Electronic Supplementary Material (ESI) for RSC Advances


## Supplemental Information

# Solution Synthesis of Homogeneous Plate-like Multifunctional $CeO_2$ Particles

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**Table SI-1** Structure refinement and crystallographic data for $Ce_2(CO_3)_3\ 8H_2O$.

| | |
|---|---|
| Empirical formula | $Ce_2(CO_3)_3 \cdot 8H_2O$ |
| Formula weight | 604.40 |
| Temperature | 293(2) K |
| Diffractometer type | Rigaku RAXIS-RAPID |
| Scan mode | $\Omega$ |
| Crystal system | Orthorhombic |
| Space group | $Pmn2_1$ (No. 31) |
| Unitcell dimensions | |
| $a$ (Å) | 9.5324(7) |
| $b$ (Å) | 8.4915(7) |
| $c$ (Å) | 8.9523(8) |
| Volume (Å$^3$) | 724.64(10) |
| Calculated density (g cm$^{-3}$) | 2.770 |
| $Z$ | 2 |
| Wavelength | 0.71075 Å (Mo Kα) |
| Absorption coefficient | 6.292 mm$^{-1}$ |
| Crystal shape, color | platelet, transparent |
| Crystal size | 0.100 x 0.007 x 0.112 mm |
| Absorption correction | numerical (NUMABS; Higashi, 1999) |
| Max. and min. transmission | 0.962 and 0.599 |
| Reflection collected | 3321 |
| Independent reflections | 811 ($R_{int}$=0.079), (684 $I > 2\sigma(I)$) |
| $\theta$ range for data collection | 3.12 to 20.82° |
| Limiting indices | $h$ = -9 -> 9, $k$ = -8 -> 8, $l$ = -8 -> 8 |
| Refinement method | Full-matrix least squares on $F^2$ |
| Final $R$ indices | $R$ [$F^2 > 2\sigma(F^2)$] = 0.0410, $wR(F^2)$ = 0.0973 |
| Goodness-of-fit on $F^2$ | 1.088 |
| Data/restraints/parameters | 811/1/67 |
| Weight | $w = 1/[\sigma^2(F_o^2)+(0.0222P)^2+4.8138P]$, where $P = (F_o^2+2F_c^2)/3$ |
| Largest diff. peak and hole | 2.23 and -1.03 eÅ$^{-3}$ |

**Table SI-2** Anisotropic displacement parameters ($Å^2$ x $10^3$) for $Ce_2(CO_3)_3 \cdot 8H_2O$.
The anisotropic displacement factor exponent takes the form:
$-2\pi^2 [ h^2 a^{*2} U_{11} + ... + 2 h k a^* b^* U_{12} ]$

| | $U_{11}$ | $U_{22}$ | $U_{33}$ | $U_{23}$ | $U_{13}$ | $U_{12}$ |
|---|---|---|---|---|---|---|
| Ce1 | 0.0181(7) | 0.0333(9) | 0.0121(7) | -0.003(3) | 0.000 | 0.000 |
| Ce2 | 0.0172(7) | 0.0317(9) | 0.0139(7) | 0.002(3) | 0.000 | 0.000 |

**Table SI-3** Selected interatomic distances (Å) of $Ce_2(CO_3)_3 \cdot 8H_2O$.

| | |
|---|---|
| Ce1 O4 | 2.494(12) x 2 |
| Ce1 O3 | 2.511(12) x 2 |
| Ce1 O3 | 2.511(12) |
| Ce1 O2($H_2O$) | 2.57(3) x 2 |
| Ce1 O1($H_2O$) | 2.636(13) x 2 |
| Ce1 O3($H_2O$) | 2.73(4) x 2 |
| Ce1 O5 | 2.746(12) x 2 |
| | |
| Ce2 O2 | 2.496(12) x 2 |
| Ce2 O5 | 2.521(13) x 2 |
| Ce2 O3 | 2.535(12) x 2 |
| Ce2 O5($H_2O$) | 2.55(3) x 2 |
| Ce2 O4($H_2O$) | 2.64(3) x 2 |
| Ce2 O4 | 2.794(12) x 2 |
| | |
| C1 O1 | 1.24(2) |
| C1 O2 | 1.34(4) x 2 |
| | |
| C2 O5 | 1.275(19) |
| C2 O4 | 1.277(19) |
| C2 O3 | 1.28(2) |

