Electronic Supplementary Material (ESI) for Nanoscale.

SUPPORTING INFORMATION

Structure and excitonic transitions in self-assembled porphyrin nanotubes and their effect on light absorption and scattering

Oriol Arteaga, Adolf Canillas, Zoubir El-Hachemi, Joaquim Crusats, and

Josep M. Ribó

Peak Force Microscopy (PFM) procedures

Images were acquired in a Multimode Atomic Force Microscope attached to a Bruker® Nanoscope V electronic unit. The imaging mode used for these experiments was Scan Assist Tapping Mode. In this operation mode, the scanning probe performs individual force curves on the sample surface while maintaining a constant vertical force. The vertical force was set between 10 pN and 20 pN that is a suitable threshold in order to ensure that there is no significant sample deformation due to the contact of scanning probe with the sample. The scanning probe used in this study was a Bruker® SLN-10 triangular probe made of silicon nitride, whose spring constant is 0.35 $nN \cdot nm^{-1}$.

Solution deposition procedure for PFM imaging in dry substrates

One drop (10 µl) of the nanoparticle solution (2 mM – 8 mM containing mostly nanotube bundles) was brought into contact with a freshly cleaved HOPG or mica surface and was blown up with a N_2 stream. For the concentrated solutions the blowing was almost immediate. Morphologic and topographic measurements of single nanoparticles were obtained by searching in the less populate regions of the deposition surface to obtain images as those of Fig. 2. In the case of more diluted solutions the drop was maintained in contact with the surface during 20s, blotted out with the tip of a sheet of filter paper and finally blow up with a N_2 stream.

Mueller matrix microscopy measurements

The Mueller matrix (MM) microscope [16] produces 16 images of a sample in around one minute. Each one of these images corresponds to a different element of the 4x4 Mueller matrix, providing the complete quantitative analysis of the modification of the polarization as the light beam is transmitted or reflected in the sample. False color is used to denote different magnitudes and signs thorough the MM elements. The MM microscope is able to measure the magnitude and orientation of linear dichroism and linear birefringence, the circular birefringence, the circular dichroism and the depolarization.

Our Mueller matrix microscope is based in the frequency analysis at the pixel level of the images continuously captured by a CMOS camera while two rotating compensators modulate the polarization of light. As the intensity detected by every individual pixel of the camera is frequency analyzed by digital demodulation, the determination of the optical properties keeps the same high lateral resolution of standard microscopy measurements. Fig. S1 shows an example of a measurement made with a 50x objective.

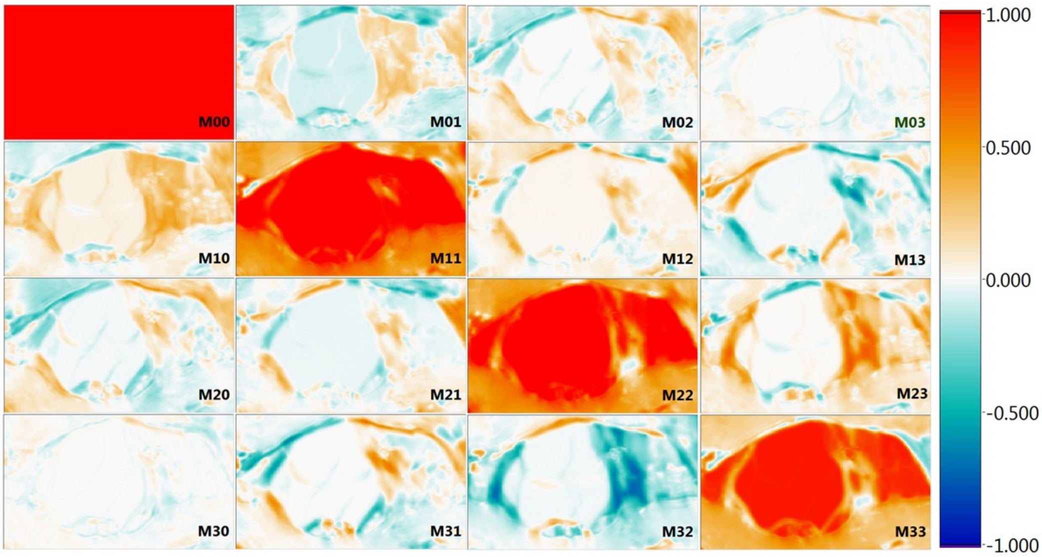

Figure S1. Example of the normalized Mueller matrix measurement with the microscope at 500nm. From the information contained in this figure we calculated the data of Fig. 3 that corresponds to 500nm.

Mueller matrix spectroscopic transmission and scattering measurements

The spectroscopic Mueller matrix polarimeter [15] that we have used has four photoelastic modulators (PEMs) that modulate the polarization state of light both before and after the sample. Fourier analysis of the time varying signal delivers simultaneously all sixteen elements of the Mueller matrix with very high precision. Fig. S2 shows a scheme of the instrument. Transmission measurements are made in the strait-through configuration (Fig. S2, top), while for scattering measurement (Fig. S2, bottom), one arm of the polarimeter is rotated to a certain scattering angle (90º for all the scattering measurements reported in the paper).

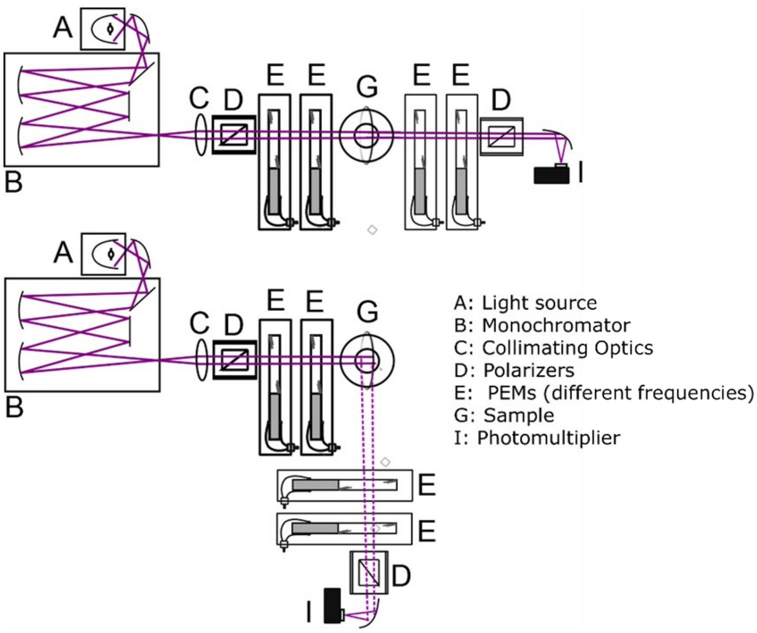

Fig. S2 Experimental setups used for transmission (top) and scattering (bottom) Mueller matrix measurements

Determination of optical properties from the Mueller matrix

The Mueller matrix provides a complete quantitative characterization of the optical response of the sample, but the individual optical properties cannot directly retrieved from the Mueller matrix elements. For example the usually weak circular birefringence and circular dichroism effects need to be well-separated from the larger linear birefringence and linear dichroism effects. The algorithm that we use to recover all these optical effects from the Mueller matrix is based on an analytic inversion [17].