# Equilibrium Dynamics in Electrolytes of Li-Ion Battery & Mid-IR Quantum dot Studied by Time-resolved Infrared Spectroscopy

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Two-dimensional infrared spectroscopy and pump-probe spectroscopy has been applied to study various chemical and biological processes with ultrafast time resolution. Recently, our group extends research interest into solvation dynamics in highly concentrated system and electron dynamics of materials absorbing and emitting mid-infrared light. Here, we will show recent results from 2D-IR and pump-probe spectroscopy in these two applications.

Electrolytes are ubiquitous and indispensable in all electrochemical devices including electrolytic cells, capacitors, fuel cells, or batteries. Their function is the same in devices for serving as the medium for the ion transport between electrodes. The electrolyte determines how fast the energy could be released by controlling the rate of mass flow within the battery. Thus, it has been suggested that the solvation structures and dynamics of Li ions in liquid electrolyte play an essential role to Li-based battery performance. To mimic commercial electrolyte composition used in commercial Li-ion battery, Li ion were dissolved in diethylcarbonate (DEC) and its solvation behavior was observed with IR spectroscopy as well as time-resolved IR spectroscopies including IR pump-probe and 2D-IR experiments. IR spectroscopic results combined with DFT study reveals the possible solvation structure and major interaction site for Li ion. Subsequent 2D-IR experiments show that there is fast equilibrium solvation dynamics around Li-ion, which might give some clues about the molecular mechanism of Li ion transport through electrolyte.

Quantum dots absorbing mid-infrared light have been synthesized and tested as a potential candidate for the promising materials for mid-IR detection. Intra-band transition is induced by the absorption of infrared photon. Electronic excited state induced by infrared field shows fast relaxation dynamics due to the strong electron-phonon coupling. The relaxation time show two characteristic relaxation times; fast one is size-independent and the other shows frequency dependence due to the structural inhomogeneity.