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Controlled fluorescence in a beetle's photonic structure and its sensitivity to environmentally induced changes

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Supplementary material 1

Optical microscopy

The beetle elytra were observed in a white light reflection mode (illumination with the visible light source and observation in the visible range) and a fluorescence mode (illumination with the UV light source and observation in the visible range) of the microscope. The elytra of dead beetles were placed on microscope slides. The flatter areas of the samples were observed in both dry and wet states (the wet state was achieved after immersing the sample in distilled water for several minutes).

Spectrofluorimetry

The incident light formed a 45° angle with the direction normal to the sample surface and the emitted light was detected at a 45° angle on the other side of the normal direction. Excitation and emission spectra were recorded using a 450 W xenon lamp as the steady state excitation source. Time-resolved dynamics of fluorescence emission from the samples were recorded in dry and wet states using a picosecond pulsed EPLED light source, operating at a frequency of 5 MHz with an excitation wavelength equal to 376 nm (i.e. close to the samples' excitation peak wavelength) and detection wavelengths equal to 466 nm (i.e. inside the PhBG of the structure) and 546 nm (outside the PhBG). The spectral resolution was equal to 3 nm. The spot size associated with the spectrofluorimeter was approximately 0.75 mm in diameter and generated fluorescent emission from many scales.

FDTD simulations

The 2D computational cell size was equal to $84a \times 84a$ ($a = 35$ nm), including perfectly matched layers (PML, strength equal 15.0) of thickness $2a = 70$ nm surrounding the computational cell. The size of the effective computational cell ($80a \times 80a$) was therefore equal to $2.8 \mu\text{m} \times 2.8 \mu\text{m}$. Inside this computational cell, the 12 bilayers composing the 1D periodic stack were included (air-cuticle mixed layers being treated as effective medium layers), with a thickness equal to a for the dense cuticle layers and to $4a$ for the effective mixed air-cuticle layers. The original 2D photonic crystal unit cell had a size of 175 nm (lateral spacing between rods) by 175 nm (thickness of the bilayer), i.e. the computational cell contained as much as 192 photonic crystal unit cells. Two additional layers were used to represent the incidence medium and the substrate in the computational cell: respectively, a top air layer and a bottom cuticle layer, both having a thickness $10a = 350$ nm. In comparison with 1D-TM method, FDTD had the advantage to afford modelling the fluorophores by point sources which could be randomly dispersed in the cuticle material. The fluorophores were modelled by Gaussian pulse sources of width equal to 5% of the central frequency ($\lambda = 560$ nm). The FDTD grid resolution was set to 10 pixels by unit distance a . The transmitted flux was recorded at 100 Fast Fourier Transform frequencies in the upper air layer and normalized regarding the flux emitted in free space in order to compute the normalized emitted intensity spectrum.

Supplementary material 2

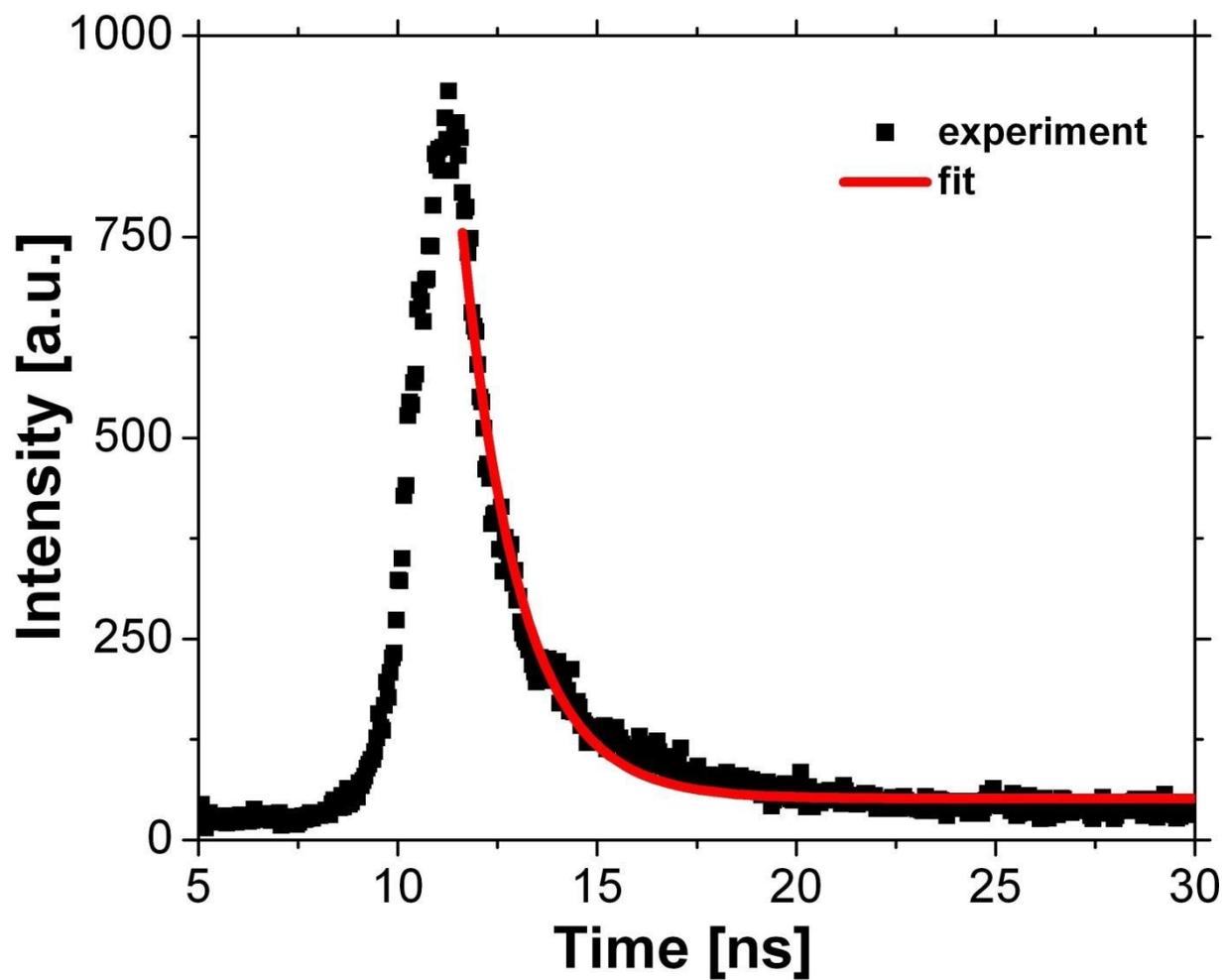


Figure S1 Time-resolved measurement of the fluorescence intensity arising from the fluorophores embedded in the photonic structure of the male *H. coerulea* beetle. The measurements were performed at 546 nm with a sample in the dry state, using an excitation wavelength of 376 nm. The best fit to the measured decay is a single exponential law.