High efficient photoluminescence of SiO₂ and Ce-SiO₂ microfibres and microspheres

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# Have the same participation in this work.
Electronic Supplementary Information (ESI),

Representative size distribution histograms of hollow crystalline silica spheres (Si2) and Ce-doped crystalline compact silica spheres (Si-Ce2), similar results are obtained for all materials.
SEM Characterization of the material templated with water/CTAB-ButOH/ iso-octane microemulsion. Nano-sheet structures can be appreciated. Such structures are probably created by the micro-droplet interaction and fusion during the material synthesis.

X-ray diffraction patterns (XRD) of crystalline Si2 material calcined at 500, 550, 650°C.
Characterization by TEM of CeO$_2$ nanoparticles prepared using a water/CTAB-ButOH-Ce(Val)$_3$/ oil microemulsions systems. No differences can be appreciated by changing the oil microemulsion phase. X-ray diffraction pattern of CeO$_2$ nanoparticles. The diffraction peaks observed show a good match with those of bulk cerium oxide (cerianite, R050379-9 from RUFF database$^1$). There is a considerable broadening of the peaks, suggesting that these particles are very small in dimensions. The observation of material microstructure by TEM, revealed the presence of small particles of CeO$_2$ of d ~ 5 nm in agreement of the results obtained by DRX.

$^1$ http://rruff.info/
Band gap energy estimation of (a) Si-Ce\textsubscript{2}, (b) Si\textsubscript{2} and (c) CeO\textsubscript{2} nanomaterials by plotting \((\alpha h\nu)^m\) of the microcrystalline materials against the photon energy \((h\nu)\).

The band gap energy was estimated by plotting \((\alpha h\nu)^m\) of the microcrystalline materials against the photon energy \((h\nu)\). Where \(\alpha\) is the absorption coefficient, \(h\nu\) is the photon energy, \(E_g\) is the band gap energy. If we assume that the transition of electrons through the forbidden zone occurs between states corresponding to the maximum of the gap and the valence band minimum conductance; taking into account only direct transitions \(m = 2\). The adsorption \((A)\) is converted to the absorption coefficient using the following relationship\(^2\) \(\alpha = (2.303 \times 10^3/\ell c) A\rho\), where \(A\) is the adsorption of the sample; \(\rho\) is the density of crystobalite (2.33 g cm\(^{-3}\)) for SiO\textsubscript{2} materials and of cerianite (7.132 g cm\(^{-3}\)) for CeO\textsubscript{2} nanoparticles\(^3\), \(\ell\) is the cuvette length (1 cm), and \(c\) is the concentration of the sample \((c = 0.001\text{g cm}^{-3}\)). The band gap energy was determined by extrapolating the adsorption coefficient \((\alpha)\) to zero. The computed band gap values for siliceous and Ce-doped silica materials \((E_{g, Si2} = 4.98\text{ eV} \text{ and } E_{g, Si-Ce2} = 4.66\text{eV})\) are highly inferior to the

experimental band gap values obtained for SiO$_2$ polymorphs (8.9 eV for $\alpha$-quartz and superior values for $\beta$-quartz, $\alpha$-cristobalite, $\beta$-cristobalite and tridymite$^4$ $^{48}$) and similar to those obtained for silicon based metal-oxide-semiconductors (MOS)$^{56}$ $^{49}$ $^{50}$. The computed band gap values ($E_g$, CeO$_2$ = 3.37 eV) for ceria nanoparticles is similar to those observed in literature$^3$ $^7$.

$N_2$ adsorption-desorption information data of the materials templated with water/CTAB-ButOH/ ciclohexane and water/CTAB-ButOH/ n-hexane microemulsions. Adsorption parameters were obtained from $N_2$ adsorption-desorption isotherms measured at 77.6 K with a Micrometrics Model Accelerated Surface Area and Porosimetry System (ASAP) 2020 instrument. Each sample was degassed at 373K for 720 min at a pressure of $10^{-4}$ Pa.

<table>
<thead>
<tr>
<th>Microemulsion System</th>
<th>$S_{BET}$ m$^2$/g</th>
<th>$S_{tpp}$ m$^2$/g</th>
<th>$S_{text}$ m$^2$/g</th>
<th>$V$ cm$^3$/g</th>
<th>$D_{aap}$ nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water/CTAB-ButOH/ciclohexane</td>
<td>65.72</td>
<td>1.23</td>
<td>64.49</td>
<td>$8.70 \times 10^{-6}$</td>
<td>9.61</td>
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<tr>
<td>Water/CTAB-ButOH/n-hexane</td>
<td>13.66</td>
<td>1.09</td>
<td>12.57</td>
<td>$3.72 \times 10^{-6}$</td>
<td>8.93</td>
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<tr>
<td>Water/CTAB-ButOH/n-heptane</td>
<td>11.08</td>
<td>0.32</td>
<td>10.76</td>
<td>$1.50 \times 10^{-5}$</td>
<td>7.49</td>
</tr>
<tr>
<td>Water/CTAB-ButOH/isoctane</td>
<td>20.37</td>
<td>0.29</td>
<td>20.08</td>
<td>$9.00 \times 10^{-6}$</td>
<td>11.25</td>
</tr>
</tbody>
</table>

$S_{BET}$, BET surface area; $S_{tpp}$, t-plot micropore area; $S_{text}$, t-plot external surface; $V$, t-Plot micropore volume; $D_{aap}$, adsorption average pore diameter by BET.