Chapter 7

Conclusions

&

Future Work

This chapter summarizes the findings of the thesis ending with a proposal about available dimensions for the future research work that can be done in this regard.

7.1 Summary

We observed that the concepts for nano structuring and hetero-structured synthesis are effective techniques to enhance the surface area, stability as well as active sites for the hybrid materials. For example, the hydrothermal synthesis approach for the synthesis of nanocomposite having three components (g-C_3N_4, oxidized red P and conductive rGO), significantly alters the electrocatalytic performance. The sheet-like structures of g-C_3N_4 play a pivotal role in the adhesion of atom/molecule and charge transfer during the H^+ reduction reaction. Similarly, rGO supports the channeling of ions over the g-C_3N_4 surface and P enhances the active and conducting islands for electron transfer reactions. Being purely a non-metal elements based catalyst, it's another class of electrocatalysts. Further, encapsulation of nano iron/iron carbide in heteroatoms doped graphitic shelled matrix by pyrolytic synthesis at a higher temperature gives rise to globular morphology in the range of a few hundred nanometres. An increase in the current density of approximately 6.5 folds with the lowest onset potentials is observed during catalytic reactions due to the synergistic effect of inclusions in composited materials as well as dopants acting as active sites.

By the means of hydrotreating and optimal use of nano semiconducting metal oxides as co-catalysts in the g-C_3N_4 matrix is another strategy in order to apply it for enhanced photocatalytic purposes. The combination of straddling and staggered type band alignments is responsible mainly herein for such enhancements. The optimal combination of 25% of Ag_2O and SnO_2 (1:1 w/w

ratio) over the g-C_3N_4 sheets gives 3D heterostructure for enhanced photodegradation ability among its other counterparts with relatively high mineralization efficiency under exposure to sunlight.

We discovered the profound effect of doping of heteroatoms over the electrochemical properties in the case of S, N-co-doped graphitic carbon encapsulated iron/iron carbide and photoluminescent features of the doped C_xN_y quantum dots. In the former case, doped heteroatoms led to the creation of a number of active sites and faster H^+ reduction, while in the later case, doped heteroatoms at the surface of QDs led to fine-tuning of photoluminescent behaviour and interaction with pollutants H_2Q by available functional group present over the surface of QDs. In the study, we concluded that the concepts of both doping and zero dimensionality as in doped C_xN_y QDs, are prominent strategies to tune the optical properties as well as direct sensing of H_2Q. The sensing behaviour of CxNy QDs was trustworthy as it was successfully employed for real samples as well.

We hope our experimental evidence quoted in the present thesis work will be inspired further to elaborate research work in diversified fields.

7.2 Spaces for Future Work

The exploration of electrochemical and photochemical attributes based on the g-C_3N_4 and porous carbon composite materials in the world of research using this thesis work is least but not limited. It points about significant spaces available for exploration in other unaddressed critical areas too under the following points

❖ Research efforts over the electrochemical H_2 generation using g-C_3N_4 based catalytic active-sites have plenty of space to work with as it has received less attention to its catalytic oxygen evolution and reduction parts.

❖ Tuning of structure dimensions and post-treatment of g-C_3N_4 provide a wider opportunity to work on enhancing its conductivity as well as mass transfer in order to bring it for larger catalytic and electronic purposes.

❖ The reaction mechanism of some of the redox process involving carbon nitride is unresolved and need to be re-investigated thoroughly.

❖ In the case of carbon matrix embedded structures, optimization of synthesis parameters and selection of doping precursors need to be looked over and its application areas need to be broadened.

❖ Efforts are required to deal with the relatively low performance of hybrid in electro/photo redox process in order to meet the requirements of industrial needs.

❖ Synthesis strategy of nanostructures with designing its architecture and simultaneously having a larger lifetime of separated charge carriers to make them into photo-related use is part of challenges and available scope.

There is a plethora of opportunity areas available to work on using graphitic carbon nitride and carbon-based nanocomposites to address the environment and energy related global issues at a larger scale, it requires the concerted efforts of the research community. This work compiled in this thesis is a small but significant effort in this direction and surely will have larger implications.