**Table SI-4** The atomic coordinates, occupancies and isotropic atomic displacement parameters of $Ce_2(CO_3)_3 \cdot 8H_2O$.

| Atom | site | occ. | *x* | *y* | *z* | $U_{eq}$(Å$^2$)[a] |
|---|---|---|---|---|---|---|
| Ce1 | 2*a* | 1.0 | 0 | 0.50146(13) | 0.5135(4) | 0.0211(4) |
| Ce2 | 2*a* | 1.0 | 0 | 0.56276(14) | 0.0135(4) | 0.0209(4) |
| C1 | 2*a* | 1.0 | 0 | 0.212(3) | 0.011(8) | 0.039(6) |
| C2 | 4*b* | 1.0 | 0.2471(18) | 0.437(2) | 0.308(2) | 0.017(5) |
| O1 | 2*a* | 1.0 | 0 | 0.067(2) | -0.006(4) | 0.058(7) |
| O2 | 4*b* | 1.0 | 0.0929(12) | 0.2991(14) | 0.0869(13) | 0.028(3) |
| O3 | 4*b* | 1.0 | 0.2425(12) | 0.4087(16) | 0.4482(13) | 0.033(4) |
| O4 | 4*b* | 1.0 | 0.3630(12) | 0.4184(15) | 0.2383(13) | 0.025(4) |
| O5 | 4*b* | 1.0 | 0.1341(13) | 0.4789(16) | 0.2428(14) | 0.025(3) |
| O6($H_2O$) | 4*b* | 1.0 | 0.3657(12) | 0.2360(16) | 0.0787(13) | 0.040(4) |
| O7($H_2O$) | 4*b* | 0.5 | 0.076(3) | 0.245(4) | 0.643(3) | 0.005(8) |
| O8($H_2O$) | 4*b* | 0.5 | 0.071(4) | 0.233(5) | 0.364(4) | 0.051(14) |
| O9($H_2O$) | 4*b* | 0.5 | 0.409(3) | 0.187(3) | 0.369(4) | 0.024(9) |
| O10($H_2O$) | 4*b* | 0.5 | 0.389(3) | 0.189(4) | 0.622(4) | 0.039(11) |
| O11($H_2O$) | 4*b* | 0.5 | 0.128(4) | -0.003(4) | 0.357(4) | 0.045(12) |
| O12($H_2O$) | 4*b* | 0.5 | 0.159(4) | 0.023(5) | 0.640(5) | 0.059(13) |

[a] $U_{eq}$ is defined as one-third of the trace of the orthogonalized $U_{ij}$ tensor.

