Development of Triplet-Triplet Annihilation Based Photon Upconversion in Condensed Systems

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論 文 名　：　Development of Triplet-Triplet Annihilation Based Photon Upconversion in Condensed Systems
(三重項-三重項消滅に基づくフォトン・アップコンバージョンの凝縮系への展開)

区　　分　：　甲

論　文　内　容　の　要　旨

Light is one of the most important energy sources because of their intriguing applications in photoreactions, including photocatalysis, photovoltaic power generation, and biotechnology. However, photoreactions occur only at a specific range of wavelengths and are difficult to utilize the light energy effectively.

In recent years, there is a rapid growth of interest in photon upconversion (UC) being a solution to the problems above. UC is a process that converts lower energy (longer wavelength) photons to higher energy (shorter wavelength) photons. Among various UC mechanisms, triplet−triplet annihilation-based UC (TTA-UC) is particularly useful, since it allows UC under low excitation power density. Most of studies on TTA-UC obtain good energy transfer efficiency by exploiting the translational diffusion of excited molecules in solutions and soft polymers. However, the use of volatile organic solvents is not suitable for device applications. Therefore, development of TTA-UC in condensed systems is required.

For the development of TTA-UC in condensed systems, it is necessary to solve three fundamental problems: (1) low triplet diffusion, (2) phase separation of triplet donor and triplet acceptor, and (3) red-shifting of acceptor emission. In this dissertation, we describe TTA-UC in condensed systems with the aim to solve the issues above.

In Chapter 2, the strategy to solve the problems of phase separation of donors and acceptors and triplet energy migration efficiency is described. This issue is solved by utilizing liquid crystalline acceptor for energy migration in the TTA-UC system. We expect that the structural flexibility and the orientation of the liquid crystal would allow homogeneous doping with the donor and fast energy-migration for efficient TTA. Furthermore, critical effect of the structural order upon the performance of TTA-UC is unveiled by systematic control over the domain size of the liquid crystal.

Chapter 3 focuses on the solution to the decrease in anti-Stokes shift. We employ 3D perovskite nanocrystals as a new inorganic triplet sensitizer. The optical properties of perovskite nano-crystals are tuned by facile halide exchange reactions, which made triplet sensitization possible with various excitation wavelengths. Moreover, studies of triplet states in 3D perovskite promote a variety of fundamental advances and optical/optoelectronic applications to the perovskite research field.

New function of TTA-UC is discussed in Chapter 4. By solving the intrinsic problems of condensed systems, we successfully obtain a stimuli-responsive dual-color TTA-UC. This function is specific to condensed systems, and the result clearly exhibited the availability of TTA-UC in condensed systems.

Chapter 5 summarizes this dissertation.

〔作成要領〕

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