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Charge transport studies in organic semiconductors using carrier extraction by linearly increasing voltage (CELIV) technique

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Organic optoelectronic devices, such as solar cells, light emitting diodes and transistors, share a common feature: their performance critically depends on the efficiency with which charge carriers (electrons and/or holes) move in the material. Understanding and improving the charge transport is the main goal when improving the device performance or designing novel organic compounds through chemical engineering. Due to low carrier mobility in disordered films, as well as due to its time, electric field and carrier density dependence, standard measurement technique like Hall effect and Time-of-Flight are either inapplicable or limited in applicability. Charge Carrier Extraction by Linearly Increasing Voltage (CELIV) technique has become a world standard used by many scientific groups to measure charge transport and recombination in inorganic and organic semiconductors. The method can be used to study the charge carrier mobility dependence on time, carrier concentration, electric field, temperature, film thickness and morphology directly in the operational devices. However, the latest research have shown that CELIV current transients and extraction maximum used for mobility evaluation is strongly dependent on experimental conditions such as carrier density, light absorption profile and electric field. Procedure, allowing estimating the correction factor in mobility relation will be presented. In contrast to inorganic crystalline semiconductors, the long-range disorder in the films of organic devices makes the charge transport properties strongly dependent on the degree of disorder and nanomorphology of the films. Carrier density, electric field and temperature dependent mobility in disordered organic semiconductors is shown to obey Arrhenius-type, Poole-Frenkel-type, Meyer-Neldel rule, and Gill's law. Stochastic transport theories are used to describe charge carrier hopping within localized Density-Of-States as opposed to delocalized band-transport in the crystals.