BRIGHT GOLD-ORGANIC FLUORESCENT EMITTERS WITH PICOSECOND LIFETIMES BASED ON COLLOIDAL NANOANTENNAS

Vincent Maillard, 1, Mickaël Busson, 1, Petru Gheneche, 2, Brian Stout, 2, Nicolas Bonod, 2, Jérôme Wenger, 2, Sébastien Bidault 1
1-Institut Langevin, ESPCI ParisTech, CNRS UMR 7587
1 rue Jussieu, 75005 Paris, France
2-Institut Fresnel, Aix-Marseille Université, CNRS UMR 7249
Domaine Universitaire St Jérôme, 13397 Marseille, France
E-mail : sebastien.bidault@espci.fr

KEY WORDS: Luminescence lifetime, fluorescence correlation spectroscopy, plasmon resonance, gold nanoparticles, DNA self-assembly, nanoantennas.

Homogeneous broadening effects strongly reduce the absorption cross-sections of organic molecules at room temperature, hindering the optical tracking of single emitters in biological environments that produce large background fluorescence.

To enhance the fluorescence properties of single molecules in an aqueous environment, we assemble them in the centre of an optical nanoantenna using a short DNA double-strand (figure 1-a). Gold nanoparticle (AuNP) dimers are obtained in large scale as a purified colloidal suspension (figure 1-b). Confocal luminescence lifetime measurements in microfluidic conditions demonstrate that these nanostructures are single photon-emitters with picosecond lifetimes [1]. To select molecules with a dipolar transition moment parallel to the dimer axis, we use radially-polarized first-order Laguerre-Gauss beams with antennas oriented perpendicularly to our sample plane (figure 1-a-c) [2].

Figure 1: (a) AuNP dimers with radial or azimuthal excitations. (b) Cryo-EM image of 36 nm dimers. (c) Lifetime of ATTO dye (light grey, 3.3 ns), azimuthally (grey, 150 ps) and radially excited dimers (black, 60 ps)

A conjunction of time-resolved luminescence and fluorescence correlation spectroscopy allows us to fully characterize the photophysical properties of these hybrid emitters that feature excitation cross-sections and decay rates enhanced by more than one order of magnitude with respect to isolated organic dyes [3]. To optimize the fluorescence quantum yield, we increase the size of the AuNPs and reach an average 44 times enhancement of the fluorescence count rate with picosecond lifetimes. These values correspond to unprecedented dipolar transition moments of isolated quantum emitters at room temperature.