PREFACE

The foremost examined semiconductors, organic conjugated polymers (OCPs) are very crucial material for their potential application in the subsequent era of electronic devices by a roll-to-roll printing method such as light transmitting diodes, photovoltaics, thin film transistors, etc. The easiness in the transportation of charge carriers inside the OCPs leads to their performance characteristics. Even though within the past two decades extensive research has been carried out by the scientific community to get it the charge transport mechanism in OCPs, agreements have been well set up that the morphology of OCPs in their thin films serves as the prime factor which impacts the device parameter profoundly. The prime reason behind such vast interest in OCPs is the excellent processability and much cost-effectiveness of organic materials, which ultimately leads to the revival of new technology, *i.e.*, polymer electronics or organic electronics. The final investigation with this technology is based on sustainability, reliability, and performance. However, hardly any materials can be found, which qualify over these criterions. From the cost perspective, although the materials cost is surprisingly low, but fabrication and packaging costs may enhance the entire cost of the device. Therefore, the successful application of organic materials will be determined by capturing a low-cost innovative fabrication technique which enables the fabrication of organic devices over large-area substrates.

Apart from the cost issue, the primary concerns are the performance of organic electronic devices. The problems connected with the device performance are further related to the degradability of materials with respect to time and application cycles, stability, and electronic properties, mainly mobility. Nearly all these parameters are directed by the structural order and alignment of the semiconducting polymer molecules/chains compared to the intrinsic electronic properties of the materials itself.

In view of the above concerns, the polymer chain orientation and nanocomposite formations is one of the imperative strategies towards its improved properties in particular applications.

For example, self-assembly of the polymer and/or incorporation of nanosized active particles in a matrix might provide a breakthrough methodology for the enhancement in the properties of resultant materials. As this, self-assembled semiconducting polymers or incorporation of nanosized active particles have segmental electronic traps within the stacks of the polymer chain or its matrix respectively, which results from the favorable charge transport by hopping or band transport.

In the current thesis work, the main objective was to optimize the self-organizing properties of rr-PQT-12-12 and rr-pBTTT-C14 alone and with bio-template via solvent driven method and a comparative junction properties study between these films and Al-metal. Furthermore; work was extended to compare junction properties study between photoactive films (matrix embedded nanosized active particles) and Al-metal. Thus, we have chosen planer polymer for their self-assembly and photoactive materials for their electronic properties (i.e., junction properties).

Finally, the whole research work had been divided into eight chapters in the present thesis. **Chapter-1** includes a brief introduction and detailed literature survey about self-assembly by utilizing different techniques and their role in electronic device performance. This chapter also describes the features of rr-PQT-12/rr-pBTTT-C14 over other derivatives of polythiophene, photoactive materials, and its implications towards charge transport. Several thin films methodologies for polymers have also been incorporated herein with a brief description of spin coating and FTM techniques over other techniques. Different cases of semiconductor-metal interfaces have now been discussed for junction properties and rectification behavior. Finally, how the various electronic parameters might be extracted from the charge transport property is discussed in this chapter.

Chapter-2 presents a short description of fibrous material and photoactive nanocomposite preparation, sample preparation and characterizations by various means like UV-vis spectrometry, Scanning electron microscopy (SEM), transmission electron microscopy (TEM), selected area electron diffraction pattern (SAED), atomic force microscopy(AFM) topography and phase imaging, and finally the device fabrication and charge transport properties measurements of organic material.

Chapter-3 Reports the long-range ordering of regioregular poly [2,5-bis(3-tetradecylthiophen-2-yl)thieno[3,2-b]thiophene], rr-pBTTT-C14 fiber, which is optimized in mixture of good and poor solvent (chloroform + toluene) blend using the idea of solvent driven self-assembly. Here, self-assembly is introduced by ageing accompanied by complete dissolution at elevated temperature in the solvent mixture. UV-visible spectroscopy is used to demonstrate the presence of long-range rr-pBTTT-C14 fibers. The fiber growth and its size are further verified by atomic force microscopy, and HRTEM exemplified that the resultant aggregation of the polymer chain in nanometric range. After that, the change in surface potential of fiber is studied by KPFM. This fibrous polymer is further sandwiched between ITO and Al-metal to study its junction behavior.

Chapter-4 deals with the systematic analysis of self-assembly of regioregular poly (3, 3'"-didodecylquarterthiophene), regioregular (rr)-PQT-12 into fiber form in chloroform by ageing process, time-dependent fiber growth monitoring by UV–vis absorption and justification by atomic force microscopy technique. After that, the existing study continues for better junction properties study based on these fibrous films with Al-metals with respect to unassembled polymers.

Chapter-5 focuses on the development of bio-organic hybrid materials based on hydrophobic DNA complex incorporated in polymer and the study of charge transport properties across the junction formed by sandwiching it between ITO and Al electrodes. The inclusion of hydrophilic DNAs, both natural DNA and synthetic DNA (single strand DNA, ss-DNA and double strand DNA, ds-DNA), in organic semiconducting polymer specially regioregular poly (3, 3‴-didodecylquarterthiophene) (rr-PQT-12), have done in chloroform. Thereafter, the as-mixed solution has been aged to obtain fibrils' growth and used for the fabrication of devices. Various parameters, including rectification ratio, ideality factor, saturation current, barrier height, and device stability, have been measured to study the nature of charge transport and effect of DNAs on the performance of devices.

Chapter-6 reports the facile synthesis of silver (Ag) nanoparticle surface plasmons resonance (SPR) - Poly (3, 3′′′-didodecylquaterthiophene) (rr-PQT-12) coupled nanocomposite and subsequent fabrication of nanocomposite thin film via Floating Film Transfer Method (FTM). The as-deposited thin film of nanocomposite was investigated via spectral characterization, morphological characterization, and structural characterization for confirmation of formation of Ag SPR- rr-PQT-12 coupled nanocomposite thin film. Pristine rr-PQT-12 thin film was also deposited via FTM for comparison. Finally, the photovoltaic property of nanocomposite was examined via fabrication of sandwiched structure ITO/rr-PQT-12-Ag/Al by measuring photo-current using the different wavelength of light and compare with pristine rr-PQT-12.

Chapter-7 presents the facile and efficient method for the hybridization of SnO_2 nanowire with reduced graphene oxide (rGO) nanosheet and subsequent investigation of enhancement in photocurrent of the hybrid material. The morphological properties have been discussed taking into account of atomic force microscopy (AFM), and scanning electron microscopy (SEM). The formation of nano-hybrid materials and structural identities of SnO_2, rGO, and SnO_2/rGO hybrid have been discussed by X-ray diffraction (XRD), FTIR, and UV-Vis spectroscopy. Further, the current-voltage (I-V) characteristics of the as-grown thin film of the hybrid are conducted using cyclic voltammetry (CV) and AFM conducting tip. The metal-semiconductor-metal (MSM) structure is characterized in the dark and in the presence of light.

Chapter-8 presents conclusive remarks of the main findings in our optimized conditions dealt about significant enhancement in charge transport properties along with suggestions for future work.

The lists of references are included at the end.