

# Femtosecond Relaxation Dynamics and Charge Transfer Mechanism: From Porphyrin-sensitized to Perovskite Solar Cells

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**Abstracts:** Upon invitation by Prof. Michael Grätzel, the winner of Ahmed Zewail Award given by Chemical Physics Letter, Elsevier, I got this opportunity to present our work in next-generation solar cells to celebrate this big event. Since I worked as a postdoctoral fellow with late Prof. Zewail during the period 1997 – 2001, I set up a femtosecond fluorescence up-conversion system to study fundamental photophysical processes in condensed phases in the beginning of my own research. At those days, I was thinking all kinds of reactions/processes with dominated ultrafast relaxation dynamics/kinetics and significantly essential for a practical application. Dye-sensitized solar cells (DSSC) pioneered by Prof. Grätzel since 90s became the best candidate for me to study because the electron injection from dye to nanocrystalline TiO<sub>2</sub> occurs on the femtosecond time scale and this ultrafast process plays an important role on the device performance of a DSSC. As a result, we studied the electron injection and energy transfer dynamics for many kinds of porphyrin dyes as efficient photo-sensitizers for DSSC. Our collaboration with Prof. Grätzel's group started at 2009, and in particular for a remarkable push-pull porphyrin dye cell, YD2-oC8, attained PCE 12.8 % in 2011. Starting from 2012, perovskite solar cells (PSC) emerged and the performance of PSC was in a rapid progress to attain PCE over 20 % within 5 years. Our group follows this trend working on PSC but with emphasizing on three directions (i) lead-free PSC, (ii) carbon-based mesoscopic PSC and (iii) planar heterojunction PSC with the p-contact layer using graphene oxide (GO) and reduced GO (rGO) derivatives. In this lecture, I will briefly introduce our recent development on PSC with a focus to understand the mechanism of charge transfer on GO and rGO-based PSC. Briefly, we found that the reduction of the oxygen-containing groups in GO significantly decreased the ability of hole extraction from perovskite to rGO and also retarded the charge recombination at the rGO/perovskite interface. When the hole injection from perovskite to GO occurred rapidly, hole propagation from GO to the ITO substrate became a bottleneck to overcome, which led to a rapid charge recombination that decreased the performance of the GO device relative to the rGO device.