ABSTRACT

In recent years, the low carbon economy of sustainable and renewable resources has become a great challenge due to climate change and the decreasing availability of fossil fuels. It is now essential to develop new, low-cost, and eco-friendly energy conversion and storage systems. Advances have already been made in energy storage which includes supercapacitor. Conducting polymers (CPs) such as polyaniline, polypyrrole, polythiophene, poly (3,4-ethylenedioxythiophene, PEDOT) etc. are the important electrode materials for pseudocapacitors. The CP nanostructures are expected to display improved performance in technological application because of the unique properties. Material chemists are attempting to design and synthesize nanostructures of CPs to realize high electrochemical performance.

Recently, PANI in the form of different nanostructures has attracted more attention as an excellent material for supercapacitor irrespective of its stability. However, the stability and electrochemical activity of PANI is very low, which needs further attention. Owing to the issue of stability and electrochemical activity of PANI, several other materials have been investigated for supercapacitor. Particularly, transition metal oxides – PANI NCs have been attempted which are more suitable material for supercapacitor than PANI alone. PANI NCs can be prepared by simply blending of polymers and other materials in the form of metal, oxides, sulphides etc. As mentioned earlier, PANI is an excellent material for supercapacitor but the PANI–other material nanocomposite is still in embryonic stage. Some transition metal oxides, such as ruthenium oxide (RuO₂), iridium oxide (IrO₂), magnese oxide (MnO₂), nickel oxide(NiO), tin oxide (SnO₂), iron oxide (Fe₂O₃), copper oxide (CuO), tungsten oxide (WO₃), vanadium pentaoxide (V₂O₅), titanium oxide (TiO₂) exhibits excellent properties as pseudocapacitive electrode materials. Nanoparticles of transition metal sulfides based polyaniline nanocomposites also been reported. Molybdenum sulfide (MoS₂), tungsten sulphide(WS₂), silver sulphide(Ag₂S) and vanadium sulphide (VS₂) etc., have been successfully established as a new paradigm for supercapacitor.

At the moment, along with metal oxides and metal sulfides, graphene oxide, reduced graphene oxide (RGO) has also been reported as an excellent material for supercapacitor. The stability is the major drawback of polyaniline for supercapacitor.
applications. The preparation and use of metal/ metal oxide/ metal sulfide/ reduced graphene oxide – polyaniline nanocomposites for supercapacitor applications are at primary levels.

**The objective behind the work:** Development of novel metal oxide, metal sulfide, graphene oxide, reduced graphene oxide - polyaniline NCs with modified properties via *in-situ* polymerization which can give rise to stability for polyaniline.

Considering the properties of metal/ metal oxides / metal sulfides/ reduced graphene oxide –polyaniline nanocomposites, we have attempted the synthesis of $\beta$ AgVO$_3$-polyaniline,Ag$_2$V$_2$S$_4$-polyaniline, reduced graphene oxide- polyaniline and lithium vanadium oxide- silver nanocomposites which are tested for supercapacitor and some of them are also tested for humidity sensing.

The work presented in the thesis is comprises of Five chapters, the outline of each chapter is briefly described below:

Chapter 1 consists of brief review and overall introduction about conducting polymers and its nanocomposites. However, special emphasis has been given on PANI based nanocomposite, its synthesis, characterization and multifunctional applications. The testing of different morphology of PANI for supercapacitor along with metal oxide-PANI nanocomposite, metal sulphide-PANI nanocomposite, RGO-PANI nanocomposite along with metal oxide - metal nanocomposite. Review on different techniques used for synthesis of PANI, metal oxide, metal, metal sulphide, RGO and their nanocomposite with PANI is presented in this chapter. A synthesis review on metal oxide-metal nanocomposite also been presented. The brief review on electrochemical performance of such reported nanocomposite and metal oxide - metal nanocomposite is also given in this chapter. The chapter is concluded by the motivation, novelty and scope of the work presented in the thesis.

Chapter 2 describes the experimental part of the work. In this chapter, we have presented the synthesis methods of PANI, PANI nanofibers, silver vanadium oxide (AgVO$_3$,SVO) nanostructures, hierarchical reduced graphene oxide, nanocomposites of reduced graphene oxide- PANI, SVO-PANI, silver vanadium sulphide (SVS) - PANI and lithium vanadium oxide-silver by *in-situ* polymerization method and hydrothermal treatments. Synthesis of lithium vanadium oxide-silver (LiV$_2$O$_5$-Ag) nanocomposite by hydrothermal treatment is also included in this chapter. The details about the characterization techniques also presented in this chapter.

Chapter 3 comprises synthesis of PANI nanostructures via *in-situ* polymerization followed by hydrothermal treatment and in particular characterizations of SVO-PANI
nanocomposites, SVS-PANI nanocomposite synthesis of graphene oxide, reduced graphene oxide-PANI nanocomposite by *in-situ* polymerization has also been presented in this chapter. The characterization of all these materials have been carried out by various physico-chemical techniques described in chapter 2.

Chapter 4 deals with the applications of as synthesized nanocomposites. The nanocomposites are tested for supercapacitor and humidity sensor. We have tabulated the results of PANI nanostructures, different nanocomposites with respect to electrochemical performances and conductivity by which we have presented the suitability of materials for supercapacitor. Chapter 5 presents an overall summary of the work reported in the thesis along with important results and conclusions.

By using such avenue of polyaniline based nanocomposite for supercapacitor, we planned to do further work in polyethylene dioxythiophene (PEDOT) based nanocomposites.