6.1 Summary

Nanocomposites are a special class of materials originating from suitable combinations of two or more such nanoparticles or nanosized objects in some suitable technique, resulting in materials having unique physical properties and wide application potential in diverse areas. Novel properties of nanocomposites can be derived from the successful combination of the characteristics of parent constituents into a single material. Materials scientists very often handle such nanocomposites, which are an effective combination of two or more inorganic nanoparticles. To exploit the full potential of the technological applications of the nanomaterials, it is very important to endow them with good processability which has ultimately guided scientists toward using conventional polymers as one component of the nanocomposites, resulting in a special class of hybrid materials termed “polymeric nanocomposites”. These materials are also intimate combinations (up to almost molecular level) of one or more inorganic nanoparticles with a polymer so that unique properties of the former can be taken together with the existing qualities of the latter. Polymers possessing high electrical conductivity are also referred as synthetic metals or conducting polymers which offer a lot of advantages over the metals. These newly developed materials will not only replace metals in many areas, but also infiltrated our day-to-day life with a wide range of products extending from most common consumer goods like batteries to highly specialized applications in space and aeronautics. Apart from these, the chemical properties of conducting polymers make them very useful for use in sensors.

Among conducting polymers, polyaniline has drawn considerable attention due to its high conductivity, simple preparation, stability and good mechanical and electrochemical properties. Extensive literature review suggests that the considerable efforts have been made by researchers
all over the world in improving the conductivity of Polyaniline by various doping techniques,. It has also been noted through literature survey that the studies on sensing properties of Polyaniline composites is scarce. To suggest any material to be used as a potential candidate for technological applications, it is essential for researchers to undertake basic studies governing electrical and sensing properties of such materials. Hence through this work, author has made an attempt to tailor various electric and sensing properties of Polyaniline by selecting appropriate materials as composites with polyaniline.

**The important outcome of the present work is summarized as follows:**

- In the present study, the author has successfully synthesized the conducting polymer, Polyaniline and the metal oxides such as Nickel Oxide, Iron Oxide, Zinc Oxide, and Zinc Ferrite. The prepared nanoparticles are used to synthesize composites with Polyaniline in various weight percentages (10 to 50 wt%). Through various characterization techniques employed in these composites, it is noticed that

- X-ray diffraction pattern of pure Polyaniline suggests that it has amorphous nature with a broad peak centered at about $2\theta = 25.53^\circ$, whereas a well ordered crystallinity in metal oxide and in composites are observed.

- IR spectra confirm the homogeneous mixing of Nickel Oxide, Iron Oxide, Zinc Oxide, and Zinc Ferrite in Polyaniline. The characteristic stretching frequencies are shifted towards higher frequency side which indicates the homogeneous distribution of Nickel Oxide, Iron Oxide, Zinc Oxide, Zinc Ferrite particles in the polymeric chain. This may be attributed due to the Van der Waal’s interaction between polymeric chain and the oxides respectively.
SEM micrographs show the presence of micro crystallinity in Polyaniline and transformation from a branched pattern to highly granular structure of Nickel Oxide, Iron Oxide, Zinc Oxide, Zinc Ferrite in Polyaniline.

From the studies made on various electrical properties, it is observed that both dc and ac conductivities carried over Polyaniline and its nanocomposites show the presence of polarons as charge carriers and confirms the extended chain length of Polyaniline.

From the LPG sensing studies it seen that there is almost linear behavior of Nickel Oxide, Iron Oxide, Zinc Oxide, Zinc Ferrite in Polyaniline to the broad range of concentration of LPG and this proves to be the promising materials as LPG sensors.

6.2 Possible Applications

- On the basis of results of electrical and sensing properties, so obtained in Polyaniline/ZnO composites, they are preferred for applications involving electrical properties and are especially used as gas sensors.
- Polyaniline-metal oxide composites can be utilized in the fabrication of capacitors in high electrical circuits.

6.3 Challenges in Sensor Research

- The search and selection of proper materials, as well as improved and novel recognition mechanisms necessary for instant identification of a target component and the mechanism to create the signal that will be obtained from the sensor.
- The development of new materials for use as matrices to effectively immobilize receptor molecules to obtain stable and reproducible sensor function, including new polymers.
- The development of solid-state versions of pH and ion-selective sensors.
- Novel sensor substrates and internal electrodes for new planar fabrication designsto facilitate the use of advanced fabrication for automated sensor manufacturing.

6.4 Scope of Future Work

The author has studied the nano samples of these composites in the present study and is interested to undertake studies on these composites in the form of thin films. As a continuation of this work, the author also wishes to develop and fabricate the toxic gas sensor device using nano composites in the near future.