Summary and conclusions

The materials engineering, especially for the enhancement of device performance, is a crucial stage to meet the criterion for advanced technology. The organic conducting polymers are explored as one of the active materials in this regard. It is nothing but a class of polymers that conducts electronic due to the presence of coplanar loosely bounded delocalized π-electrons system. However, such polymers are lacking from some properties like poor conductivity in sufficiently reduced states, poor processability in common solvents, etc. Therefore to overcome the conductivity issue, the doping process is one of the meaningful choices, but still, this is not an effective way to get the optimal conductivity (up to the mark). The proper alignment of polymer chains is expected to be a good strategy for improved conductivity nowadays. As in this technique, the long-range interchain hopping predominates along with as usual intrachain hopping. The molecular planarity of the polymers plays a significant role in its orientation, which results from the regioregularity of the same.

In the view of better processability in the common solvents, the introduction of the long alkyl chain is a mandatory criterion. Thiophene-based Regioregular polymers like rr-P3HT, rr-PQT-12, and rr-pBTTT-C14 satisfies such benchmarks. Due to chain rigidity, rr-PQT-12 and rr-pBTTT-C14 might have better transport properties than that of rr-P3HT. For the same reason, this thesis work is mainly focused on rr-PQT-12 and rr-pBTTT-C14. There exist several strategies for the orientation of these plane polymers which includes ageing, marginal solvent driven self-assembly, pressure dependent assembly, evaporation of the solvent, orientation through rubbing, orientation through FTM (over lyophilic substrate), LB/ LS methods, etc. In all these techniques one isolated polymer behaves as the template for others.

Among these, ageing and solvent (marginal) driven self-assembly are much easier, low cost and doesn't require the sophisticated labs. Polymer packing via self- assembly resembles three types of orientations on the desired substrate *viz.* edge-on, face-on, and end-on. In the case of end-on, assembly occurs along the alkyl groups. Face-on resembles the assembly along planer thiophene rings. Similarly, in end-on, assembly takes place through the conjugation length of polymers. Among these stated assemblies, face-on is much favorable orientation towards the charge transport phenomenon in case of vertical diodes, while edge-on orientation is much desirable in the case of OFETs.

Apart from the concept of chain assembly in polymeric chains, incorporation of foreign conducting materials can be other effective option to enhance the charge transport properties. This is due to the formation of conducting chunks that favors charge transport through interdomain hopping process.

Present thesis work comprises the optimization of rr-pBTTT-C14, rr-PQT-12, and GC rich DNA templated rr-PQT-12 for it's self-assembly into fibers and study of its charge transport properties by making polymer/metal interface.

The optimized time for rr-pBTTT-C14 fiber (dia=11 nm) formation is 17 minutes for concentration of 0.005% w/v in solvent mixture of chloroform and toluene in 9:1 ratio v/v. The device based on fibrous rr-pBTTT -C14 exhibits ~9 times higher mobility and ~6.5 times higher forward current density than its isolated analogue.

The optimized time for rr-PQT-12 fiber (dia=~10 nm) formation is 45 minutes for concentration of 0.125% w/v in chloroform solvent. The device based on fibrous rr-PQT-12

exhibits ~8 times higher mobility and ~10 times higher forward current density than its isolated analogue.

In the case of DNA templated rr-PQT-12 fibers, the optimized concentration of GC rich ss-/ds-DNA is 200μM in fixed amount of rr-PQT-12 solution that is able to exhibit better charge conduction than its counterparts. Though, the surface of DNA is hydrophilic in nature but can be made it hydrophobic by interacting with DDAB salt. Herein, positively charged end of DDAB is able to interact with negatively charged phosphate group of DNAs and leaving outside a long hydrophobic alkyl chain. Both GC rich ss- and ds- DNA exhibits better charge transport properties than natural DNA and pristine rr-PQT-12 fibers.

GC rich content favors the carrier transport via hopping under the influence of electron donor rr-PQT-12 (hot carrier injection phenomenon). Here GC-rich ds-DNA/rr-PQT-12 exhibit better charge transport properties than its counterparts due to better rigidity of ds-DNA and hot carrier injection in DNA by the polymer.

Apart from this, thesis work also includes the incorporation stabilized Ag NPs into the rr-PQT-12 matrix and incorporation of rGO into the fibrous SnO2 for the study of its photoactive properties.

Incorporation of stabilized AgNPs in rr-PQT-12 solution (0.5 % w/v) is responsible for 20 % enhancement of photocurrent with respect to that of pristine rr-PQT-12 and 70 % enhancement in photocurrent as compared to its dark current when making contact with ITO by FTM technique. This is expected due to the formation of metal NPs plasmonic effect (SPR)

Similarly, incorporation of reduced graphene oxide in fibrous SnO_2 (dia=10nm) and making the sandwich configuration between Al metals (like MSM), exhibits 10^2 orders enhancement in the photocurrent (under the illumination of blue light) as compared to its dark current. This is due to the synergic charge transfer via. rGO from SnO_2 after illumination. This hybrid material is proposed for short wavelength photodetector.

Suggestions for future work

- There may be a possibility to compare the extent of the rigidness of rr-PQT-12 and rr-pBTTT-C14 polymer backbones towards charge transport by taking the polymers with almost same molecular weight. Consequently, it may be an effective work to conclude the transport effect.
- It will be an excellent opportunity to extend the same optimized work for the charge transport properties by the fabrication of OFETs.
- The similar optimization/ composite formation may be done with n-type polymers to have better anisotropy in charge transport.
- The optimized incorporation of metal NPs may create a better platform to explore the photoactive properties in polymer with fibrous morphology.
- The optimized incorporation of rGO in rr-PQT-12 and rr-pBTTT-C14 fibers may be an effective choice to uplift the transport properties than fibrous analogue.