

Supplementary Materials for

Photoswitchable single-walled carbon nanotubes for super-resolution microscopy in the near-infrared

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The PDF file includes:

Legend for movie S1

Fig. S1. SP-MC nanotube hybrid.

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Fig. S3. Theoretical modeling of the luminescence intensity of a nanotube with quencher molecules.

Fig. S4. Influence of the residence times on the intensity ratio.

Fig. S5. Error estimation of the parameter theoretical ϕ .

Other Supplementary Material for this manuscript includes the following:

(available at advances.sciencemag.org/cgi/content/full/5/9/eaax1166/DC1)

Movie S1 (.avi format). Movie showing the photoluminescence of single CNTs.

Movie 1. Movie showing the photoluminescence of single CNTs. Movie of (10,2) carbon nanotubes (CNTs) carrying randomly distributed SP-MC molecules (~ 1 per 100 carbon atoms) spin-coated on a microscope glass cover slip excited in wide-field configuration using a circularly polarized 730 nm laser line for resonant excitation of the S_{22} transition. Photoluminescence of the (10,2) CNTs which occurs at ~1065 nm was imaged using a near-infrared InGaAs camera. CNTs showed bright and stable photoluminescence when illuminated *via* the resonant S_{22} transition excitation. We observe a significant overall decrease in intensity associated with independent blinking events when UV illumination is added. Imaging rate = 20 Hz. Scale bar = 5 μm .

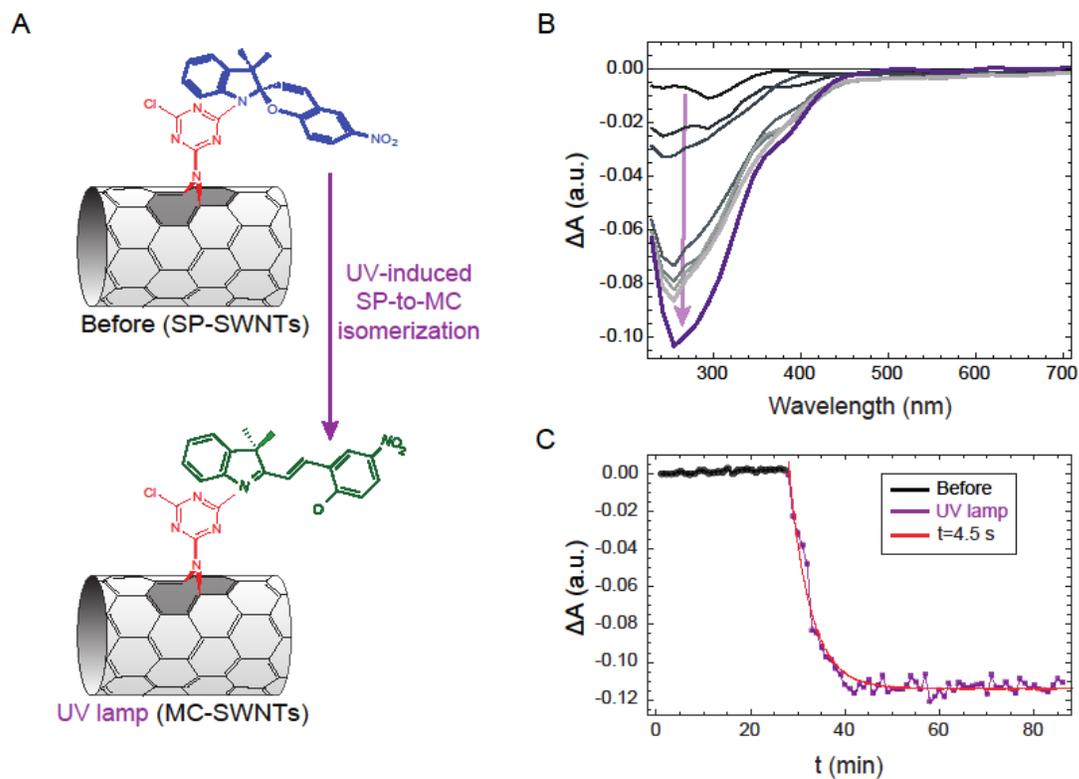


Fig. S1. SP-MC nanotube hybrid. (A) Spiropyran is covalently attached to a carbon nanotube *via* a triazine anchor group. The functionalization preserves the conjugated π -electron system of the CNT. Upon UV illumination the SP functional group (top) transforms into MC (bottom). (B) This process is monitored by the appearance of an optical absorption band in the UV. (C) Dynamics of the SP-MC isomerization follows a mono-exponential decay with a time constant of 4.5 s.

