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Generating electricity in organic materials

Increasing environmental concerns in the past decade gave rise to the development of various alternative clean energy generation concepts. Solar energy was calculated to have potential of providing thousand times the required energy and thus is the main source for future energy production. Despite the accelerating development of photovoltaic technology the large-scale commercial applications are delayed due to cost issues and complicated manifacturing process. Organic polymer-based solar cells recently attracted much attention as an efficient and inexpensive light-to-electricity conversion solution. However, the mechanism behind charge generation processes in organic materials is still not fully understood due to complex nature of carbon-based compounds.

The rapid growth of the organic solar cells was initiated after the A. J. Heeger, A. MacDiarmid and H. Shirakawa reported high conductivity in organic-based polymers in 1977, which was awarded Nobel Prize in Chemistly in 2000. Soon, the concept of bulk heterojuntion (BHJ) solar cells employing conductive polymer was introduced, which allowed to reach up to 10% solar cell power conversion efficiency. Relatively high efficiency is allowed by the specific charge-transfer (CT) states that are present at the interface of electron donor (conjugated polymer) and acceptor (fullerene derivative) material interface. These states were found to significantly reduce the energy barrier for excited molecule to dissociate into free charges, which is illustrated in Figure 1. Here it is evident that charge-generation process in organic materials consists of many steps, which limit the overall efficiency of the solar cell.

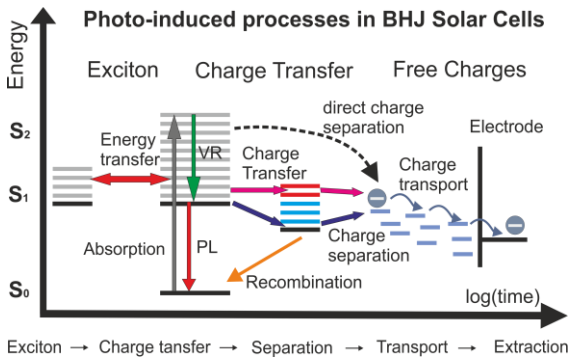

Figure 1. Photo-induced processes of BHJ solar cells in an energetic perspective.

This research included detail investigation of the energy and charge transfer processes in the BHJ polymer-fullerene blends. Charge photo-generation was studied as a function of changing conditions such as excitation energy, driving force and electric field in the solar cell to determine the efficiency of certain processes. Since most of the transitions occur in the timescale of femtoseconds, the insight into the processes was only made possible by employing the ultrafast time-resolved photoluminescence (TRPL) spectroscopy techniques. The investigation of two similar polymer structures with intrinsic energetic differences allowed to assume several charge generation scenarios that are currently disscused by the scientific community.

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