

Electronic supporting information

**Multi-shelled ceria hollow spheres with tunable shell  
number, thickness and their superior catalytic activity**

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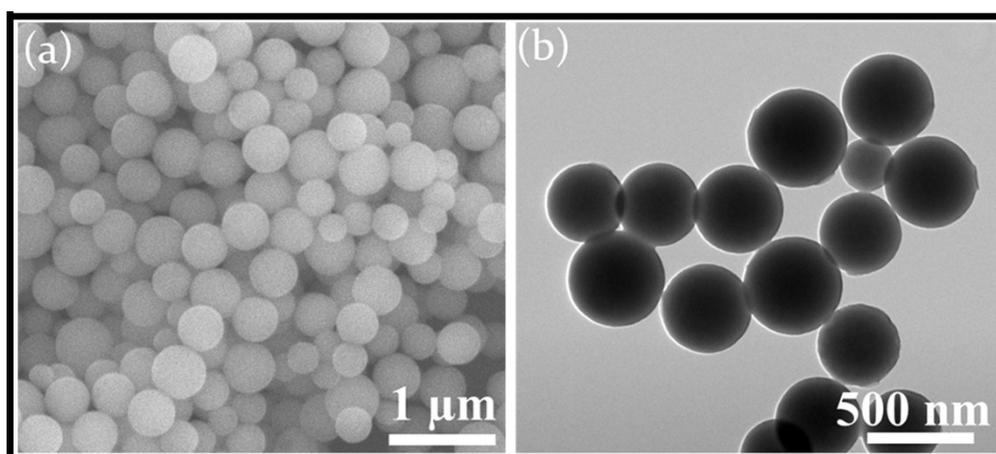
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Table S1 Samples and Corresponding Experimental Parameters.

Sample	Reaction time (h)	Reaction			Molar ratio of Ce <sup>3+</sup> and 2,5-H <sub>2</sub> PDC	Calcination temperature (°C)
		Temperature (°C)	Solvent composition			
0	12	200	16 mL DMF+16 mL EtOH	1:3	no calcination	
1	12	200	16 mL DMF+16 mL EtOH	1:3	600	
2	12	80	16 mL DMF+16 mL EtOH	1:3	600	
3	12	120	16 mL DMF+16 mL EtOH	1:3	600	
4	12	160	16 mL DMF+16 mL EtOH	1:3	600	
5	1	200	16 mL DMF+16 mL EtOH	1:3	600	
6	6	200	16 mL DMF+16 mL EtOH	1:3	600	
7	12	200	28 mL DMF+4 mL EtOH	1:3	600	
8	12	200	24 mL DMF+8 mL EtOH	1:3	600	
9	12	200	8 mL DMF+24 mL EtOH	1:3	600	
10	12	200	32 mL DMF+0 mL EtOH	1:3	600	
11	12	200	16 mL DMF+16 mL EtOH	1:1	600	
12	12	200	16 mL DMF+16 mL EtOH	1:2	600	
13	12	200	16 mL DMF+16 mL EtOH	1:4	600	



**Fig. S1.** (a, b) SEM and TEM images of sample 0.

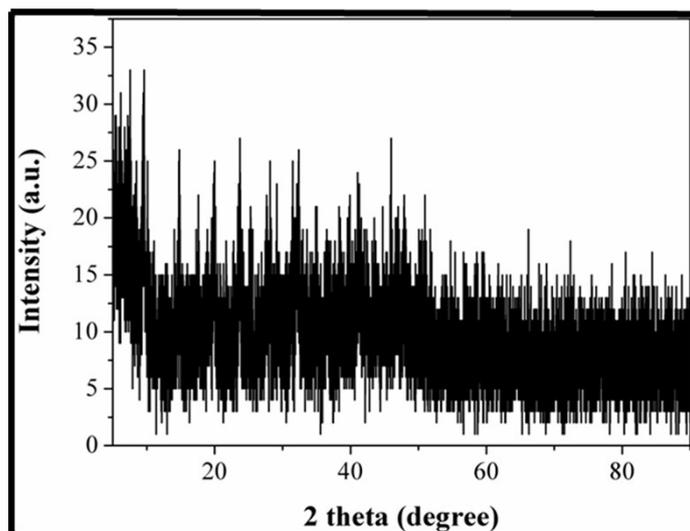


Fig. S2. XRD images of sample 0.

