# Chapter 7

# Conclusions

This thesis describes the synthesis of reduced graphene oxide and reduced graphene oxide-based nanocomposite materials. The literature review helpful to a guide about the synthesis, properties, application of reduced graphene oxide and its composites. The sol-gel method, two-step method were used for the fabrication of rGO-ZnO composites. The structural morphology of ZnO exhibits a variable morphology, and their distribution and aggregation on the GO plane have also been investigated. The optical properties of nanocomposites photocatalytic materials have been studied. The degradation behaviour of organic pollutant with synthesized photocatalyst materials has also been tested. Furthermore, the recent progress in rGO-ZnO composites for photocatalytic applications are also reviewed, focusing on the lotus-like, columnar-like structure morphology of ZnO with rGO nanocomposites and also focusing hexagonal plate-like structure morphology of ZnO. However, there is a long way to go before the fabrication of rGO-ZnO composites can meet the requirements of industrial applications. In furtherance of this goal, we present our research work on an innovative rGO-ZnO composite material with excellent photocatalytic properties for degradation of organic pollutant application. Firstly, the innovative, improved synthesis process of modified graphene oxide using chemical modification and centrifugation to reduce the number of GO layers has successfully produced. The reduced layer of GO sheets, which provides the opportunity to determine the structure and distribution of lotus-like, columnar-like structure morphology of ZnO into layers of the rGO or on the rGO plane. Secondly, a better understanding has been achieved by imaging GO, and rGO-ZnO samples with a variety of characterization methods such as, XRD, SEM, TEM, HRTEM, Raman, and Uv-

visible spectroscopy. The reduced structure of GO produced by the innovative chemical modification process has been confirmed by Raman spectroscopy. The distribution and controlled lotus-likee, columnar- like the morphological structure of ZnO synthesized with the presence of rGO have been characterized with SEM, HRTEM, and Raman spectroscopy. The morphology of ZnO having a nano-sized range which is confirmed by SEM and HRTEM.

In the fourth chapter, controlled lotus-like ZnO morphology in the temperature range of 700C to 900C with rGO has been successfully synthesized by the sol-gel method. These composites further utilized for a photocatalytic application for degradation of phenol. The results would have significant consequences in the photocatalytic removal of phenol due to lotus-like ZnO morphology.

In the fifth chapter, columnar- like ZnO morphology at pH~6 have been successfully synthesized by a two-step method. This composite further utilized for a photocatalytic application for degradation of natural dye. The results would have significant consequences to confirm that the morphology of the material has influenced the absorption and photocatalytic activity of natural dye under sunlight irradiation.

In the six-chapter hexagonal pate like-ZnO morphology at room temperature has been successfully synthesized by sol-gel method. The effect of different annealing temperature $700^0$C, $900^0$C, and $1100^0$C on the hexagonal plate-like morphology with constant heating rate has been investigated by characterization technique. The results would have significant consequences to confirm that annealing temperature alters the morphology of ZnO that have influenced the optical and dielectric properties.

***Scope of the future work***

In this thesis, the reduction of GO and its photocatalytic application with ZnO nanoceramic particles has been discussed. However, it is challenging to the complete reduction of GO due to

the chemistry and structure of GO. Therefore, further, it should focus the future investigation on the reduction method of rGO and controllable oxygen functional group of rGO for specific applications. For enhancing the photocatalytic properties of ZnO, it can be used for rGO based nanocomposites. The excellent catalytic performance of rGO-ZnO based nanocomposites have been frequently noted but, more work in the future is required for a better understanding of the structural morphology of ZnO for application in degradation of organic pollutant. The future project is to investigate and develop improved materials to address the above limitations of the photocatalyst.