Single-molecule emission/absorption spectroscopy and real-space investigation of intermolecular energy transfer

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Excitation of molecules by light irradiation triggers various important processes including luminescence, photovoltaic effect and photochemical reactions, and detailed understanding of the molecular excited states is crucial to improve organic opto-electronic devices. Absorption spectroscopy is a powerful tool to describe the molecular excitations and the combination with emission (luminescence) spectroscopy which deals with deexcitation processes is effective to investigate the excited states. Single-molecule luminescence detection has progressed rapidly and become indispensable in quantum physics, physical chemistry, and biophysics. However, despite considerable effort and progress, absorption spectroscopy is far behind; number of molecules are still necessary to obtain an absorption spectrum. A difficulty lies in the difference between the diffraction limit of excitation light and absorption cross section of a single molecule.

Here I introduce our recent progress in measurement of the single molecule luminescence and absorption spectra of a single molecule using a scanning tunnelling microscope (STM) equipped with optical detection facilities. I will discuss about the single molecule reaction of a single metal-free phthalocyanine molecule on the NaCl ultrathin film on Ag(111) with tunneling electrons and accompanied optical property changes in a single-molecule optical spectra. Application of the single-molecule emission/absorption spectroscopy to the real-space investigation of energy transfer between molecules will be also introduced.

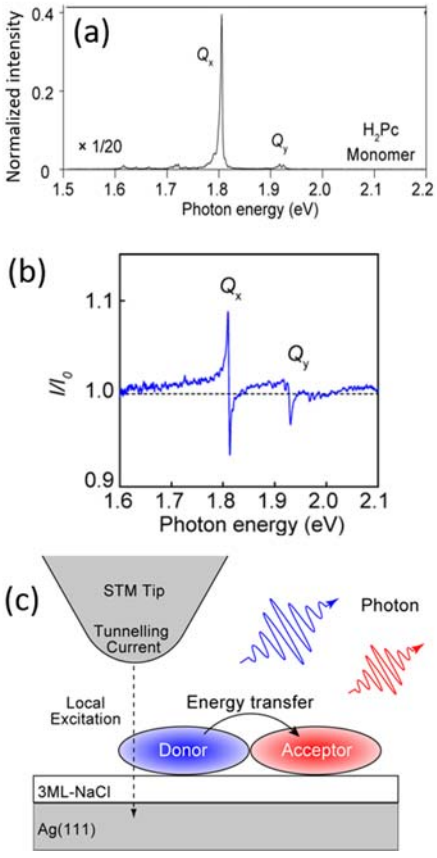

Fig.1 (a) Fluorescence and (b) absorption spectra of a single H2Pc molecule on 3-ML NaCl film grown on Ag(111). (c) A schematic of resonance energy transfer between two molecules.

[Referemce]
H. Imada, K. Miwa, M. Imai-Imada, S. Kawahara, K. Kimura and Y. Kim, Nature 538 (2016) 364.