CHAPTER VI

CONCLUSION AND SCOPE FOR THE FUTURE WORK

General Conclusion

The present research work addresses the preparation of tailor made novel supported photocatalytic composites by using the hydrothermal technique with desired qualities. This thesis directs about the importance of hydrothermally prepared novel supported photocatalytic composites in photocatalytic applications and their suitability by means of photodegradation efficiency of organic pollutants. The primary outcome from this work can be summarized as follows:

- Highly active photocatalysts like TiO$_2$ and ZnO were effectively deposited onto calcium alumino-silicate beads supports (CASB) under mild hydrothermal conditions in a single step without involving multiple or post-treatments like high temperature calcinations, sintering or drying.
- The phase compositions, specific surface area, pore volume, pore size distribution, low density, and surface roughness of CASB promise for the effective deposition/immobilization of photocatalysts.
- Mild hydrothermal temperature (< 250°C) and short duration (< 48 hrs) of experimental runs are beneficial for promoting and preparation of highly active novel supported photocatalytic composites with desired properties like crystalline phase, surface morphologies, porosity and microstructures.
- Simple, handy, corrosive resistant hydrothermal apparatus were used for the preparation of novel supported photocatalytic composites in a closed system. The hydrothermal technique is economic, eco-friendly and consumes less energy.
- Starting materials such as the sources of metal, solvents and experimental conditions like temperature, experimental duration, $pH$ and % fill played a significant role on the properties of final products.
- The size, shape, morphology and microstructure, crystalline phase and porosity of photocatalysts (TiO$_2$ and ZnO) deposited on the surface of supporting material were varied with respect to the starting charges and solvents used with applied hydrothermal experimental conditions.
• The elemental analysis like XRF and ICP-MS results showed effective deposition of photocatalysts (TiO$_2$ and ZnO) onto the CASB supports with desired properties and powder XRD and SEM results confirmed the crystalline phase obtained and structure of deposited photocatalysts on CASB supports. PALS results showed the increased rate of porosity under hydrothermal conditions.

• The structural elucidation and functional groups existed in the hydrothermally prepared supported photocatalytic composites were studied by FTIR techniques and it showed well interfacial regions of supports and photocatalysts in the composites.

• Hydrothermally prepared supported photocatalytic composites were tested for their photocatalytic degradation efficiency using various industrial dyes as model pollutants. Hydrothermally prepared supported photocatalytic composites showed two-three times higher photocatalytic degradation efficiency than commercially available TiO$_2$ and ZnO powders.

• Hydrothermally prepared supported photocatalytic composites have not only shown promise in photocatalytic degradation of model pollutant (organic dyes), but also have demonstrated effective degradation efficiency in the treatment of real-time industrial effluents, which contain large amount of organic load.

• Treatment of industrial effluents, containing large amount of organic load (effluents of paper and pulp industries, textile industries, pharmaceutical industries and pesticides industries, etc.) can be completely achieved in a short duration by implementation of photocatalytic treatment.

• The effective and strong deposition of TiO$_2$ nanoparticles on the surface of other supporting materials such as alumina filter and cordierite filter was demonstrated under hydrothermal conditions. As-prepared supported photocatalysts showed higher rate of photocatalytic degradation efficiency.

• Hydrothermally synthesized TiO$_2$ filled polymer composite was prepared and its photocatalytic degradation efficiency was studied.

• The photocatalytic degradation studies of hydrothermally prepared supported photocatalytic composites showed the beneficial characters of alkaline
condition as well as acidic condition of media for the high rate of photocatalytic degradation efficiency.

- The photocatalytic degradation studies with varied experimental parameters illustrate the effect of photocatalyst load, irradiation time, initial concentration of pollutants, light intensity and temperature on the rate photocatalytic degradation efficiency. It helps to understand the clear mechanism of semiconductor based photocatalysis and optimum experimental conditions for the design and construction of photo reactors or treatment plants in large scale.

