Supporting Information

Synthesis of Amino-Functionalized Silica Colloids

Large silica colloids with a low polydispersity were obtained from small silica seed particles of \( r = 26 \) nm radius using the Stöber procedure: \(^1\) 35.41 g TES and 43 mL ammonia were added to 1000 mL ethanol (final concentrations 0.17 M TES, 0.69 M NH\(_3\), 1.56 M H\(_2\)O). These particles were grown larger in the subsequent reaction steps by seeded growth: \(^2\)\(^-\)\(^4\) The dispersions were diluted in every step to silica volume fractions of 0.5% and the ammonia and water content were kept at a concentration of 0.69 M NH\(_3\) and 1.56 M H\(_2\)O. 30 mL TES (0.134 M) was added per 1000 mL dispersion for each step. 7 and 9 seeded growth steps, respectively, were needed to reach final particle radii of 106 and 192 nm.

Small silica colloids with a low polydispersity (see Table S1) were prepared in a microemulsion synthesis. \(^5\) 1.22 mL ammonia were added to a mixture of 200 mL cyclohexane and 10.25 mL Igepal CO-520 and stirred for 30 min. After that, 1.25 mL TES were added and after further stirring for 5 minutes the microemulsion was kept without stirring for 6 days at constant temperature. Subsequently, the microemulsion was reduced to a volume of about 4 mL by evaporation of the solvent. The highly viscous residue was redispersed in a mixture of 30.2 mL ethanol and 1.44 mL ammonia by ultrasonification. Finally, 656 \( \mu L \) TES were added to the reaction mixture under stirring and the mixture was kept stirring for another 12 h. Silica colloids with a final radius of 35 nm are obtained (see Table S1).

The silica particles were functionalized with APS by a method described in ref. \(^6\) The amount of APS was calculated to be sufficient to provide an approximately 2.5 monolayer coating on the silica particles. \(^7\) The area on the nanoparticle surface covered by each organosilane molecule was assumed to be nominally 0.6 nm\(^2\). \(^8\) E.g., 53 \( \mu L \) APS (3.0*10\(^{-4}\) M) was added to 200 mL of an ethanol dispersion of silica spheres (\( r = 192 \) nm, \( c = 10 \) g/L) containing 0.69 M NH\(_3\) and 1.56 M H\(_2\)O. This mixture was stirred for 12 h and it is then refluxed for 1 h. Excess reactants were removed from the APS-functionalized particles by repeated centrifugation (300 g) and redispersion in pure ethanol for at least five times.
Synthesis of CdSe/ZnS quantum dots\textsuperscript{9,10}

The procedures for the synthesis of CdSe/ZnS core-shell QD were performed in a glove box under a nitrogen atmosphere. All reagents were used as purchased without further purification.

In a typical synthesis 0.0813 g (0.6 mmol) CdO and 0.7140 g (2.5 mmol) of stearic acid were loaded into a 50 mL three-neck flask and heated to 150°C. After the CdO was completely dissolved, the mixture was allowed to cool to room temperature. TOPO and HDA 10.00 g of each component were added to the flask, and the mixture was heated to 320°C to form an optically clear solution. At this temperature, a solution containing 0.5000 g (6.3 mmol) of Se powder dissolved in 8.0 mL TOP was swiftly injected into the reaction flask. After injection, the temperature was set to 290°C for preparing the growth of the nanocrystals. The reaction was stopped after 100 s by removing the heating mantle. Methanol (5 mL) was added into reaction flask to precipitate the nanocrystals at around 50°C. The nanocrystal precipitate was separated by centrifugation and decantation, and was then diluted in chloroform. In a capping experiment, the QD-solution was added to 5.00 g TOPO and 2.50 g HDA. Chloroform was pumped off immediately. A stock solution was prepared with 0.106 mL (0.5 mmol) (S(TMS)\textsubscript{2}) in 0.400 mL of TOP by adding 0.711 mL (0.7 mmol) ZnMe\textsubscript{2} in 3.20 mL TOP. The QD/TOPO/HDA mixture was heated up to 160°C and the Zn/S/TOP stock solution was slowly dropped into the reaction flask. Upon cooling the reaction mixture was stirred at 90 – 100°C for 2 h. The nanocrystals were purified by precipitation with methanol. The precipitate was collected by centrifuging and subsequently washed for three times with methanol. The resulting wet precipitate was stored under nitrogen for later use.

Size and polydispersity of the synthesized particles

The size and the polydispersity of the nanoparticles, silica colloids, and multi-core colloids were obtained from transmission electron microscopy (TEM) measurements and extinction spectroscopy, as summarized in Table S1. The polydispersity is the standard deviation of the particle radii of at least 200
particles imaged by TEM and analyzed using the measurement tools of the software Simple PCI (C-Images).

**Table S1. Size and polydispersity of the synthesized particles**

<table>
<thead>
<tr>
<th>Nanoparticles (type)</th>
<th>CdSe/ZnS nanoparticles</th>
<th>Gold nanoparticles</th>
<th>Maghemite nanoparticles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanoparticles</td>
<td>1.6*</td>
<td>**</td>
<td>8.3</td>
</tr>
<tr>
<td>Silica colloid cores***</td>
<td>35</td>
<td>1.8</td>
<td>188</td>
</tr>
<tr>
<td>Multicore particles with thin silica shell</td>
<td>39</td>
<td>4.1</td>
<td>208</td>
</tr>
<tr>
<td>Multicore particles with thick silica shell</td>
<td>49</td>
<td>2.3</td>
<td>-</td>
</tr>
</tbody>
</table>

* Determined from extinction spectra of the CdSe quantum dots according to the calibration from ref. 9 and assuming an average ZnS shell of 1.6 monolayers. The other data are obtained from TEM measurements

** An exact estimation of the polydispersity was neither possible from the extinction nor photo luminescence spectra.

*** The silica colloids are the cores of the multicore particles listed below.

**Calculation of the Extinction Spectra**

The extinction spectra were calculated using a program (freely available on http://www.wavescattering.com) developed by Moroz11 for particles with multiple shells based on Mie theory.12 The calculations require the input of the refractive index of the silica core ($n_D=1.45$, which is assumed to be constant compared to the high dispersion of gold) as the embedding medium, the frequency dependent dielectric constant of gold,13 and the radius of the embedded nanoparticles.
References