Supporting information

Methods

Dispersion of Eu-SWCNTs in 1% pluronic F127 solution

The detailed synthesis of the Eu-SWCNTs is presented elsewhere.[4] The Eu-SWCNTs were dispersed in 1% pluronic F127 solution as follows. The Si wafer on which the Eu-SWCNTs were synthesized were placed in a 50 ml centrifuge tube and filled with 15 ml of deionized (DI) water. This tube was sonicated for 30 minutes in a 30 W bath sonicator. The shear force of the sonication allowed the Eu-SWCNTs along with any free nanoparticles catalysts present on the Si wafer to release into the DI water. The Si wafers was then removed and the vials were kept in a centrifuge at 5000 x g for 30 minutes. The centrifugation allowed the hydrophobic Eu-SWCNTs to settle to the bottom. The supernatant containing hydrophilic free nanoparticles was decanted. This process of batch sonication followed by centrifugation was repeated two more times. Next, 50 ml of 1% F127 solution (1gram of F127 in 100 grams of water) was added to the centrifuge tube with the spun-down Eu-SWCNTs. The tube was probe-sonicated (ColePalmer, Vernon Hills, Illinois) at 300 W for 10 minutes followed by centrifugation at 5000 x g for 30 minutes. The supernatant containing the dispersed Eu-SWCNTs was decanted and used for the photo-physical studies.

Preparation of the controls

The detailed synthesis of the Eu_2O_3 nanoparticles are presented elsewhere.[4] These Eu_2O_3 nanoparticles used in the preparation of Eu-SWCNTs were dissolved in 1% pluronic F127 solution as follows. The Si wafer on which the Eu_2O_3 nanoparticles were synthesized was first

placed in the CVD equipment. They were kept at the same conditions used for the growth of the SWCNT, but without any passage of the carbon feedstock gas. The Si wafers were next removed from the CVD chamber, and placed in a 50 ml centrifuge tube and filled with 15 ml of 1% pluronic F127 solution. This tube was sonicated for 30 minutes in a 30 W bath sonicator. The shear force of the sonication allowed the Eu_2O_3 nanoparticles present on the Si wafer to be release into the 1% pluronic F127 solution. The Si wafers was then removed and solution was used for the photo-physical studies.

The $EuCl_3$ used in the preparation of the Eu_2O_3 nanoparticles were dissolved in 1% pluronic F127 solution as follows. Appropriate amounts of $EuCl_3$ solid were added to 1% pluronic F127 solution, and vortexed to achieve the final [Eu] concentration of 4 μM.

The commercial SWCNTs (Carbolex Inc, Broomall, PA) suspended in 1% pluronic F127 and mixed with Eu_2O_3 nanoparticles were prepared as follows. 1 mg of commercial SWCNTs was dispersed in 15 ml of 1% pluronic F127 solution in a 50 ml centrifuge tube by probe sonication. The tubes then next kept in a centrifuge at 5000 x g for 30 minutes. The supernatant containing the dispersed individual SWCNTs was decanted, transfer into a separate 50 ml centrifuge tube. Their concentration determined, and adjusted to 1 μg/ml by adding more 1% pluronic F127 solution. Next, the Si wafer on which the Eu_2O_3 nanoparticles were synthesized was placed in this 50 ml centrifuge tube containing the SWCNTs dispersed in 1% F127 solution. This tube was sonicated for 30 minutes in a 30 W bath sonicator. The shear force of the sonication allowed the Eu_2O_3 nanoparticles present on the Si wafer to be release into the solution. The Si wafers was then removed, and solution was used for the photo-physical studies.

Absorption spectra

The optical absorption spectra of the Eu-SWCNT in 1% pluronic F127 were taken with a Shimadzu UV-260 recording spectrophotometer over a wavelength range of 190-800 nm and a cell path length of 1 cm. Reference cells contained 1% pluronic F127 to account for any absorption effects due to the surfactant.