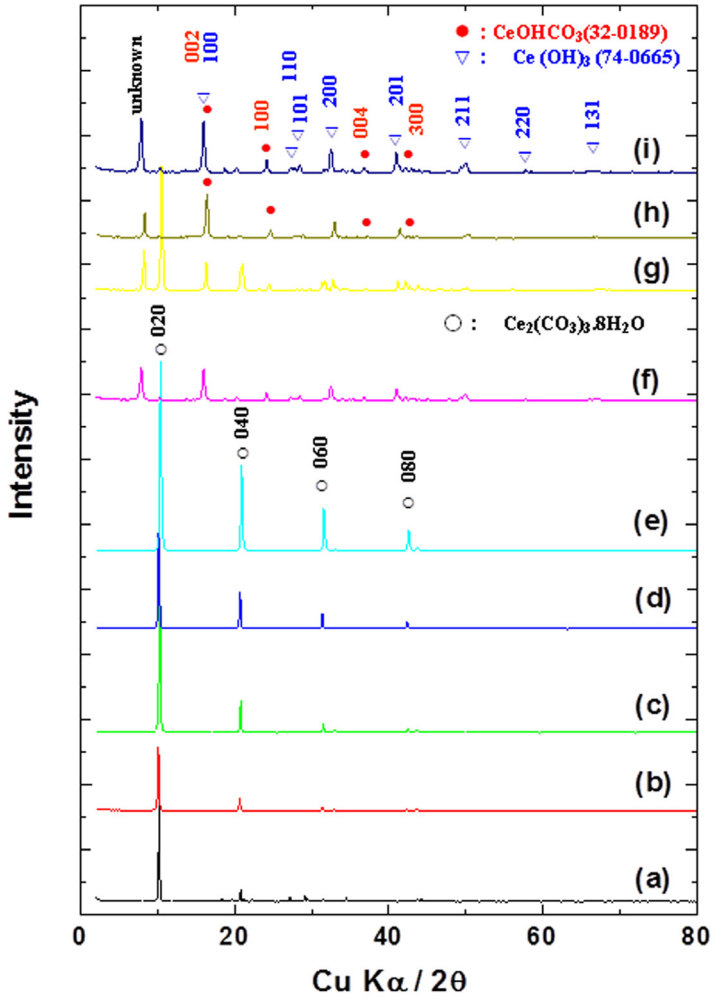


**Fig.SI-1** XRD patterns of the cerium precursors prepared at (a)pH 4.81, (b)pH5.66, (c)pH5.74, (d)pH5.99, (e)pH6.04, (f)pH6.74, (g)pH6.87, (h)pH8.69, and (i) pH9.83

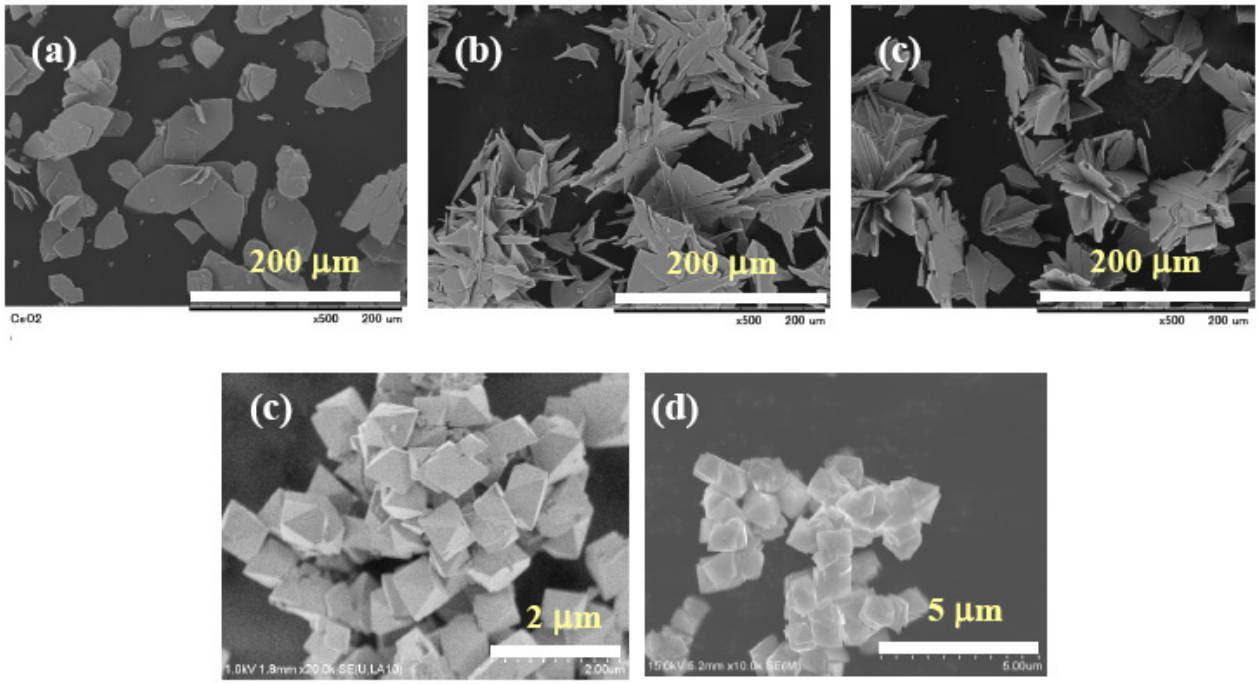


**Fig.SI-2** SEM images of the particles synthesized in 0.1M $Ce(NO_3)_3$ solution (a) 25°C, (b) 50°C, (c) 75°C, (d)100°C and (e)200°C, using 0.3M $NaHCO_3$ solution as precipitator.