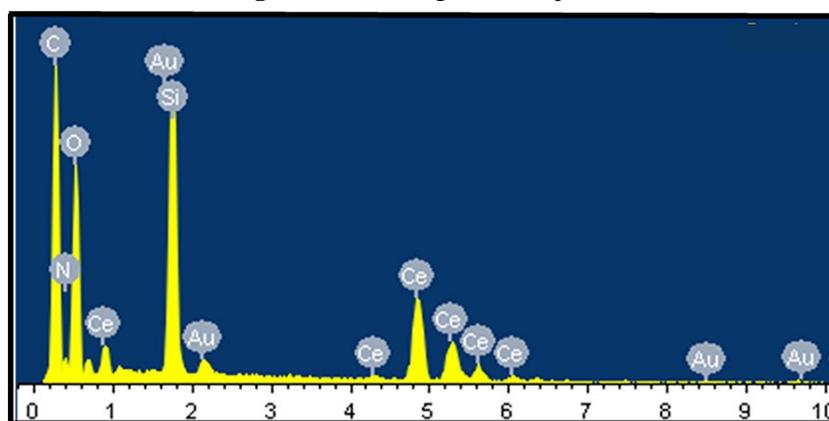


Fig. S3. EDX images of sample 0.

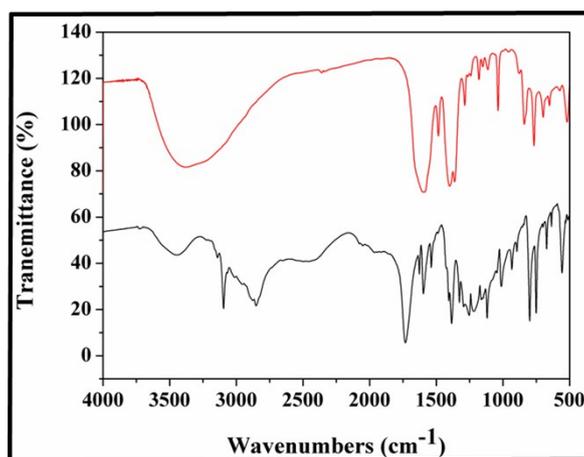


Fig. S4. FTIR spectra of sample 0 (red) and pure 2,5-pyridinedicarboxylic acid (black).

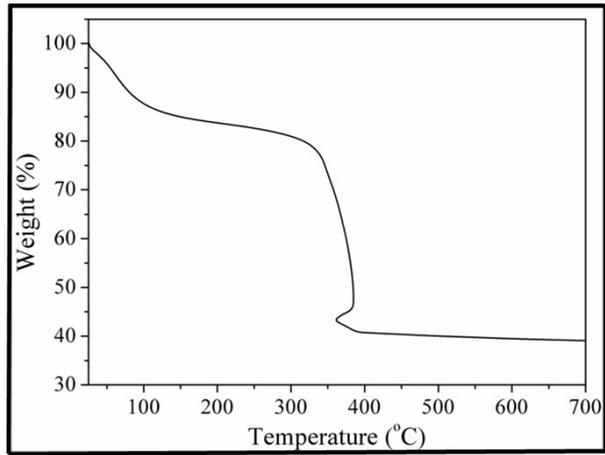


Fig. S5. TG curves of sample 0.

