Using *in-situ* Terahertz Spectroscopy to investigate Charge Transport in In-plane Oriented Organic Mixed Ionic-Electronic Conductors

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Organic bioelectronics deals with the study of organic electronic devices which are working at the interface of biology and electronics. A type of material that proved to be perfectly suited for this are organic mixed ionic-electronic conductors (OMIECs) as they enable the transport of ions as well as electrons. Other advantageous properties of OMIECs are their soft and flexible nature, versatile processing and synthetic tunability making it possible to span a wide range of applications.[1] In recent years a lot of studies were focused on device fabrication and on the different material options. However, there is still a lack of a more in-depth understanding of the fundamental effects occurring during the functioning of OMIECs.[2] An organic polymer showing high charge-carrier mobility is PBTTT, its conductivity can be efficiently improved by inserting alkyl side chains with a single ether group as this is facilitating the uptake of ions into the polymer matrix.[3,4] The charge transport is happening mainly on the backbone of the organic semiconductor. Therefore, in this study we investigated PBTTT-^{8}O films, that were oriented using high temperature rubbing, for comparison the same experiments were carried out with a OMIECs model material P3HT, which was already characterized by multiple different research groups.[5] The alignment of the backbones will further enhance the charge transport as well as help to unravel the fundamental processes of the charge transport.

To study these effects, we used *in-situ* terahertz (THz) spectroscopy, where we measured films with electrochemical and chemical doping, furthermore spectro-electrochemistry and chronoamperometry were carried out. With THz spectroscopy we can detect the scattering frequencies of charge carriers in semiconductors, this allows us to get the intrinsic nanoscale conductivity and short-range mobility of the studied OMIECs, which is not affected by any grain boundaries or electrodes. The analysis of the complex THz conductivity unveils the mobility and density of charges altogether. We were able to get conductivities of more than 1000 Scm^{-1} for P3HT and PBTTT-^{8}O for electrochemical doping. Furthermore, with chemical doping conductivities of more than 2000 Scm^{-1} were obtained and band like transport behavior was observed for PBTTT-^{8}O, showing the large effect of high in plane orientation of OMIECs.

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