DOCTORAL THESIS

Charge transport and injection in amorphous organic electronic materials

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Charge Transport and Injection
in
Amorphous Organic Electronic Materials

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Abstract

This thesis presents how we use various measuring techniques to study the charge transport and injection in organic electronic materials. Understanding charge transport and injection properties in organic solids is of vital importance for improving performance characteristics of organic electronic devices, including organic-light-emitting diodes (OLEDs), photovoltaic cells (OPVs), and field effect transistors (OFETs).

The charge transport properties of amorphous organic materials, commonly used in organic electronic devices, are investigated by the means of carrier mobility measurements. Transient electroluminescence (EL) technique was used to evaluate the electron mobility of an electron transporting material - *tris*(8-hydroxyquinoline) aluminum (Alq_3). The results are in excellent agreement with independent time-of-flight (TOF) measurements. Then, the effect of dopants on electron transport was also examined.

TOF technique was also used to examine the effects of tertiary-butyl (*t*-Bu) substitutions on anthracene derivatives (ADN). All ADN compounds were found to be ambipolar. As the degree of *t*-Bu substitution increases, the carrier mobilities decrease progressively. The reduction of carrier mobilities with increasing *t*-butylation can be attributed to a decrease in the charge-transfer integral or the wavefunction overlap.

In addition, from TOF measurements, two naphthylamine-based hole transporters, namely, N,N'-diphenyl-N,N'-bis(1-naphthyl)(1,1'-biphenyl)-4,4'diamine (NPB) and 4,4',4''-tris(n-(2-naphthyl)-n-phenyl-amino)-triphenylamine (2TNATA) were found to possess electron-transporting (ET) abilities. An organic light-emitting diode that employed NPB as the ET material was demonstrated. The electron conducting mechanism of NPB and 2TNATA in relation to the hopping model will be discussed. Furthermore, the ET property of NPB applied in OLEDs will also be examined.

Besides transient EL and TOF techniques, we also use dark-injection space-charge-limited current (DISCLC) to study the charge injection properties of three phenylamine-based (PA) compounds, MTDATA (4,4’,4’’-Tris(N-3-methylphenyl-N-phenyl-amino)triphenylamine), NPB, and TPD (N,N’-diphenyl-N,N’-bis(3-methyl phenyl) (1,1’-biphenyl)-4,4’diamine).Poly(3,4-ethylenedioxythiophene) doped with polystyrenesulphonic acid (PEDOT:PSS) was used as a hole-injecting anode in current-voltage (*JV*) and DISCLC. Clear DISCLC transient peaks were observed over a wide range of electric fields in all cases. For MTDATA and NPB, hole mobilities evaluated by DI experiments are in excellent agreement with mobilties deduced from TOF technique. It can be concluded that, for the purpose of *JV* and DI experiments, PEDOT:PSS forms an Ohmic contact with MTDATA and a quasi-Ohmic contact with NPB despite the relatively low-lying highest occupied molecular orbital of the later. In the case of TPD, hole injection from PEDOT:PSS deviates substantially from Ohmic injection, leading to a lower than expected DI-extracted hole mobility. Finally, a composite anode will be demonstrated to improve the hole injection efficiency.

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