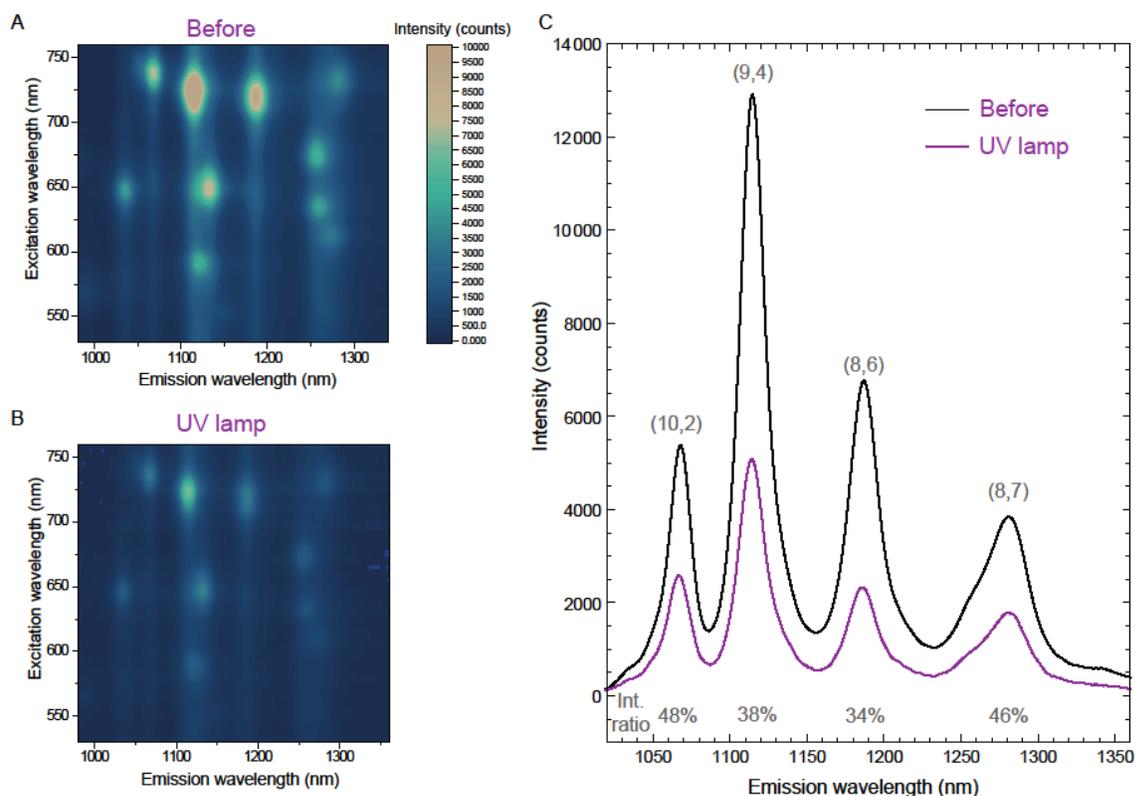


Fig. S2. SP-CNT luminescence in solution. (A) Intensity of the CNT luminescence as a function of excitation and emission wavelength for the SP-CNT hybrid. Each peak corresponds to a particular CNT chirality (n,m). (B) Upon UV illumination the hybrid switches into the MC-CNT form, which is accompanied by an overall loss in intensity. (C) Luminescence before (black line) and after (purple) UV illumination excited with 730 nm excitation wavelength (identical to the single tube experiments). The nanotube chiralities and their loss in luminescence intensity (intensity ratio before/after UV) are indicated. The (10,2) tube shows an intensity ratio of 48%.

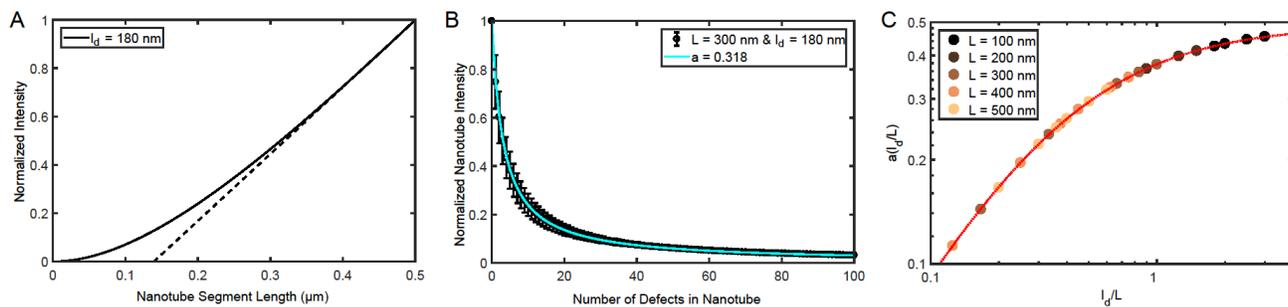


Fig. S3. Theoretical modeling of the luminescence intensity of a nanotube with quencher molecules. (A) Luminescence intensity of a perfect nanotube segment of length x with $l_d = 180 \text{ nm}$. This curve was calculated using equation (1) and the intensity was normalized by the intensity of a nanotube of length $L = 500 \text{ nm}$. To generate this graph, the illumination intensity was assumed constant. (B) The influence on the whole nanotube intensity ($L = 300 \text{ nm}$ and $l_d = 180 \text{ nm}$) when n molecules undergo a transition from a luminescent and to a quenching state. The intensity can be approximated by the function $1/(1 + a \cdot n)$ where the variable a is only a function of the ratio l_d/L (C). The red dotted line corresponds to the best fit of the equation $a(l_d/L) = c_1 \cdot (l_d/L)^{c_2} / (1 + c_3 \cdot (l_d/L)^{c_2})$, where c_1, c_2 and c_3 are constants.

