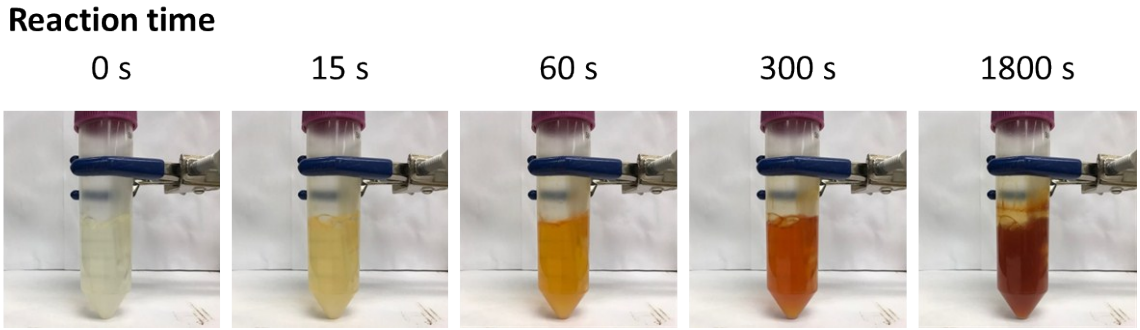

Fig. S8 Synthesis of ceria NPs prepared by ozonating an ethanol solution of cerium (III) nitrate. (Left to right) Optical images of reaction mixtures from different reaction times: 0 s, 15 s, 60 s, 300 s and 1800 s.

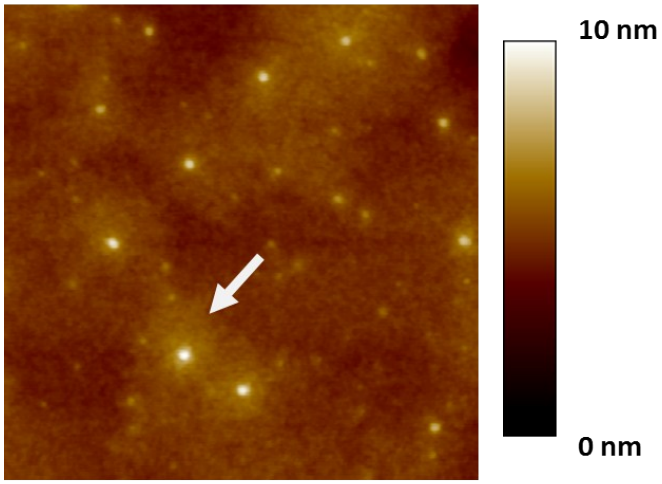

Fig. S9 Topographic AFM image of ceria nanoparticles synthesized with 1 h of ozonation in ethanol. White arrow indicates polymer-like species encapsulating some nanoparticles. The image size is 1 μm x 1 μm. Note that no patches of polymer-like species were observed in control topographic AFM images of poly-*L*-lysine coated mica discs.

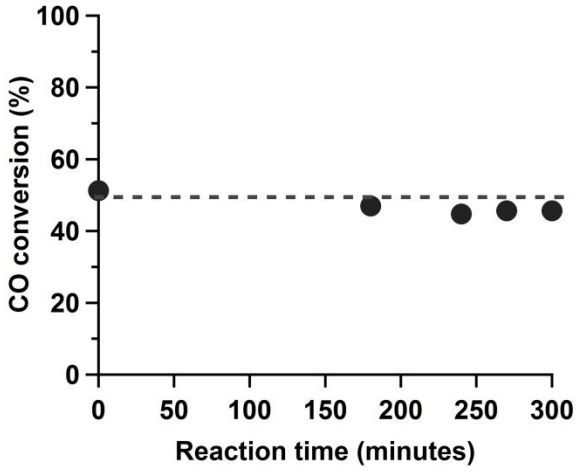

Fig. S10 Catalytic activity of activated ceria NPs towards CO oxidation. Plot of CO conversion (%) vs. reaction time at reaction temperature of 310 °C.