

Efficient Visible-to-Ultraviolet Photon Upconversion using Excited Triplet States in Molecular Diffusion Systems

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(分子拡散系における励起三重項状態を用いた高効率な可視 - 紫外
フォトン・アップコンバージョン)

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論 文 内 容 の 要 旨

Photon upconversion using excited triplet states (TTA-UC) is a methodology to convert low-energy photons to higher-energy photons, and in particular, the conversion from visible light into ultraviolet (UV) light is beneficial for practical solar applications, such as photo-catalysts and photo-reactions. However, visible-to-UV TTA-UC systems were not widely investigated since the efficiency of TTA-UC was limited, and the required excitation light was higher than solar irradiance. In this thesis, efficient visible-to-UV TTA-UC in molecular diffusion systems is discussed.

Chapter 1 describes the thesis overview and background, including the fundamental properties of TTA-UC. The pioneering example of a visible-to-UV TTA-UC system in solution was reported in 2006, combining a pyrene derivative and an iridium complex as an acceptor and donor, respectively. Subsequently, the reports on visible-to-UV TTA-UC systems have increased. However, the efficiency was low until a new efficient emitter was developed, which is mainly discussed in this thesis. The current situation of TTA-UC systems generating UV light is summarized in this chapter.

Chapter 2 describes developing an efficient TTA-UC system showing high efficiency and low threshold excitation intensity. The system contained a UV-emitting naphthalene derivative as an acceptor and an iridium complex as a donor. The acceptor showed high fluorescence quantum yield and high singlet generation efficiency. Furthermore, the donor had strong visible and small UV light absorption. As a result, this pair showed excellent properties of TTA-UC with the highest efficiency ever reported and a lower threshold excitation intensity than solar irradiance. This system also demonstrated TTA-UC under solar-simulated and room LED light.

Chapter 3 describes a new, simple method to prepare an efficient visible-to-UV TTA-UC using a porous film and a low-volatile solvent. The film fabricated by this method showed high efficiency and a relatively low threshold excitation intensity. In addition to the powerful advantage of maintaining the efficient properties in solution, this film can be integrated with a microlens array that can focus excitation light, and it showed much lower threshold excitation intensity than sunlight, providing a way to achieve various applications in film form under solar irradiance.

Chapter 4 summarizes this thesis and exhibits future remarks.