Fluorescence steady state and time resolved measurements

The steady state photoluminescence emission measurements (excitation wavelength = 390 nm) on the Eu-SWCNT in 1% pluronic F127 and the control samples were recorded using a Fluorolog spectrofluorimeter (Horiba Jobin Yvon). The decay of the Eu^{3+} emitting state was recorded using the same instrument by using the emission intensity at 619 nm with an excitation wavelength of 390 nm. The decay data was analyzed with a least-square fitting program to obtain the lifetimes (τ_1, τ_2 and τ_3) and the relative amplitudes (A1, A2 and A3). The average fluorescence lifetime was then calculated using the formula:

$$T(Avg) = (\tau_1 \times A1 + \tau_2 \times A2 + \tau_3 \times A3) / (A1 + A2 + A3)$$

The overall quantum yields (Φ_{ov}) was determined using a comparative method using a well characterized standard sample of quinine bisulphate in 1N H_2SO_4 with a known Φ value (Φ = 0.546, experimental error of 13%).[9]

Calculation of $\Phi_{Eux`x}$

$\Phi_{Eu} = \tau \cdot A_{MD,0} \cdot n^3 \cdot (I_{tot}/I_{MD,0})$

$A_{MD,0}$ = a constant spontaneous emission probability (14.65 s^{-1} for Eu^{III} or Tb^{III}),

n = refractive Index (1.5 for water)

I_{tot} the total area of the emission spectrum ($^5D_0 \rightarrow {}^7F_J$, j =1-4) = 233

$I_{MD,0}$ the $^5D_0 \rightarrow {}^7F_1$ band area = 48

Transition	Area mm^2
$^5D_0 \rightarrow {}^7F_1$	48
$^5D_0 \rightarrow {}^7F_2$	160
$^5D_0 \rightarrow {}^7F_3$	5
$^5D_0 \rightarrow {}^7F_4$	20

Supplementary Figures

Figure S1: (a) Representative high resolution transmission electron microscope (HRTEM) image of Eu-SWCNT bundles grown on the Eu_2O_3 nanoparticles (average size of 1.9 nm) as catalysts with an average diameter of 2 nm. (b) The SWCNT root with the Eu_2O_3 nanoparticle (red circle) (size of the bar = 20 nm). The exact growth mechanism of the Eu-SWCNT is still unclear. However, the nanoparticles could be acting as templates in the formation of the SWCNT caps similar to the recent report of SWCNT growth from semiconductor nanostructures of sizes less than 5 nm.[5] Transmission electron microscopy (TEM) was performed on the samples using a Tecnai12 BioTwinG2 (FEI, Hillsboro, OR) at 80 kV. Digital images were acquired with an AMT XR-60 CCD Digital Camera System.

Figure S1a

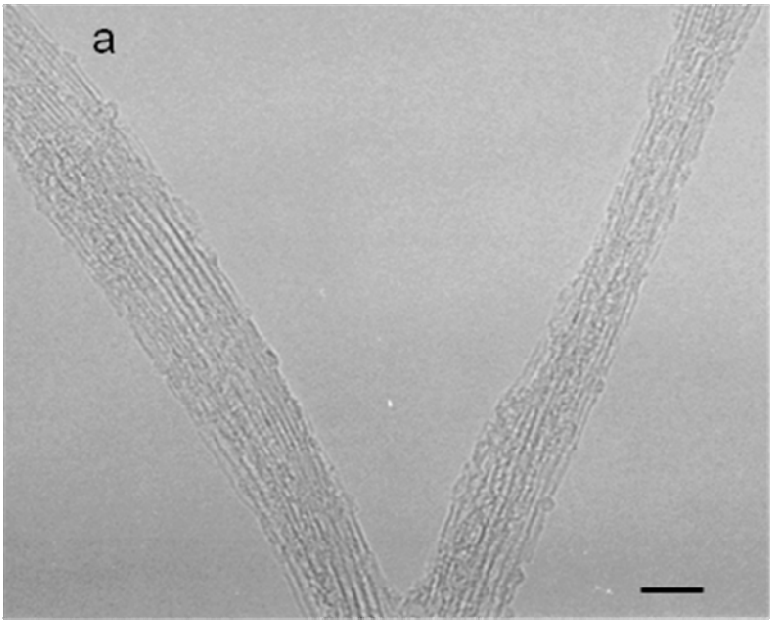

Figure S1b

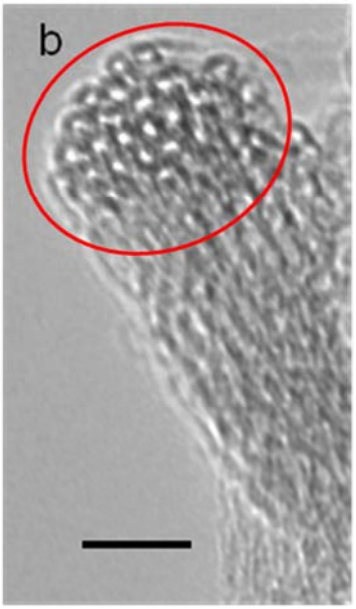

Figure S2: Steady state excitation spectra of Eu-SWCNTs in 1% pluronic F127.

