Visible-to-UV Photon Upconversion in Aqueous Bilayer Membranes

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Triplet-triplet annihilation-based photon upconversion (TTA-UC) is a promising photonic manipulation for converting lower-energy visible light to higher-energy UV light.[1)] The characteristic of TTA-UC, such as low excitation intensity and high quantum yield, are beneficial for applications including photovoltaics, photocatalysis and bioimaging. However, most photon upconversion matrices have been limited to volatile organic solvents due to the poor water solubility of chromophores. In addition, the oxygen quenching of the photo-excited triplet state in the solution has been a severe issue.

Inspired by the structure and elegant functions of the Thylakoid membrane, we show in this work an air-stable visible-to-UV TTA-UC by ordered chromophore assemblies in water. Cationic aqueous bilayer membranes modified with naphthalene chromophores (Lipid-Naph) were synthesized (Fig. 1a). By introducing anionic donor molecules Irsppy into the aqueous bilayer membrane of Lipid-Naph, an upconverted emission was successfully observed even in aerated water, and the TTA-UC emission was almost unaffected by dissolved oxygen molecules (Fig. 1a, b). The good oxygen blocking ability is characteristic of the ordered bilayer membrane of Lipid-Naph in the gel-state, as supported by reversible modulations of the UC emission intensity associated with the gel-to-liquid crystalline phase transition phenomena (Fig. 1c).

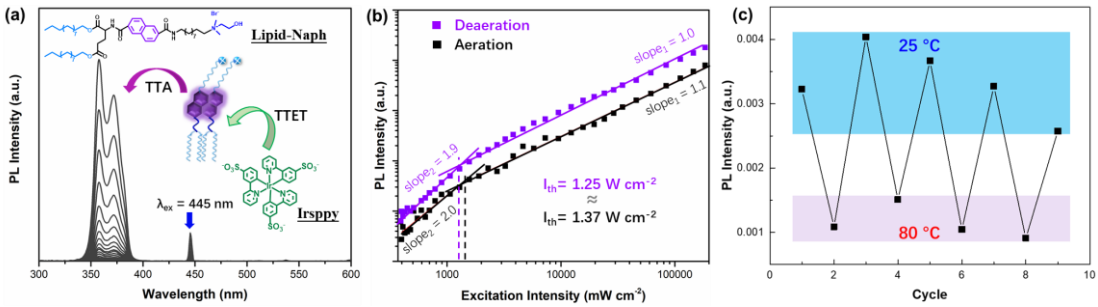

Fig. 1 Photoluminescence spectra (a) and excitation intensity dependence of UC emission intensity (b) of the Irsppy (0.05 mM)/Lipid-Naph (2 mM) assemblies in aerated (a) and aerated/deaerated (b) water under different incident power density of 445 nm laser at room temperature. (c) UC emission intensity of Irsppy/Lipid-Naph in air-saturated water in the heating/cooling cycles.

1) T. N. Singh-Rachford, F. N. Castellano, *Coord. Chem. Rev.* **2010**, *254*, 2560.