Supplemental Information

A strategy to facilitate the assemble of DNA and upconversion nanoparticles for biosensor construction

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Fig. S1 (A) TEM and (B) HRTEM image of the DNA-AgNPs.
Fig. S2 Particle size distribution histograms of DNA-AgNPs
Fig. S3 Normalized UCL spectrum of the UCNPs@PDA (line red) and UV-vis absorption spectrum of Apt-AgNPs (line black).
**Fig. S4** (A) UV-vis spectrum of Apt-AgNPs at various concentrations (0-0.3 μM). (B) The plot of absorbance at 420 nm against the concentration of DNA-AgNPs.
Fig. S5 Zeta potentials of (A) UCNPs@PDA and (B) DNA-AgNPs.
**Fig. S6** TEM image of UCNPs@PDA-AgNPs.
Fig. S7 (A) Emission of UCNPs@PDA (0.2 mg/mL) in the different shell thickness (0-10.2 nm) in Tris-HNO$_3$ buffer (10 mM, 100 mM NaNO$_3$, pH 7.4) and (B) Shell thickness dependence UCL of the UCNPs@PDA.
Fig. S8 Time dependence of the UCL quenching of 0.2 mg/mL UCNPs@PDA by 0.25 μM DNA-AgNPs.
Fig. S9 (A) Normalized UCL emission intensity of the biosensor incubated at 37°C for different times. (B) Photostability of the biosensor under continuous illumination by 980 nm laser.
Fig. S10 Normalized UCL emission intensity of the biosensor incubated at different pH values.
Relative luminescence intensity \((F-F_0)/F_0\), where \(F\) and \(F_0\) represent the emission intensity of biosensor in the presence and absence of CEA, respectively) of the biosensor in the presence of different DNA sequences with the same amounts of CEA (200 ng/mL). All experiments were performed in Tris-HNO\(_3\) buffer (10 mM, 100 mM NaNO\(_3\), pH 7.4).
Table S1. Analytical results of the determination of CEA in five diluted human serum samples by the biosensor

<table>
<thead>
<tr>
<th>Sample</th>
<th>Measured (ng/mL)</th>
<th>Added (ng/mL)</th>
<th>Found (ng/mL)</th>
<th>Recovery</th>
<th>RSD (n=3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.48</td>
<td>100</td>
<td>97.14</td>
<td>96.7%</td>
<td>2.5%</td>
</tr>
<tr>
<td>2</td>
<td>0.93</td>
<td>100</td>
<td>99.50</td>
<td>98.6%</td>
<td>3.7%</td>
</tr>
<tr>
<td>3</td>
<td>2.30</td>
<td>100</td>
<td>100.64</td>
<td>98.4%</td>
<td>3.2%</td>
</tr>
<tr>
<td>4</td>
<td>4.62</td>
<td>100</td>
<td>105.13</td>
<td>100.5%</td>
<td>4.5%</td>
</tr>
<tr>
<td>5</td>
<td>8.56</td>
<td>100</td>
<td>113.83</td>
<td>104.8%</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

Samples 1-5 were human serum.