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Significant Performance Enhancement of Triplet-Triplet Annihilation Upconversion Systems Based on Strong Light-Matter Interactions

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Triplet-triplet annihilation upconversion (TTA-UC) is a technique that converts low-energy light into higher-energy light and has garnered significant attention for its wide range of potential applications. In TTA-UC, porphyrins are commonly used as sensitizer molecules, but the method faces several limitations. These include a narrow excitation wavelength range, restricted by the molecules' spectroscopic properties, and a low molar absorption coefficient due to weak interactions with light. This study aims to significantly enhance TTA-UC performance by achieving strong interactions between light and sensitizer molecules through localized surface plasmon (LSP) resonance.

It is well-known that strong light-matter interactions can give rise to upper (UP) and lower (LP) polariton states. By utilizing these states, it is anticipated that the excitation wavelength range can be extended, and excitation efficiency can be improved through these enhanced interactions. To realize this, we employed a plasmonic structure composed of a 2D assembly of metal-polymer thin films and metal nanoparticles, designed to exhibit pronounced LSP resonance. This structure also facilitates macroscopic observation of upconverted emission through strong light-molecule interactions.

Additionally, based on synthetic methods from metal-organic frameworks, we fabricated an aggregate structure of sensitizer molecules (Pd porphyrin derivatives) and integrated them with the plasmonic structure. These composite systems exhibited spectral characteristics indicating strong interactions between light and excitons in the sensitizer molecules, as evidenced by anticrossing behavior. Furthermore, the upconverted emission was found to be significantly amplified, demonstrating the potential of this approach for enhancing TTA-UC performance.

Biography:

I have studied nanoparticles, nanostructures and photochemistry at Nihon University for two years. I am very interested in the plasmons expressed by nanoparticles. Therefore, I am studying in detail the effects of nanoparticles expressing plasmons on molecules.