Cavity-Free Quantum Electrodynamic Chemistry

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In this talk, I will briefly introduce my latest development in an emerging field "QED chemistry". In the past few years, exploring chemical processes induced by vacuum electromagnetic fields has attracted considerable attention because the entry of quantum electrodynamics into chemistry is a new concept in basic chemistry. Quantum light can affect molecules in various aspects, and I will focus on three topics (i) molecular fluorescence [1]-[4], (ii) resonance energy transfer [5]-[8], and (iii) electron transfer [9]. First, in the framework of macroscopic quantum electrodynamics, I developed a unified theory of molecular fluorescence, which enables us to describe the dynamics of molecular fluorescence coupled to quantum light from weak to strong light-matter couplings in a complicated dielectric environment. Based on this theory, we derived a parameter-free formula which can be used to estimate the exciton-polariton coupling for single molecules in a nanostructure. Our theory is in good agreement with the reported experimental results [Chikkaraddy et al., Nature 2016, 535, 127-130]. Second, I developed a unified theory of radiative and non-radiative resonance energy transfer based on macroscopic quantum electrodynamics. The proposed theory allows us to describe long-range resonance energy transfer between two entities in spatially dependent vacuum electric fields. Third, we generalized famous Marcus theory and developed a theory of electron transfer based on quantum electrodynamics. Our theory shows that QED effects can significantly enhance the kinetic rate of electron transfer reactions by several orders of magnitude in the absence of cavities, which is implicitly supported by experimental reports.

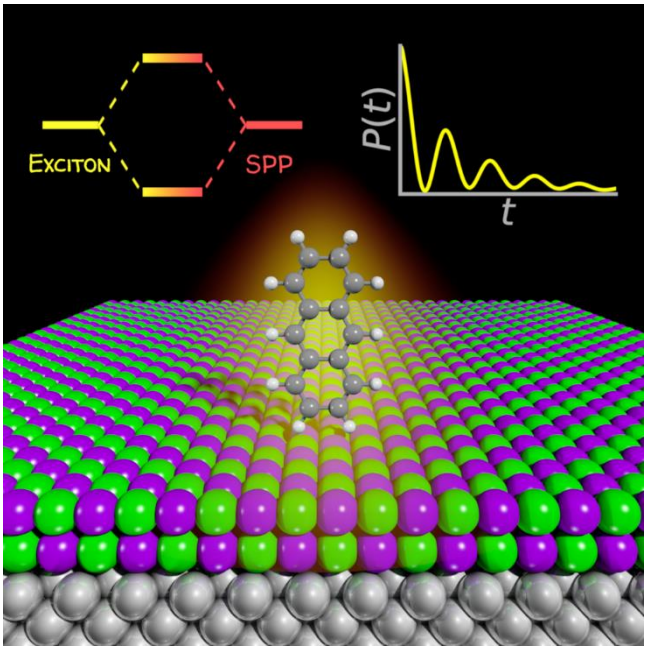

Fig 1. Molecules strongly coupled with vacuum electromagnetic fields

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