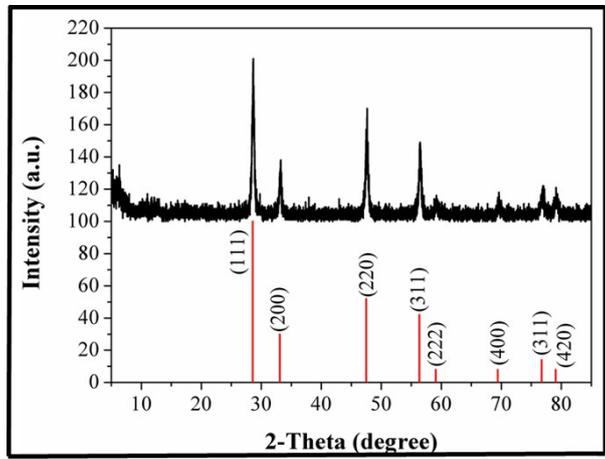


Fig. S6. XRD pattern of sample 1, and the red line is the standard data for CeO<sub>2</sub> (JCPDS card 34-0394).

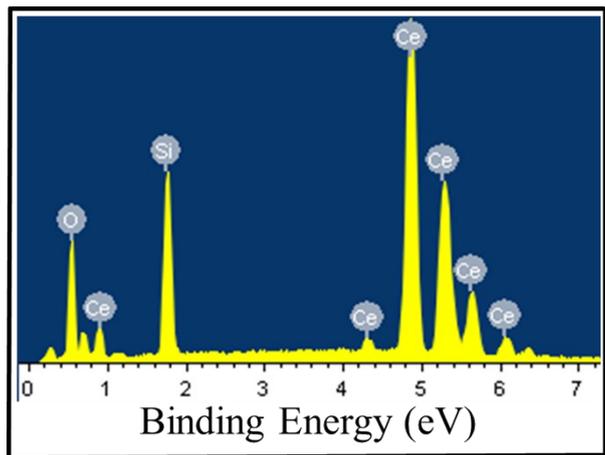
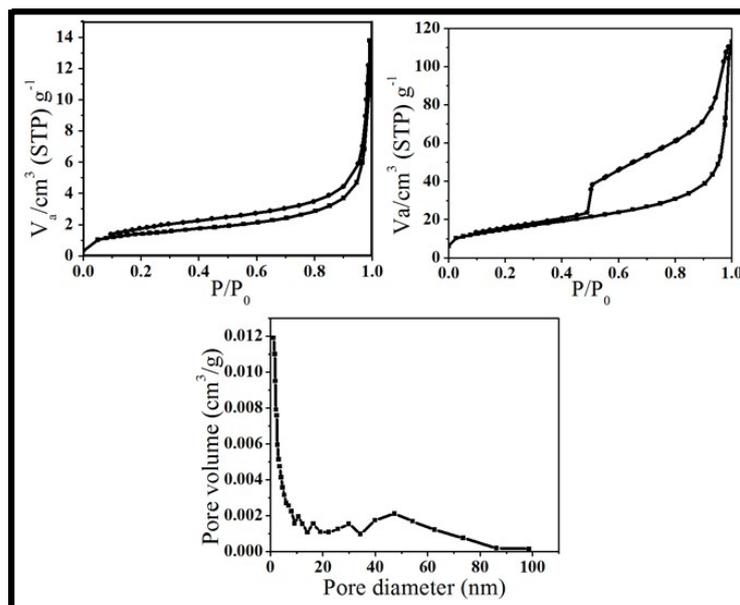
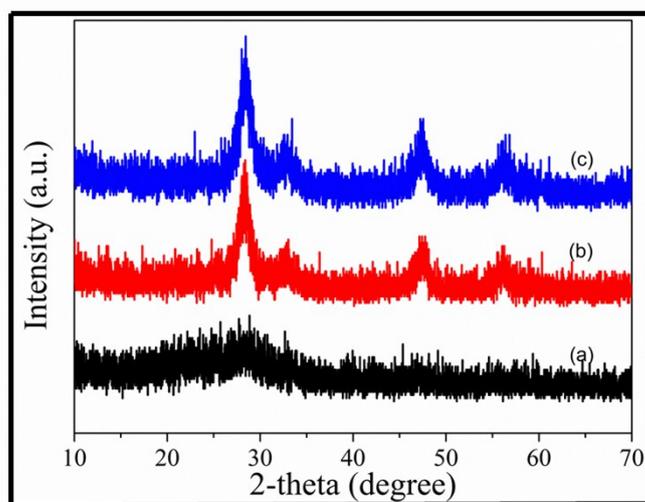