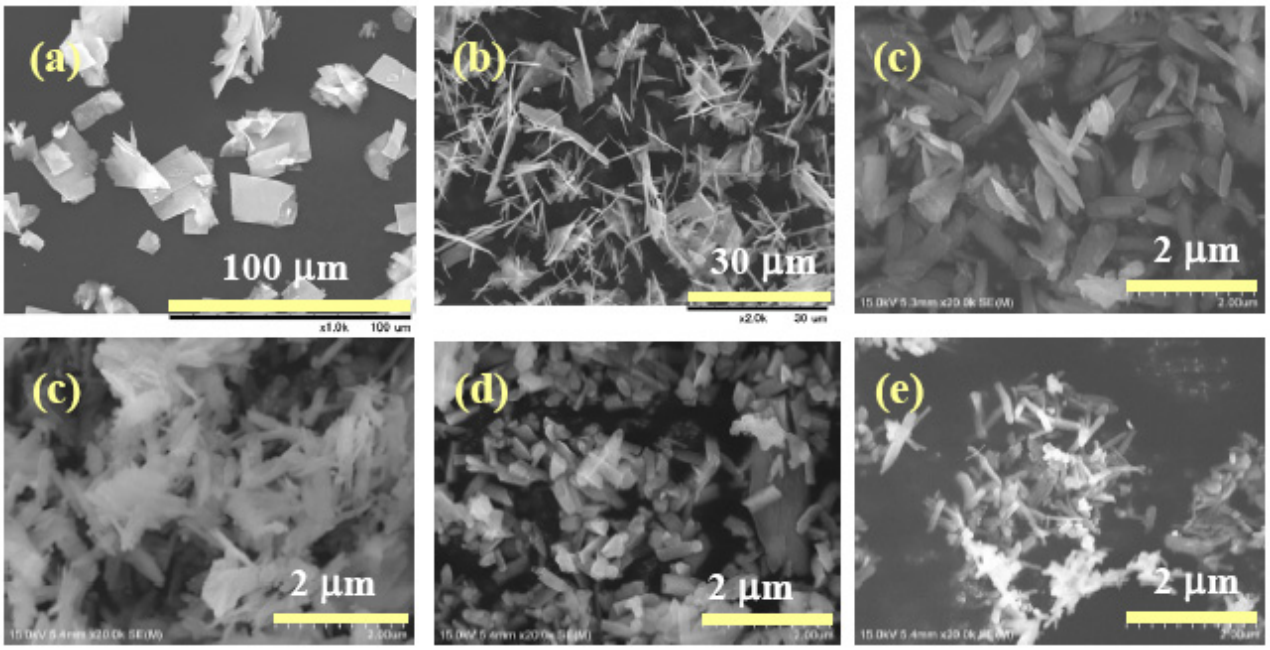


**Fig.SI-3** SEM images of the particles synthesized in 0.1M $Ce(NO_3)_3$ solution (a) 25°C, (b) 50°C, (c) 75°C, (d)100°C, (e) 150°C and (e)200°C, using 0.27M $NaHCO_3$/ 0.03M $Na_2CO_3$ mixed solution as precipitator.