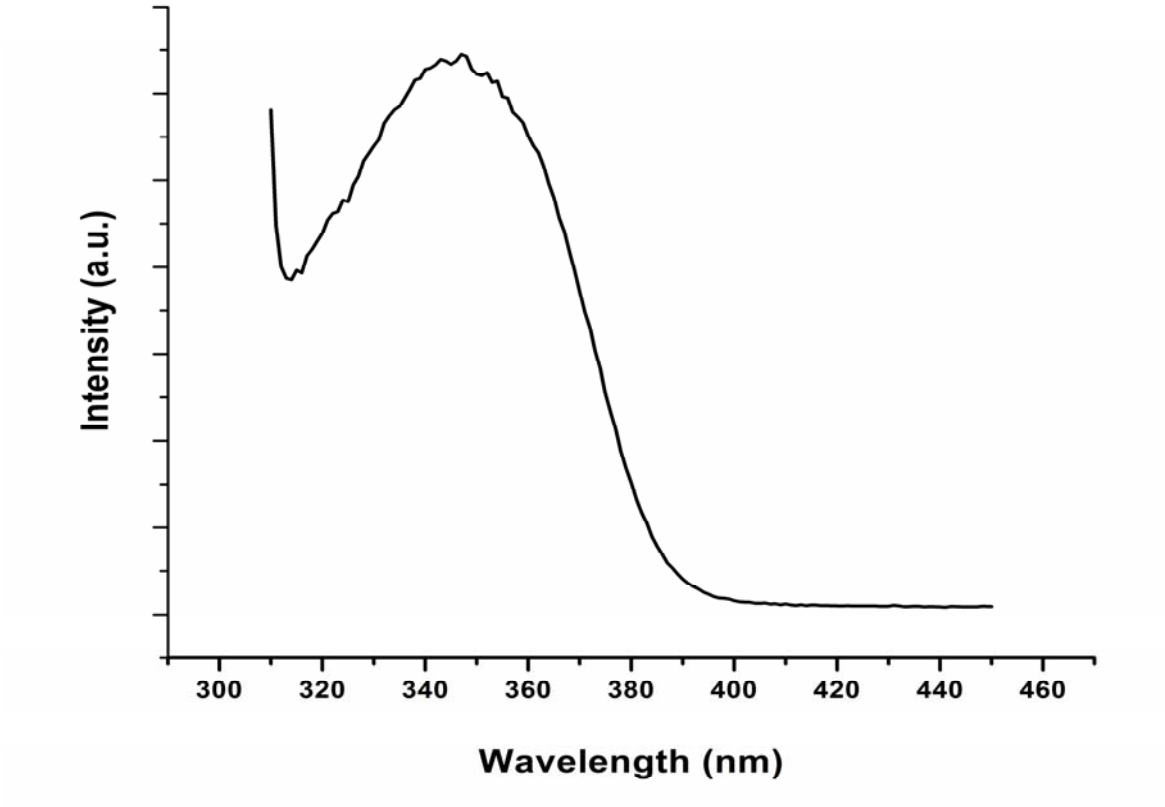

Figure S3: Steady state emission spectra of $EuCl_3$ used in the preparation of the Eu_2O_3 nanoparticles dissolved in 1% pluronic F127 solution.

