Synthesis of mesoporous-silica-coated Gd$_2$O$_3$:Eu@silica particles as cell imaging and drug delivery agents

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The FT-IR spectrum provides the insight into the chemical composition of the as-prepared sample (Figure S1). A broad absorption band peaking at 3400 cm\(^{-1}\) and a shoulder located at 1645 cm\(^{-1}\) are the characteristic absorption of water of hydration in the structure or surface adsorbed water and hydroxyl groups (OH\(^{-}\)).\(^1\) The presence of carbonate anions in the molecular structure was confirmed by the appearance of absorption doublets in the region 1350–1600 cm\(^{-1}\) (\(v_3\) of CO\(_3^{2-}\), peaking at \(~1408\) and 1504 cm\(^{-1}\)) and also by the occurrence of multiple absorptions ranging from 500 to 1000 cm\(^{-1}\) (\(v_2\) and \(v_4\) of CO\(_3^{2-}\)).\(^2,3\) The elemental analysis quantifies the elemental components (mass %) of the as-prepared precursor. Elemental contents of the dried particles analyzed by the inductively coupled plasma (ICP) spectrophotometric method were listed in Table S1, yielding a (Gd+Eu):C:O molar ratio of about 1:1.01:5.10. Assuming that all the carbon was from CO\(_3^{2-}\) and considering molecular neutrality, the chemical formula of the as-prepared product may be expressed as Gd(OH)CO\(_3\)·H\(_2\)O. The results are consistent with the pioneering work of Matijevic \textit{et al.} and the work by Lechevallier’s group.\(^4\)

The thermogravimetric analysis (TGA) curve of the as-prepared sample was shown in Figure S2. The weight loss of Gd(OH)CO\(_3\)·H\(_2\)O:Eu undergoes a three-step process. The first one (25-170°C) is due to the desorption of water molecules adsorbed at the particles surface due to the storage in air. The second weight loss (170-550°C) is related to the removal of water molecules due to the dehydration of hydrated compounds and the self-condensation of hydroxyl groups (O-H). The third one (550-750 °C) originates from the release of CO\(_2\) molecules.\(^4\)
**Figure S1.** FT-IR spectra of the as-prepared Gd(OH)CO$_3$·H$_2$O:Eu (a) and the samples calcinated at 550 ºC (b) and 750 ºC (c), respectively.

**Figure S2.** Thermogravimetric analysis curve of the precursor Gd(OH)CO$_3$·H$_2$O:Eu measured in air.

**Table S1.** Elemental content of as-prepared particles (mass %).

<table>
<thead>
<tr>
<th>Element</th>
<th>Mass %</th>
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<tbody>
<tr>
<td>Gd</td>
<td>58.2%</td>
</tr>
<tr>
<td>Eu</td>
<td>3.7%</td>
</tr>
<tr>
<td>C</td>
<td>4.8%</td>
</tr>
<tr>
<td>O</td>
<td>31.6%</td>
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Figure S3. XRD pattern of Gd(OH)CO$_3$·H$_2$O·Eu after calcination at 750 °C. Upon calcination, the amorphous Gd(OH)CO$_3$·H$_2$O is converted into cubic phase gadolinium oxides (Gd$_2$O$_3$).

Figure S4. Confocal fluorescence microscopy image of Mesoporous-silica-coated Gd$_2$O$_3$·Eu@silica particles particles first dispersed in ethanol and then smeared on a glass slide.
Figure S5. Concentration effect of the core-shell particles on cell viability via incubation for 72 h.

Figure S6. The morphology of the HeLa cells incubated with the DOX-loaded mesoporous particles as a function of incubation time. a) 0 h; b) 24 h; c) 72 h

References