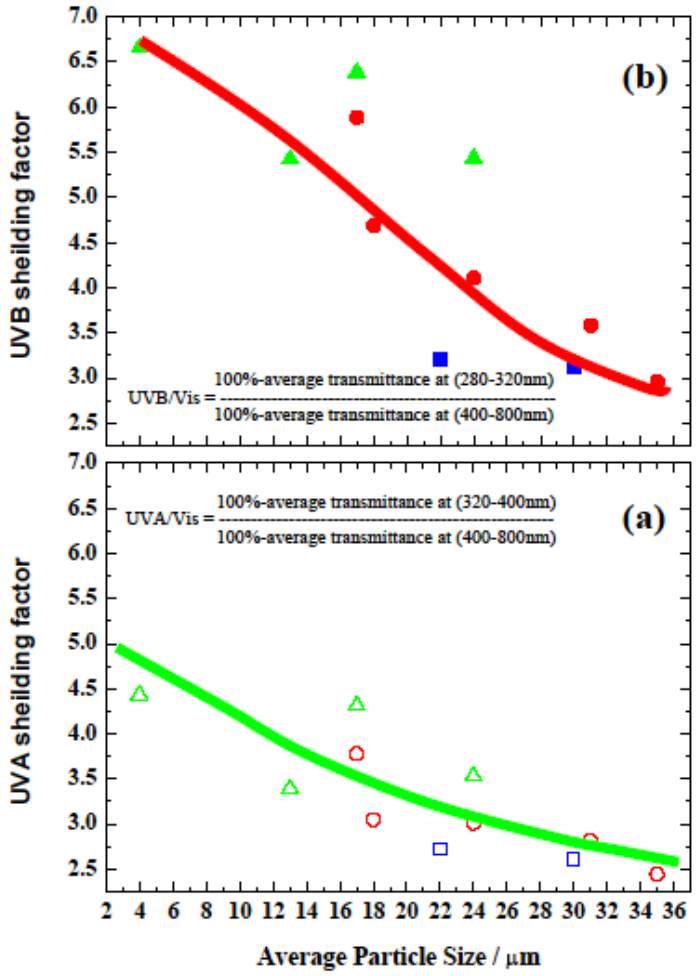


**Fig.SI-4** The relationship between average particle size and (a) UVA/Vis shielding factor; (b) UVB/Vis shielding factor. Different marks indicated the samples synthesized in different solvents.●, ○: aqueous solution; ▲, △: ethylene glycol solution; ■, □: ethanol solution.

$$\text{UVA/Vis} = \frac{\text{100\%-average transmittance at (320-400nm)}}{\text{100\%-average transmittance at (400-800nm)}}$$

$$\text{UVB/Vis} = \frac{\text{100\%-average transmittance at (280-320nm)}}{\text{100\%-average transmittance at (400-800nm)}}$$

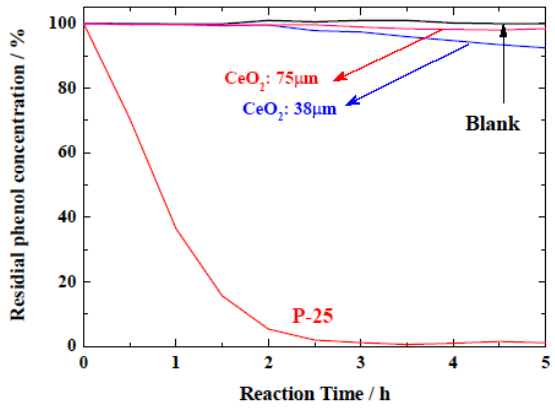


**Fig.SI-5** Photocatalytic catalytic activity of plate-like cerium oxides , together with those of blank test and commercial titania particles P-25.

