Supporting Information

Designing lanthanide-doped nanocrystals with both up- and down-conversion luminescence for anti-counterfeiting

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Fig. S1 Integrated fluorescence intensity versus absorbance of oleic acid-stabilized NaYF₄:Yb,Er nanocrystals and quinine sulfate.
Fig. S2 The 1H NMR spectra of a) free OA dispersed in CDCl₃, b) OA-stabilized NaYF₄:Yb,Er nanocrystals dispersed in CDCl₃. Chemical shifts are reported in parts-per-million (δ): 5.2-5.45 (-CH=CH-), 2-2.4 (-CH₂-), 1.2-1.4 (-(CH₂)₆-), 0.8-1.00 (-CH₃).
**Fig. S3** XPS spectrum of C 1s core-level for the OA-stabilized NaYF₄:Yb,Er nanocrystals. C-C (284.6 eV), O–C=O (288.6 eV).

**Fig. S4** XRD pattern of the product obtained after evaporating the YCl₃ aqueous solution.
Fig. S5 TGA curves of a) oleic acid-stabilized NaYF₄:Yb,Er nanocrystals prepared in our strategy and b) oleic acid-stabilized NaYF₄:Yb,Er nanocrystals obtained by the thermal-decomposition trifluoroacetates method.

Fig. S6 Fluorescence decay curve of oleic acid-stabilized NaYF₄:Yb,Er nanocrystals in cyclohexane.
Fig. S7 EDX pattern of the fingerprint impressed on the transparent film.

<table>
<thead>
<tr>
<th>samples</th>
<th>NaYF₄:Yb,Tm</th>
<th>NaYF₄:Yb,Er</th>
<th>NaYbF₄:Er</th>
</tr>
</thead>
<tbody>
<tr>
<td>stoichiometric molar</td>
<td>0.75:0.25:0.003</td>
<td>0.80:0.18:0.02</td>
<td>0.98:0.02</td>
</tr>
<tr>
<td>ratio of Y/Yb/Er/Tm</td>
<td></td>
<td></td>
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<tr>
<td>actual molar ratio</td>
<td>0.74:0.247:0.003</td>
<td>0.762:0.186:0.02</td>
<td>0.981:0.02</td>
</tr>
<tr>
<td>of Y/Yb/Er/Tm</td>
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</tbody>
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Table S1. Stoichiometric and actual molar ratios of Y/Yb/Er, Y/Yb/Tm and Yb/Er in lanthanide-doped fluoride nanocrystals.