CHAPTER-6

SUMMARY
6.1 Summary

Polymer based semiconductor filled nanocomposites have emerged as the most demanding desired systems with wide range of applications extending from electronics, optoelectronics to medical industry. Recently attention has been focused on the synthesis of PNs with semiconductor fillers with their uniform and homogenous dispersion via chemical bondage in polymer matrix in order to transform the final PNs having beneficial properties. Typically, applications of PNs related to PSAN/ZnO PNs includes stability against UV light with UV blocking ability, food packaging with antibacterial activity, surface cleaning, design of thermally stable medical equipments etc. Among various synthesis techniques that have been employed for synthesis of low cost PNs, emulsion based polymerization has been found as the best method.

The first chapter consist of introduction related to polymer, polystyrene, polyacrylonitrile and copolymer of PS and PAN i.e. PSAN. This chapter also includes literature survey pertaining to different fillers including ZnO and different polymers focusing on PSAN based PNs.

The second chapter has the detailed synthesis procedure of Ag doped ZnO NPs and PSAN/ZnO PNs. This chapter also includes details of different characterization techniques/instruments used in present study with their working and principles. Different techniques named as XRD, FESEM, TEM, UV-Vis., TGA, DSC, FTIR, EDAX, WCA, Zeta sizer have been used to study and explore the synthesized materials.

The chapter 3 reported the study of different properties of silver doped ZnO NPs which is synthesized through co-precipitation method. The structural purity of synthesized ZnO NPs has been confirmed by XRD technique. The crystallite size changed from 46.67 nm to 54.80 nm and lattice strain changed from 23.90 x10^{-4} to 22.36 x 10^{-4} for pure ZnO to maximum silver doped ZnO NPs respectively. XRD, EDAX and UV-Visible spectroscopy studies have indicated the presence of silver in ZnO matrix. The dye degradation capabilities of different silver doped ZnO NPs have been studied under visible light exposure. The % degradation efficiency for ZnOAg0, ZnOAg1, ZnOAg2, ZnOAg3 and ZnOAg4 of MB increased from 41.55 to 96.78, 43.70 to 97.59, 44.24 to 97.72, 44.77 to 97.83, and 45.58 to 98.66 % respectively. Similar trend has been observed for BB dye also. The initial degradation efficiency of MB have slow propagation due to + I effect by –CH₃ on its structure. Further, with increase in reaction time of dye and
photocatalyst, the MB degradation efficiency increases in comparison to BB dye because of less chromophoric sites. Finally, the silver doped ZnO NPs synthesized by co-precipitation method has been proposed as useful, economical with effective application based treatment of polluted water coming from textile, pharmaceutical industry etc.

The chapter 4 covers the second objective of the work based on the characterization of PSAN/ZnO PNs by insitu emulsion polymerization. The different properties have been explored including structural, morphological and thermal properties. The effective dispersion of ZnO in polymer matrix has been confirmed by SEM, EDAX and TEM study. The alteration in the -CN vibration of PSAN with ZnO incorporation established the chemical bondage of ZnO with PSAN. The presence of ZnO diffraction peaks in PSAN matrix clearly follows their effective incorporation and presence in polymer matrix. The elemental presence of zinc in polymer matrix in addition to other elements (C, H, N, S, and O) has been confirmed by EDAX study. Crystallization temperature $T_c(\degree C)$ shift towards higher value (by 7.3$\degree C$) with ZnO addition due to nucleating ability of nanoparticles. The value of $T_{max}(\degree C)$ was also found to increase by 29.8$\degree C$ with respect to PSAN. With the increase in oxygen index (OI) of PNs from 35 to 36.5 % with incorporation of ZnO in polymer matrix, they can be used as a fire retardant. Thus, the improved thermal stability of PSAN/ZnO with flexibility can be utilized in medical industry (scissor, forceps, microgrips etc.).

Chapter 5 comprises of the study of structural, optical, luminescence, morphological, colloidal stability and surface wettability properties of PSAN/ZnO PNs. The UV absorption edge shifted to 375 nm (PSAN10) from 305 nm (PSAN) with content of ZnO from 0.5 wt % to 10 wt % respectively. The $E_{opt}$ get tuned from 5.84 eV to 4.44 eV for direct transition and 5.83 eV to 4.47 eV for possible indirect transition respectively. The effective emissive ability of PNs at 422, 460 and 522 nm has been proposed for luminescence based applications. The elemental presence in PNs has been established using EDAX and its mapping mode. The conversion of hydrophilic (WCA=70$\degree$) to super-hydrophilic surfaces of PNs (WCA=10$\degree$) is attributed to increased roughness and zeta potential. Conclusively, PSAN/ZnO PNs UV shielding, luminescence and super-hydrophilic features can be utilized in UV blocking, antifogging and antifouling based applications in different devices.
6.2 Future scope

Future studies may be carried out to complete the understanding of the effect of filler (ZnO) on the PSAN polymer matrix in term of mechanical properties. The mechanical properties of PSAN PNs are important in respect to strength, flexibility, design and fabrication of different products of PSAN PNs. Further the synthesis of PSAN/Ag doped ZnO PNs may also be considered as these are important in antibacterial and photocatalytic applications. To understand the behavior of PSAN copolymer completely, one needs to study the effect of variation in monomers (styrene & acrylonitrile) ratio to the properties of PSAN/ZnO PNs.

Main points for future research on these materials are:

- To study the mechanical properties of PSAN/ZnO PNs
- Synthesis of PSAN/Ag doped ZnO PNs by in situ emulsion polymerization for photocatalytic and antibacterial applications.
- To study the effect of variation in monomer ratio to properties of PNs with synthesis of PSAN/ZnO PNs (1:1 ratio of styrene and acrylonitrile monomer) by in situ emulsion polymerization.
- To study the electrical properties of PSAN PNs for electronic devices.