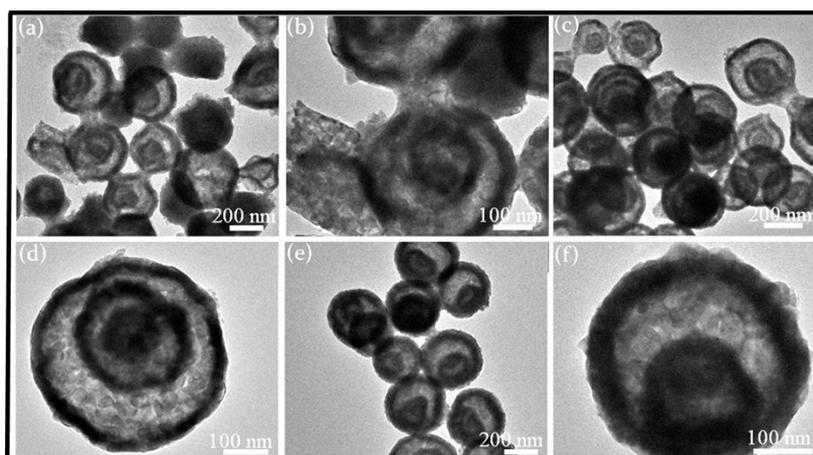
Fig. S7. EDX spectrum of sample 1.



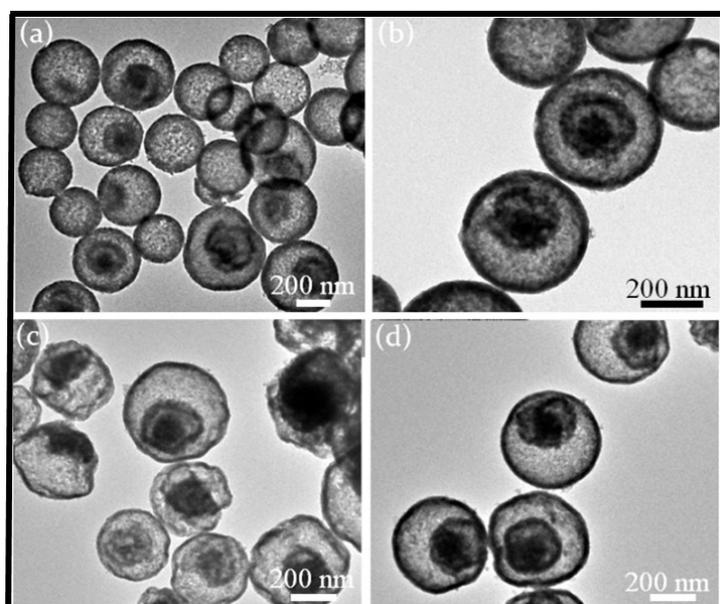
**Fig. S8.** Nitrogen adsorption-desorption isotherms of the as-prepared product. (a) sample **0**, (b) sample **1** and (c) BJH pore size distribution of sample **1**.



