Preface

The present thesis is focused on rational design and synthesis of \( \pi \)-conjugated donor-acceptor (D-A) type oligomers and polymers. It is organized in six different chapters and a brief discussion on the content of the individual chapter is provided below.

Chapter 1 briefly describes the charge transport properties of organic semiconductors followed by recent development of different organic semiconducting materials mainly for applications in OFET and solar cells have been highlighted.

Chapter 2 explores the synthesis and characterization of two new liquid crystalline, D-A type bithiophene-benzothiazole derivatives. The liquid crystalline properties of the materials have been studied in detail with optical polarizing microscopic images and differential scanning calorimetry and found that these materials possess highly ordered smectic A liquid crystalline phase. Their charge transport properties have also been investigated by fabricating OFET devices.

Chapter 3 describes the photophysical properties and OFET performance of quinoxaline based donors-acceptor-donor (D-A-D) type molecules. Depending on the flexibility and rigidity of the conjugated backbone these materials show liquid crystalline behaviour. Investigation of their OFET performance indicated that these molecules exhibit p-type mobility up to \( 9.7 \times 10^{-4} \) cm\(^2\)V\(^{-1}\)s\(^{-1}\) and on/off ratio of \( 10^4 \).

Chapter 4 investigates excited state properties and OFET behavior of D-A-D type diketopyrrolopyrrole (DPP) derivatives end-capped with alkoxy napthalene group. UV-Visible spectroscopy measurement shows strong intramolecular charge transfer (ICT) between donor and acceptor unit. Steady-state and time-resolved fluorescence measurements confirm the formation of excimer. The excited state interactions, the interchromophore separation and geometry of the molecules influence the extent of excimer formation. Finally, the OFET behavior of these DPP based materials has been studied using different dielectric layers.
Chapter 5 discusses the synthesis, characterization and properties of two new thieno[3,2-b]thiophene-DPP based donor-acceptor (D-A) type low band gap polymers (PTTDPP-BDT and PTTDPP-BZT). Investigation of OFET performance indicated that polymers exhibited ambipolar behaviour with hole mobility upto $1.0 \times 10^{-3} \text{ cm}^2/\text{Vs}$ and electron mobility upto $8 \times 10^{-5} \text{ cm}^2/\text{Vs}$. Using polymer PTTDPP-BDT with electron acceptor C70PCBM, power conversion efficiency (PCE) around 3.26% in bulk heterojunction solar cell has been achieved.

Chapter 6 describes the approach to tailor the energy levels of conjugated polymers (PTDPP-IDT and PTTDPP-IDT) based on Indacenodithiophene (IDT) coupled with DPP moieties. We have studied the photovoltaic performance of these conjugated polymers by blending with PCBM and P3HT. The importance of these materials in polymer/polymer blend solar cell has been emphasized. The photovoltaic devices with polymer/polymer blend solar cell exhibit high open-circuit voltages ($V_{OC}$) of $\sim 0.8$ V.

In summary, the work presented in this thesis describes synthesis, characterization and photophysical properties of new organic semiconductors and their importance in optoelectronic devices. This work also describes a general design principle of nonfullerene organic solar cell. The results described here show that these materials have potential application as active components in plastic electronics.