J-aggregate self-assembly on carbon nanotubes for new nanoscale devices

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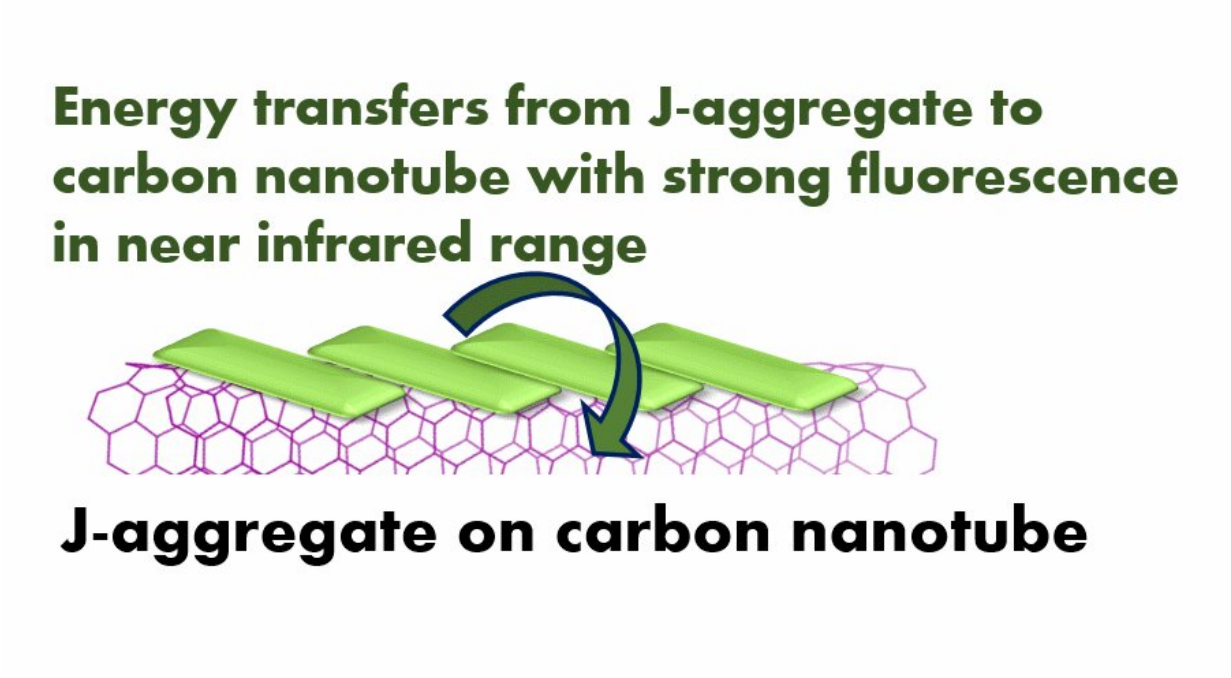

Credit: Aston University

Novel self-assembly of resonant J-aggregates on carbon nanotubes with advanced features and high potential for versatile practical applications is discovered recently. Last decade, the nanoscale devices become much closer to industrial applications due to the progress made in the areas of high-precision instrumentation and nanotechnology.

Natural self-assembly of molecules for creation and/or improvement of such nanoscale devices enables controlled and simple fabrication techniques for the future innovations. Self-assembly of individual molecules into complex J-aggregates, where molecules are well ordered into long 'staircase' shape, has a unique property due to a coupling of the molecules. The coupling facilitates strong coherent resonance of delocalized charge carriers (called excitons) inside such self-assemblies, and such excitons can easily move inside the J-aggregates. Furthermore, coherent coupling between J-aggregates and other nanomaterials provides opportunity to extend such resonant delocalization empowering development of advanced applications in nanoscale photonics and optoelectronics.

The researchers from Aston University in the U.K. and collaborators have revealed for the first time a technique to create resonantly coherent J-aggregates on outer walls of carbon nanotubes. They discovered that such aggregates very efficiently transfer all the energy of absorbed light to the nanotubes. As a result of such efficient energy transfer, the fluorescence of J-aggregates is completely quenched and the emission form the carbon nanotubes is strongly enhanced. The aggregate formation is associated with favorable self-assembly of cis-isomer form of the aggregated molecules having a bended molecular structure and aligning well to the convex nanotube surface.

Importantly, such findings show formation of a unique type of nanomaterials with a breakthrough functionality of extended resonant delocalization of excitons. This discovery lays foundations for physical chemical exploration and nano-engineering applications of efficient resonant interaction of self-assembly J-aggregates and nano-tubular materials in biomedical imaging and treatment, nanoscale optoelectronic and photonic devices for logic, high-speed communications, and next-generation electronic and excitonic technologies.

More information: Petro Lutsyk et al. Self-Assembly for Two Types of J-Aggregates: cis-Isomers of Dye on the Carbon Nanotube Surface and Free Aggregates of Dye trans-Isomers, *The Journal of Physical Chemistry C* (2019). DOI: 10.1021/acs.jpcc.9b03341