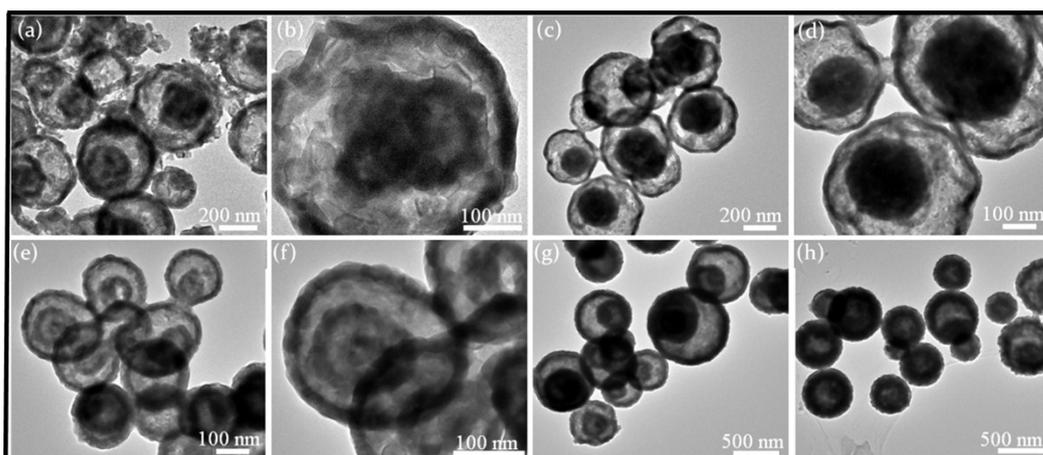
**Fig. S9.** XRD patterns of immediate products obtained by calcining sample **0** at different calcinations stage. (a) 300 °C; (b) 350 °C; (c) 400 °C.



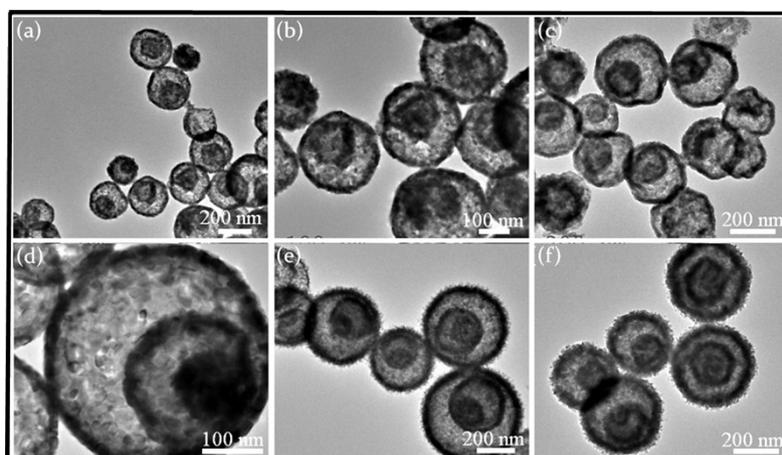
**Fig. S10.** TEM photos of the products obtained after calcining the CPs precursors prepared after different reaction temperature. (a, b) sample 2; (c, d) sample 3; (e, f) sample 4.



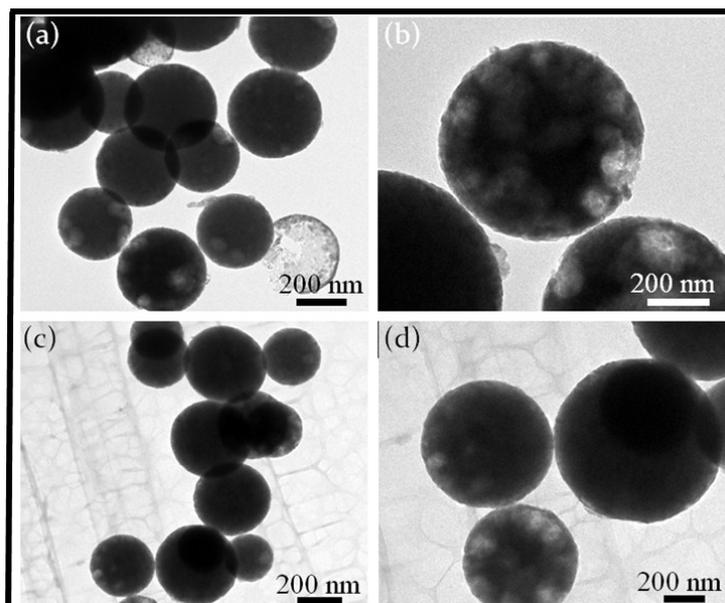
**Fig. S11.** TEM photos of the products obtained after calcining the CPs precursors prepared after different reaction time. (a, b) sample 5; (c, d) sample 6.



