Spectroscopic investigation of charge dissociation and transport in organic solar cells

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We present here results from electro-modulated differential absorption (EDA) spectroscopy on organic photovoltaic (OPV) materials. OPVs show advantages such as transparency, flexibility, low cost and light weight over inorganic solar cells.[1] However, they are still lagging behind when it comes to power conversion efficiencies (PCEs). A lot of work has been done in the last decades to optimize materials and their morphology and to understand the mechanism of charge generation. This has allowed to increase the PCE from 5% to even more than 17%[2] in blended OPVs with an electron donor (D) and a non-fullerene acceptor (NFA) as electron accepting (A) material. Either the D or A material of the blend can absorb a photon at their respective absorption wavelength to generate an exciton which then can diffuse to a D-A interface, creating a charge transfer (CT) state and eventually separate into unbound charges. To increase the efficiency of OPVs, charge transport is an important process which needs to be further investigated and optimized. Time-resolved EDA spectroscopy can be used to determine charge mobility. On an ultra-short timescale, the changes in electro-absorption (EA), which occur due to transport and extraction of photogenerated unbound charges, can be tracked with a resolution of 100 femtoseconds. We present here EDA results of NFA-based blends excited at different wavelengths. Whether CT states remain bound or dissociate into unbound charges is a matter of their local environment.[3] But unlike unbound charges, CT states cannot be tracked by conventional EDA. Therefore, we show here a new technique to record also their local environment: A third low-energy, high-wavelength beam can be included to re-excide CT states to increase their chance to separate. With this 'push'-EDA, it should be possible to get an idea about the local mobility of push-separated CT states and why they rather stayed bound than dissociate by themselves. Combining both spectroscopic techniques will lead to a better understanding of the mechanism of charge separation and will help to design more efficient NFA OPVs in the future.

References:

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