- Photocatalytic degradation studies with hydrothermally prepared supported photocatalytic composites have demonstrated the importance of aeration and stirring mechanism during photocatalytic degradation process and it showed drastic improvements in the degradation efficiency of organic pollutants.

- Photocatalytic decomposition of total bacteria present in the municipal sewage waste water clearly showed that the bacterial inactivation behaviour of hydrothermally prepared supported photocatalytic composite, especially TiO$_2$ deposited CASB support composite showed effective deactivation of the bacterial growth in the waste water and drastic reduction of total bacterial concentration was observed under UV light with optimum amount of TiO$_2$ deposited CASB support composite.

- Photocatalytic degradation of organic pollutants was performed under different light sources and in most of the cases the higher degradation efficiency was found under the UV light due to higher absorption rate of photons by TiO$_2$ and ZnO under UV regions. In some cases the degradation efficiency was considerably increased under natural sunlight as well as under UV light. The hydrothermally prepared TiO$_2$ and ZnO based supported photocatalytic composites showed less photocatalytic degradation efficiency under visible light when compared to natural sunlight and UV light.

- TiO$_2$ deposited CASB supports showed higher photocatalytic degradation efficiency than the TiO$_2$ deposited alumina filter supports and TiO$_2$ deposited cordierite filter support under constant light intensity.

- Hydrothermal deposition of highly active photocatalysts onto suitable supporting materials are beneficial to recover and separation of photocatalysts after completion of photocatalytic reaction. The easy recovery and reuse of
hydrothermally prepared supported photocatalytic composites reduce the operation cost of the treatment plant in large scale.

- Finally it could be concluded that the hydrothermal technique is one of the major techniques extensively used for the preparation and processing of photocatalytic composites and this technique is economic and eco-friendly. Hydrothermally prepared supported photocatalytic composites can be used in the large scale applications like treatment of industrial effluents and municipal waste water treatment with suitable large scale reactor or degradation plant.

**Scope for the Future Work**

Based on the work carried out in the present thesis work and the conclusions drawn there in, the scope for the future work can be listed below:

- Efforts to minimize the hydrothermal experimental temperature and duration for the preparation of highly active photocatalysts in large scale for the photocatalytic treatment of waste water and industrial effluents.
- In spite of an increase in the photocatalytic degradation efficiency at higher acidic and alkaline pH, it is not fully benign to use such pH range in waste water treatment, because it may cause corrosion of the entire waste water treatment system.
- Photocatalytic degradation efficiency of hydrothermally prepared supported photocatalytic composites can be increased under visible light by doping selected transition metals in to the photocatalysts under suitable hydrothermal conditions.
- Introduction of an appropriate surfactant can provide a desired surface property to the composite making it either hydrophobic or hydrophilic for specific applications.
- Investigation and preparation of highly active polymer supported photocatalytic composites, which might lead us to newer areas of applications including LED device.
- Although the photocatalytic degradation of organic pollutants and treatment of waste water have been extensively studied and consolidated its benefits, it is still limited in commercial applications due to the lack of suitable large scale reactor or treatment plant. For commercialization and development of
photocatalytic application in the treatment of waste water a well designed suitable large scale reactor is suggested to achieve a realistic and practically feasible alternative to conventional degradation techniques within reasonable time.

- Hydrothermally prepared calcium alumino-silicate beads supported photocatalysts showed higher porosity, well crystallized phase and nanostructures in morphology. Moreover, these supported photocatalytic composites are highly active in the degradation of organic pollutants and bacteria in the aqueous medium. These superior properties of hydrothermally prepared supported photocatalytic composites may help in the decomposition of organic pollutants and bacteria in the polluted air effectively. This opens up new areas to tailor make composite photocatalysts that can be tuned to absorb light in the visible region and thus enhance the light harvesting ability of a photocatalyst. Novel catalysts are needed to provide economical and commercially viable alternative to waste treatment.