**Fig. S12.** TEM photos of the products obtained by calcining the CP precursors prepared at different solvent compositions. (a, b) sample **7**; (c, d) sample **8**; (e, f) sample **9**; (g, h) sample **10**.

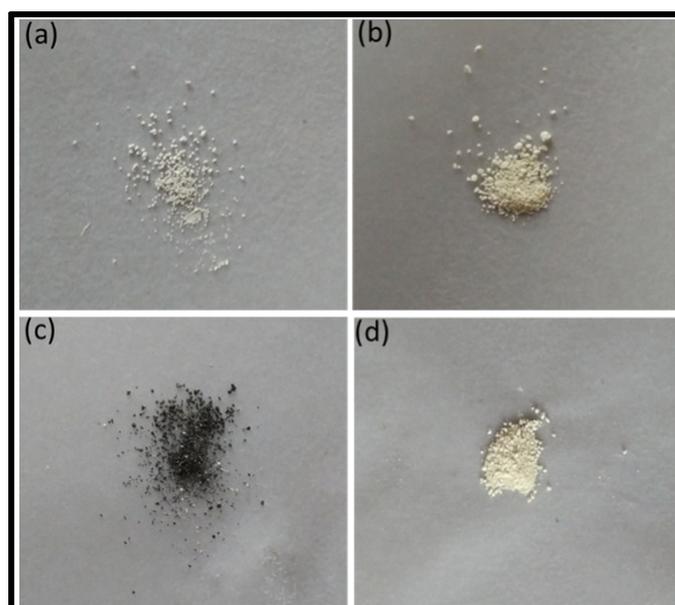


**Fig. S13.** TEM photos of the products obtained by calcining the precursors prepared with different metal-ligand ratios. (a, b) sample **11**; (c, d) sample **12**; (e, f) sample **13**.



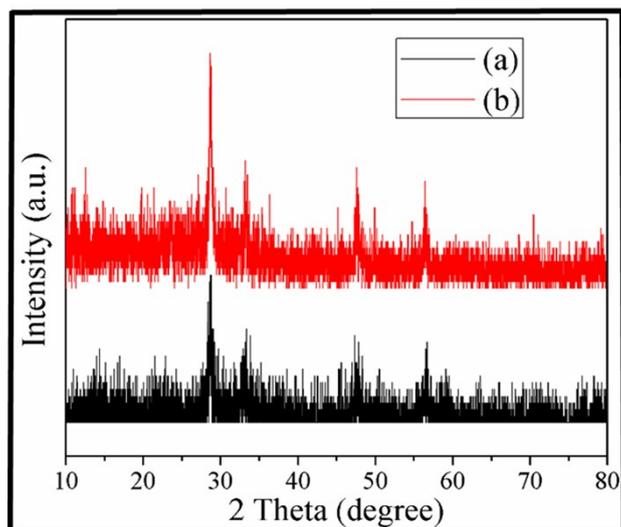
**Fig. S14.** TEM photos of the products obtained by calcining sample **0** at different atmospheres.

(a,b)  $N_2$ ; (c, d) Ar.