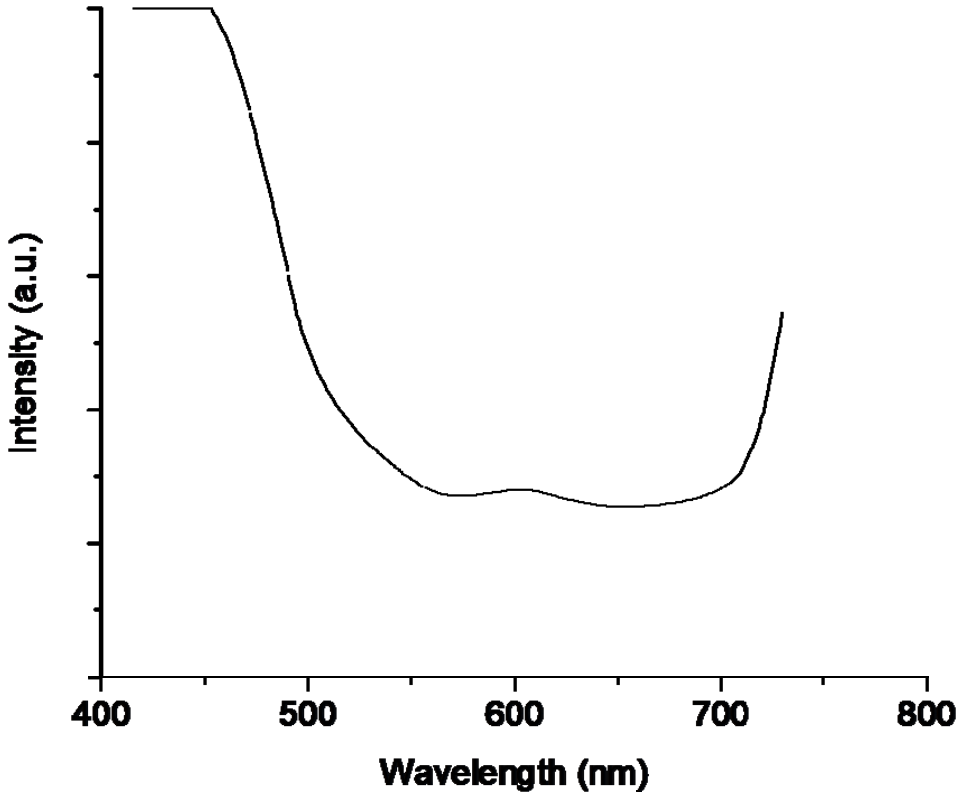

Figure S4: Steady state emission spectra of commercial SWCNTs (Carbolex Inc, Broomall, PA) suspended in 1% pluronic 127 and mixed with Eu_2O_3 nanoparticles.

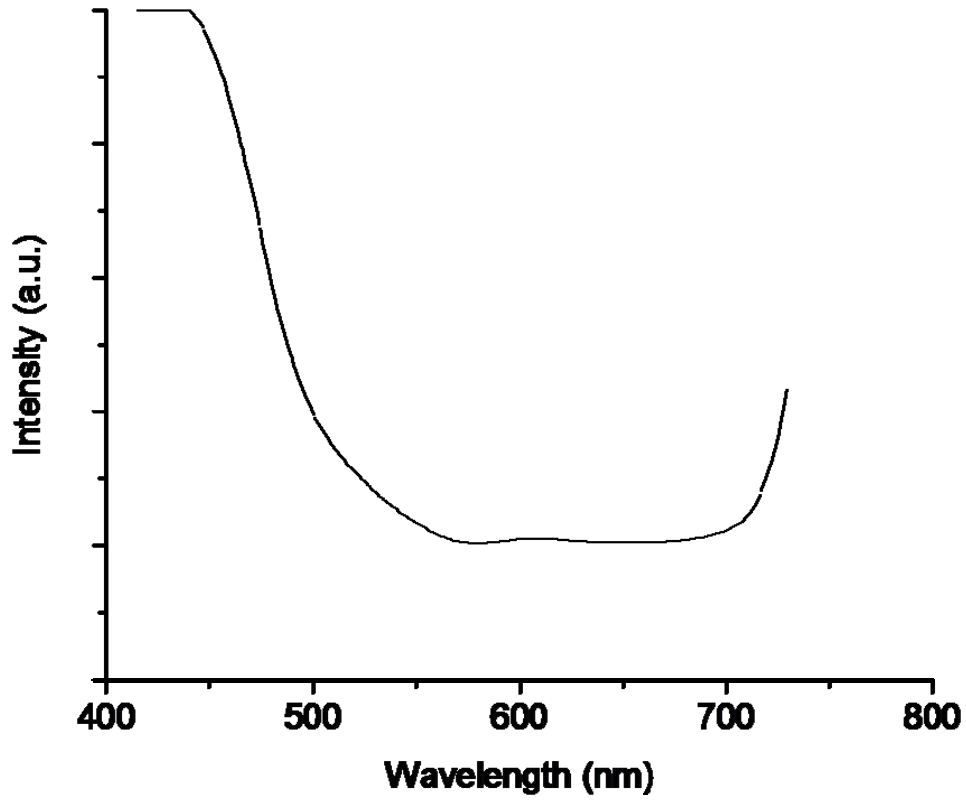

Figure S5: Steady state emission spectra of plain 1% pluronic F127.