Preface

This thesis titled as ***"Polymers functionalized porphyrin and carbon materials for electrochemical applications***" consists of two major research topics *viz.* modification of carbon materials with polyindole and polyaniline and polyindole-Porphyrin hybrid material for electrochemical application. In either case of study, we tried to improve the electrochemical performance of our as-designed materials both under potentiostatic and potentiodynamic conditions. In general, hybrid materials having huge charge storage properties have attracted considerable attention in both industries and academia as electrochemical energy storage, sensors, catalysis, electronics, optoelectronics fields, memory back-up systems, industrial power, and energy management due to their multifunctional performance under the given service condition. Particularly, the performance of supercapacitors (SCs) is strongly dependent on electrochemical characteristics of electrode materials and an appropriate electrolyte. Hence, enormous research efforts have been dedicated to the development of novel electrode materials to achieve enhanced performance. SCs are classified into three types based on their different storage mechanism i.e. electric double-layer capacitors (EDLC), Pseudocapacitor (PC) and Hybrid capacitors (HCs). EDLC achieves capacitance due to accumulation of electrostatic charge on the electrode-electrolyte surface and strongly dependent on the surface of the electrode material available to electrolyte ions. Carbon-based materials are often used as electrode material for EDLC, but provide unsatisfactory energy density due to their limited interface area towards electrolyte. PC used metal oxides and conducting polymers electrode materials and store charges via a faradaic process involving the charge transfer between the electrode and electrolytes. Though the capacitance is higher in PC relative to EDLC, but the power performance is low. These electrodes swell and shrink during the charge/discharge cycling causes poor mechanical stability and cycle life. Both of these SCs have some merits and demerits, so hybrid capacitors coupled both of these in three different ways to achieve better performance. Based on the coupling and designing of EDLC and PC, HCs are classified into three types: (1) Composite, (2) Asymmetric and (3) Battery-type. Among these, composite HCs became the main research hub of the scientific community nowadays to discover novel electrode material with enhanced electrochemical properties (i.e. high gravimetric and volumetric capacitance). In above contexts, there are various kinds of nanomaterials including metal nanoparticles (NPs), carbon-based nanomaterials, graphene (GR), quantum dots (QDs), carbon nanotubes (CNTs), nitride based composites and polymeric nanoparticles has been widely accepted. Apart from these, bio-wastes are now introduced since the few years back and considered as good source of porous carbon with low costs and became excellent candidate for electrochemical SCs among most of the researchers. They are coupling carbonic material with redox active components in order to get synergistically improved materials having optimal performance. In the present investigations, we proposed a low costs procedure(s) in order to get improved binary HCs electrode materials having customized architectures by incorporating conducting polymers (polyindole, PIn and polyaniline, PAni) in some carbon-based materials (graphitic C_3N_4, activated carbon derived from bio-wastes) and metal activated porphyrin molecule for huge charge storage application. Thus whole work is divided into seven chapters as described below:

Chapter 1 elaborates brief introduction about carbon materials, porphyrin and conducting polymers along with its hybrids materials particularly used in electrochemical applications. This chapter also explains about importance of modification of such materials and their effects on electrochemistry, some important literature survey directly related to present work, research gaps and motivations.

Chapter 2 describes brief information about instruments that we did for our research work. Herein, it includes working principle and instrument application that we directly used in our case of study.

Chapter 3 deals with about the utilization of PIn to functionalized g-C_3N_4 surface *via* a simple one-step *in-situ* chemical polymerization of indole monomer with APS oxidant in presence of g-C_3N_4. It includes optimization of g-C_3N_4-PIn hybrid formation along with PIn and g-C_3N_4 alone too. This chapter explains about the structural and morphological results and discussion of all as-synthesized materials. It also explains about the excellencies of fraction 1:2:: g-C3N4:PIn hybrid towards charge storage application over other fractions of g-C_3N_4-PIn hybrid and individual components.

Chapter 4 deals with the optimization of highly porous and electro active carbon material from *Eichhorniacrassipes* plants by using pyrolysis method along with structural, morphological, thermal and electrochemical discussions. It also explains about the excellencies of ECC 800 towards better charge storage application over other counterparts.

Chapters 5 highlights about the synthesis procedure of PAni in presence of oxidized activated carbon (as explained in chapter 4) using APS and also deals with the study of these as-synthesized materials for structural, morphological and electrochemical properties. This chapter also explains about the marginal increment in their specific capacitance of as-optimized hybrid material from 569.4 F/g to 1542.84F/g due to the presence of conducting PAni.

Chapter 6 deals with PIn functionlization with iron inserted-octaethylporphyrin and used as active material for enhanced electrochemical properties and better junction behavioral when making a sandwich between ITO and Al-metal. This chapter gives an idea about new and facile strategy for Fe insertion in OEP central core surface first and then synthesis of PIn in presence of Fe inserted OEP.

Chapter7 summarizes a conclusion of the thesis work and some suggestions for future work.