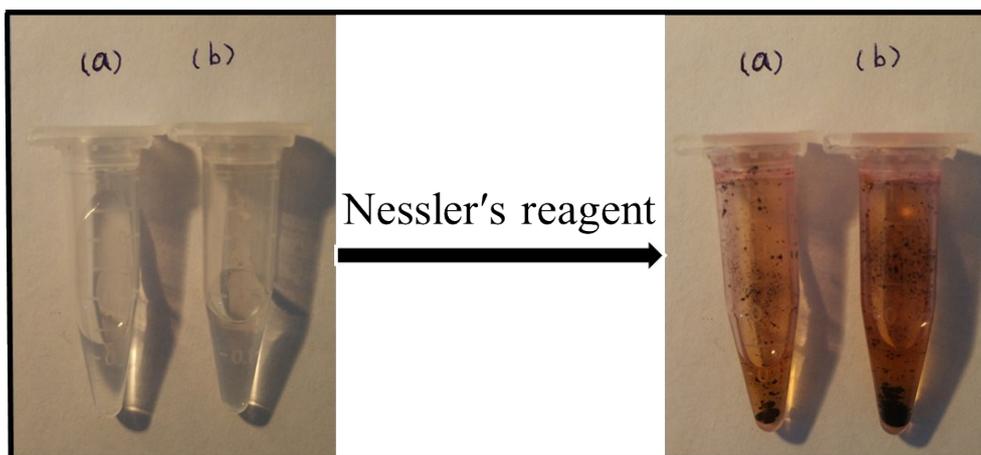
**Fig. S15.** Photos of the products obtained by calcining sample **0** at different atmospheres. (a) $N_2$ ; (b)

calcining (a) at Air; (c)Ar; (d) calcining (c) at Air.



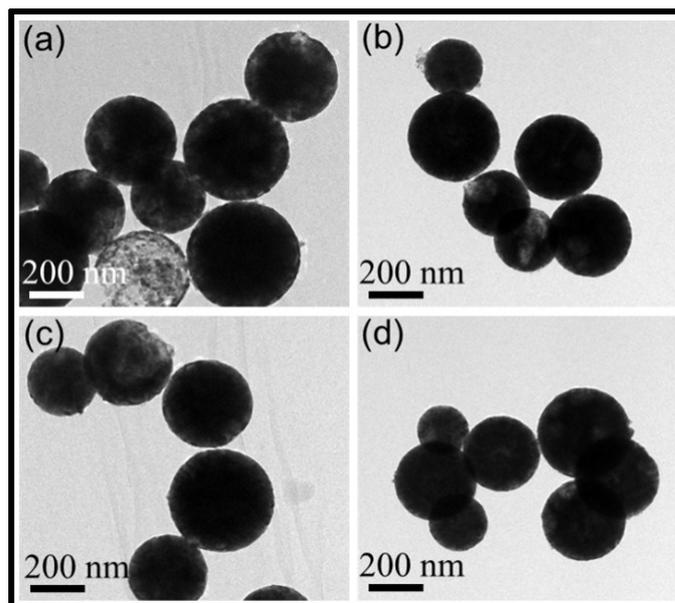
**Fig. S16.** XRD patterns of the products after calcining sample **0** at different atmospheres.

(a)N<sub>2</sub>; (b)Ar.

