PREFACE

The primary objective of the thesis is to develop graphene oxide-polyaniline-bimetallic oxide based supercapacitor electrodes for energy storage applications.

Energy is becoming more and more in demand, as well as being consumed. From our homes to our workplaces, electrical energy has become a necessary component of daily life. The overuse of non-renewable resources for energy production, such as coal, petroleum, natural gas, etc., is causing their depletion and contributing to global warming. As a result, the focus has turned to environmentally benign renewable energy sources including solar energy, wind energy, tidal energy, hydropower, biomass energy, etc. The production is hampered by the seasonality and irregularity of some renewable resources. In order to store all the energy produced by renewable sources, there is now a greater need for energy storage technology. Currently available energy storage devices include conventional capacitors, batteries, and supercapacitors. Conventional capacitors have a very poor energy density. Batteries are devices with a high energy density and a low power density. They also have a very short cycle life. Supercapacitors have more power density, cycle life, and energy density than capacitors. They fill the gap between batteries and conventional capacitors.

To make supercapacitor electrodes, several carbon-based, conducting polymers, and metal oxide materials are employed. Redox transitions are the basis for the charge storage mechanism in metal oxides and conducting polymers. They have a higher energy density than carbon-based materials because of redox processes, but their cycle life is poor because of the sudden volumetric shift that occurs when charging and discharging. Electrostatic adsorption allows carbon-based materials to hold a charge; as a result, they have a better power density and cycle life than conducting polymers and metal oxides. So, a ternary hybrid system of carbon based-conducting polymer-metal oxide material was prepared to get the benefits of the individual systems. Graphene oxide was taken as the source of carbon-based material. Polyaniline was taken as the source of conducting polymer as it provides excellent electrochemical activity due to π-conjugation. Bimetallic oxides ($CuCo_2O_4$, $CuFe_2O_4$, $CoFe_2O_4$) were synthesized, which provided multiple oxidation states due to the presence of two metals. Very limited work has been done on bimetallic oxides, graphene oxide, and ternary composites. The main objective of the current work is to synthesize graphene oxide-based hybrid ternary composites and use them as supercapacitor electrodes. The primary objective is to increase the specific energy and cycle life of energy storage devices. Various electrochemical characterizations were done to observe the electrochemical activities of the systems.

The current study has been divided into **6 chapters**. **Chapter 1** contains an introduction about supercapacitors and their classifications along with the materials used in synthesizing supercapacitor type systems. **Chapter 2** consists of a literature review on various configurations and materials used in supercapacitors, the research gap, and the objective of the research work. **Chapter 3** deals with the materials, methods, and various characterization techniques used during the research. **Chapter 4** compares between electrochemical properties of graphene oxide-based single, binary, and ternary systems have been done. The ternary composite (graphene oxide-polyaniline-copper cobaltite) based supercapacitor electrodes show outstanding electrochemical performances. It exhibited the highest specific energy of 62.54 Wh/kg. **Chapter 5** compare all the ternary system's structural and electrochemical properties of graphene oxide-polyaniline-copper cobaltite

($GO/PANI/CuCo_2O_4$), graphene oxide-polyaniline-copper ferrite ($GO/PANI/CuFe_2O_4$), and graphene oxide-polyaniline-cobalt ferrite ($GO/PANI/CoFe_2O_4$) for supercapacitor electrodes. The summary and scope of the future work have been described in **chapter 6**.