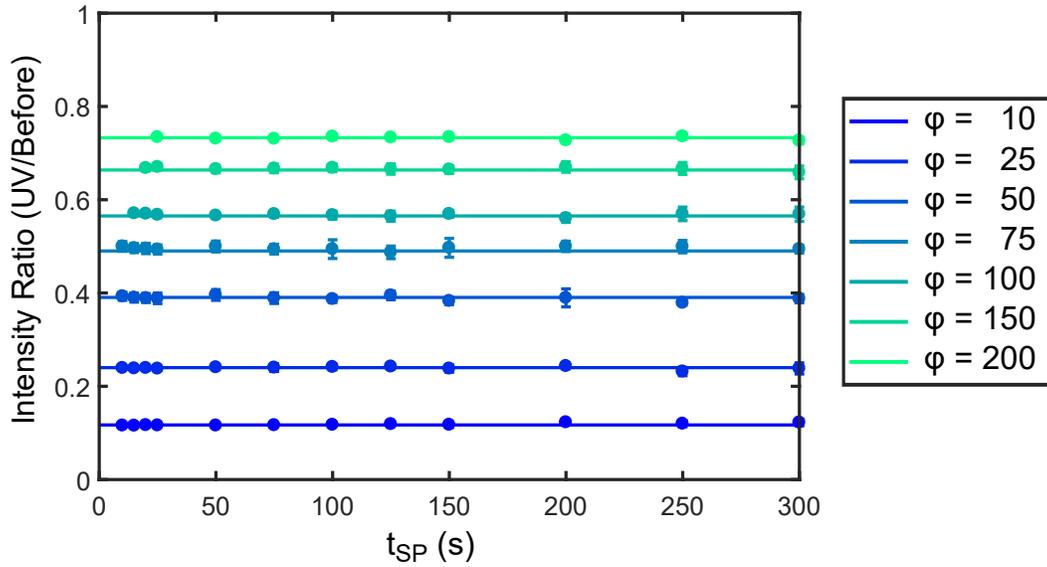


Fig. S4. Influence of the residence times on the intensity ratio. Graph showing that the luminescence intensity ratio during and before UV irradiation is dependent on the residence times only through their ratio $\varphi = t_{SP} / t_{MC}$, thus enabling unambiguous determination of this parameter from the measured mean intensities. This data set is obtained for $N_{SM} = 1$ per nm, $L = 300$ nm and $l_d = 180$ nm and was used to generate Fig. 3A.

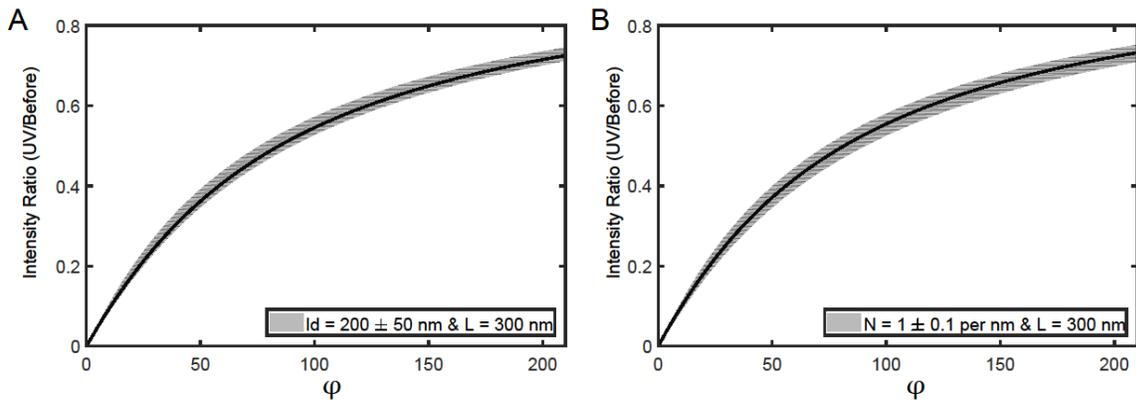


Fig. S5. Error estimation of the parameter theoretical φ . The influence of φ on the mean intensity ratio is presented for a nanotube segment of $L = 300 \text{ nm}$. The grey shaded areas correspond to the error of the estimated φ for $N_{SM} = 1.0 \pm 0.2 \text{ per nm}$, $L = 300 \text{ nm}$ & $l_d = 180 \text{ nm}$ (A) and $N_{SM} = 1 \text{ per nm}$, $L = 300 \text{ nm}$ & $l_d = 200 \pm 50 \text{ nm}$ (B).