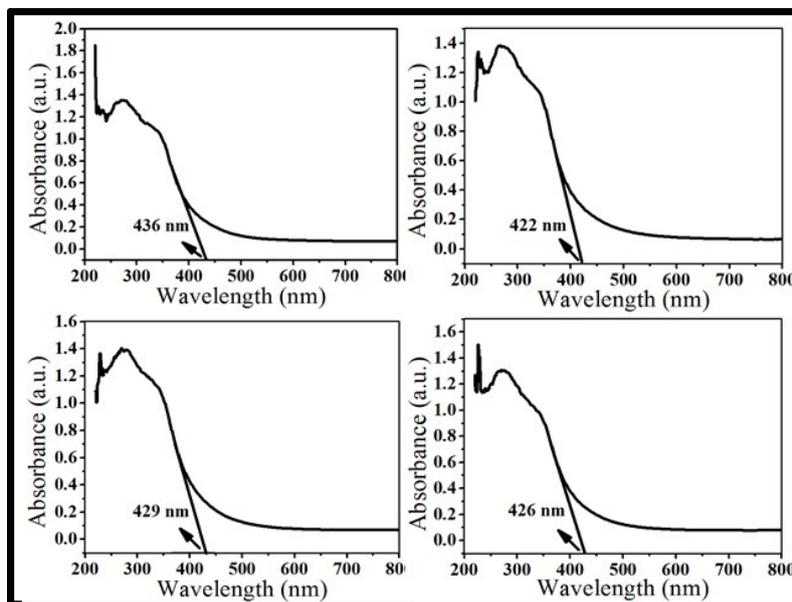


**Fig. S17.** Photographs of the products after calcining sample **0** at different atmospheres (left)

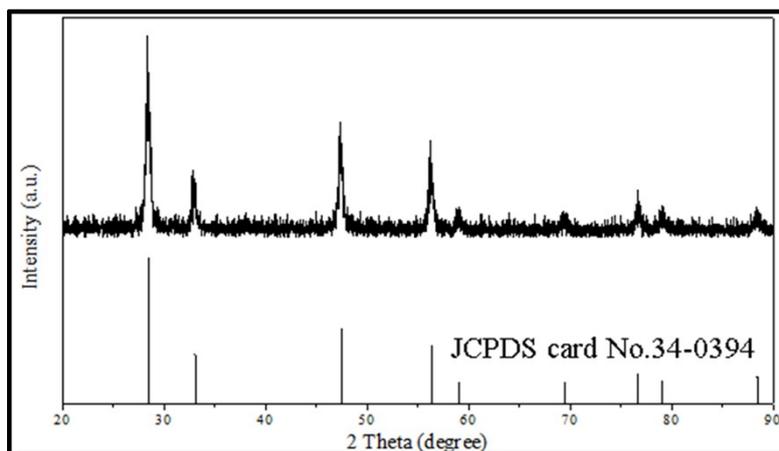
before and (right) after the addition of Nessler's reagent. (a)N<sub>2</sub>; (b)Ar.



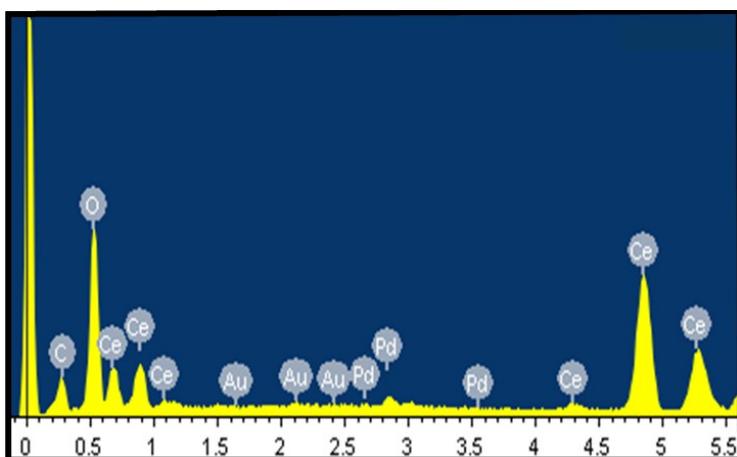
**Fig. S18.** TEM photos of the products obtained by calcining sample **0** at different atmospheres and then calcining in air. (a, c)  $N_2$ ; (b, d) Ar.



**Fig. S19.** UV-vis spectrum of the samples. (a) sample **1** (tri-shelled hollow spheres), (b) sample **5** (majorly composed of solid spheres), (c) sample **8** (di-shelled hollow spheres) and (d) sample **13** (tri-shelled hollow spheres with porous surface).



**Fig. S20.** XRD pattern of the as-prepared AuPd/CeO<sub>2</sub> multi-shelled hollow structures.



**Fig. S21.** EDX spectrum of the as-prepared AuPd/CeO<sub>2</sub> multi-shelled hollow structures