Recently graphene has acquired an important place in material research and is being explored for its use in various areas of science and technology. One–atom–thick layer of carbon has excellent properties like extreme mechanical strength, exceptionally high electronic and thermal conductivity, impermeability to gases and many other extraordinary properties. However, graphene has not yet fulfilled the expectations for its commercial exploitation due to difficulties in its synthesis and poor dispersing behavior. One of the aims of research presented in this thesis is to carry out the dispersing studies of functionalized graphene oxide (GO). Functionalization results in the improvement of the dispersion behavior along with its thermal and electrical properties. Electrical properties have been studied as a function of temperature. It has been found that electrical behavior of functionalized graphene oxide is better than GO. The functionalized GO has been used for detection of humidity and hydrogen sulphide gas. Another objective of research work is to investigate photocatalytic properties of metal oxides (TiO$_2$ and ZrO$_2$) used for removal of various types of dyes from water. Metal oxide/graphene composites have been successfully synthesized by chemical method and analyzed as a photocatalyst. The present investigation in this thesis certainly will contribute to fill the gap to some extent in exploring the functionalization and its role in photocatalysis process.

**Layout of thesis**

The thesis has been divided in to six chapters for the following tasks:

1. To synthesize high quality graphene oxide and reduced graphene oxide using a cost effective chemical and thermal method.
2. To synthesize amide functionalization graphene oxide to study thermal and dispersion behavior.
3. Thin film preparation of graphene oxide and amide functionalized graphene oxide to investigate the structural and electrical properties.
4. To study response of GO and amide functionalization graphene oxide towards humidity and hydrogen sulfide gas.
5. To synthesize TiO$_2$/graphene and ZrO$_2$/graphene composites to explore their structural and thermal properties.
6. To explore the applications of synthesized metal oxide/graphene composites for degradation of dyes.

The description of various chapters is as follows:

**Chapter 1:** This chapter covers the general introduction and motivation toward graphene. It elucidates the properties, different synthesis methods and applications of graphene. The functionalization and its types have been described. A brief introduction of photocatalysis process has been included. The scope and objectives of the present research work has been discussed.

**Chapter 2:** A brief review of work carried out by different researchers on graphene is presented in this chapter. The chapter describes the covalent functionalization and its types. The traditional methods used to eliminate the dyes have been discussed. It includes the general introduction of different dyes and their side effects. The effect of graphene concentration, pH, oxygen and catalyst concentration on photocatalysis process have been demonstrated. It also includes detailed literature review of metal oxide/graphene composites and their application in removal of different dyes. The general properties, structure, types, synthesis method, applications of TiO$_2$ and ZrO$_2$ have been included.

**Chapter 3:** This chapter describes the synthesis route of graphene oxide and graphene. It demonstrates the effect of oxidation on the interlayer distance of graphite. The various types of functional groups, charge, composition of elements, morphology of GO and reduced graphene oxide has been determined by using different characterization techniques. Dispersion behavior of graphene oxide and reduced graphene oxide has also been studied.

**Chapter 4:** The amide functionalization of graphene oxide by using different amine at room temperature has been explained. FTIR studies have been carried out to found the success of functionalization. The effect of functionalization on chemical composition has been determined by EDX spectroscopy. The thermal properties of amide functionalized GO has been included. To study electrical behavior of amide functionalized GO the films has been prepared on SiO$_2$/Si substrate and variation in sheet resistance as a function of temperature was studied. Hydrogen sulfide gas and humidity sensor of GO and amide functionalized graphene oxide has also been described.

**Chapter 5:** This chapter describes the photocatalytic degradation of methyl orange, methylene blue and rhodamine B dyes from water. It has been divided in to two sections.
First section describes the synthesis and characterization of TiO$_2$ and TiO$_2$/reduced graphene oxide (TiO$_2$/GR) composite. Further, TiO$_2$ and TiO$_2$/GR composites have been used as photocatalyst to remove methyl orange dye from water using photocatalysis process. The synthesis method of ZrO$_2$ and ZrO$_2$/reduced graphene oxide (ZrO$_2$/GR) composites has been discussed in section B. Characterization required for photocatalytic analysis of these composites in the removal of methyl orange, methylene blue and rhodamine B from water has been discussed. The photocatalytic performance of various catalysts with varying parameters like pH, amount of catalyst, GR concentration in composite have been included.

**Chapter 6:** This chapter highlights the essence of the complete study undertaken in the present research work. It includes the important conclusion and future aspects for investigations on the basis of the author’s experiences obtained during the research work.