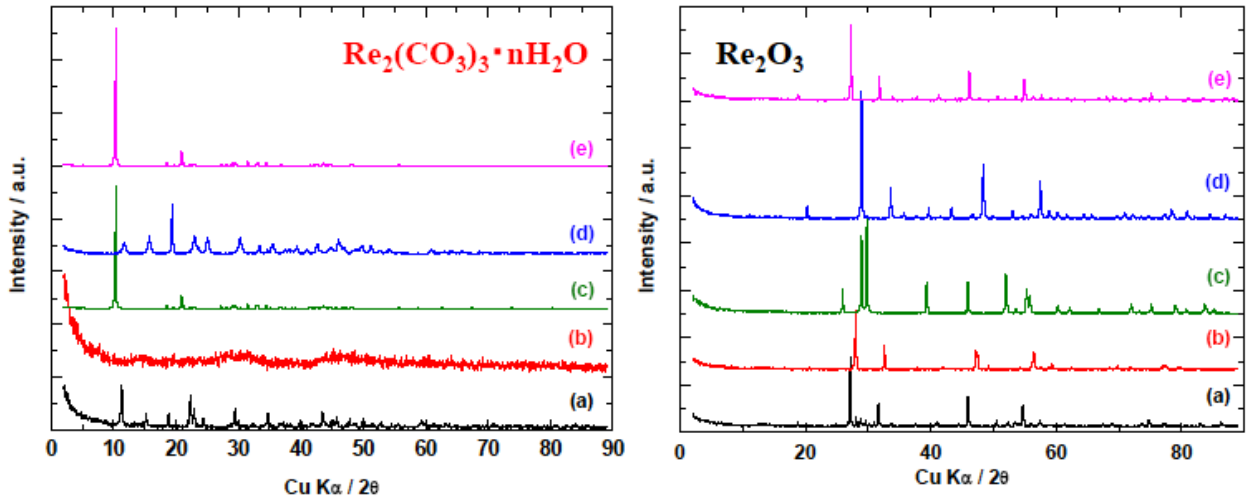


**Fig. SI-6** XRD patterns of plate-like rare earth carbonates $Re_2(CO_3)_3 \cdot nH_2O$ (left) and rare earth oxides $Re_2O_3$ (Re = Sm (a), Tb (b), La (c), Y (d), and Eu (e)) particles synthesized by the similar manner in 0.3M $NaHCO_3$ solution at 25°C, followed by calcination in air.

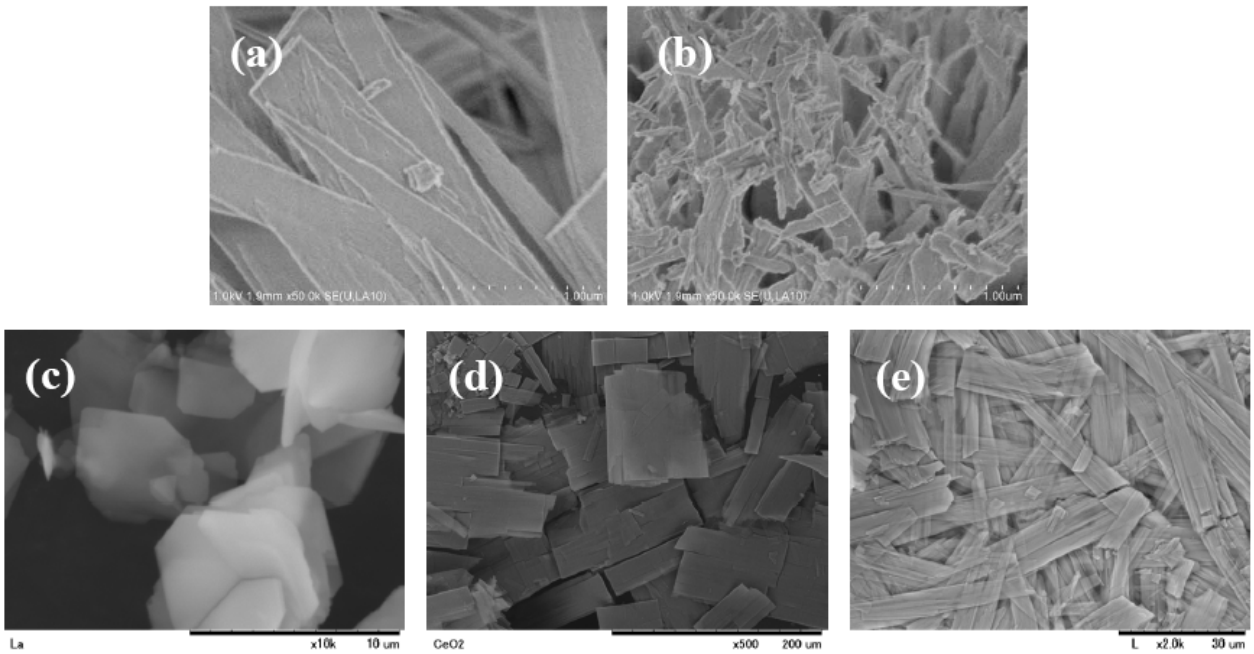


**Fig.SI-7** SEM images of (a) $Sm_2O_3$, (b) $Tb_2O_3$, (c) $La_2O_3$, (d) $Y_2O_3$, and (e)$Eu_2O_3$ plate-like particles synthesized by the similar manner in 0.3M $NaHCO_3$ solution at 25°C, followed by calcination in air.