8
Conclusion

8.1 Summary

The main study of the thesis is centered around developing new functional nanomaterials via facile synthesis methods which can be further used for applications addressing energy and environmental issues.

The major findings in the thesis are as follows:

1) Black TiO_2 doped with HfO_2 and hydrogen with tunable bandgap and spherical morphology was successfully synthesized. The formed spheres were observed from the TEM image to be comprised of a collection of numerous smaller TiO_2 nanoparticles. The reduced bandgap facilitated better absorption in the UV-visible region of the solar spectrum. It was observed that when used as photocatalyst for degradation five different industrial dyes that the synthesized material worked as good catalyst degrading almost 75-90 % of the dyes in 60 min. Amongst all the dyes methylene blue in alkaline condition was degraded the best achieving almost 90% degradation after 10 min of exposure to simulated light. These results demonstrate that TiO_2 as a photocatalyst works as a good photocatalyst when its property is tuned.
2) HfO_2 and Ni-Co co-doped clay catalyst have been successfully synthesized and used as a catalyst for oxidation of harmful soot particles. The results show the creation of oxygen vacant sites when annealed under hydrogen and nitrogen atmosphere which plays a vital role in decreasing the peak temperature. Additionally, HfO_2 was used further for an accelerated thermal test to confirm the stability of the synthesized catalyst.
3) Nitrogen doped carbon having the different structure- hollow and solid sphere were synthesized and successfully used for multifunctional application. These carbons were coupled with ZnO doped TiO_2 and rice grain structured TiO_2 and used as photoanode in DSSC where a 10.4 % PCE was observed. Additionally, these carbon materials were used in place of Pt and successfully fabricated DSSC with 7.8 % PCE. Furthermore, these carbons with high nitrogen content as observed from the XPS scans showed good CO_2 capture activity with maximum absorption of 2 mmol/g for the solid sphere. Finally, these materials were successfully tested for potential applications in supercapacitor.
4) $CsPbX_3$ all-inorganic based perovskites were synthesized successfully by a hot injection method. To improve the stability Ti, Sn, Ta and Mo based metal oxides and monolayer sheets of graphitic carbon nitrides were used to make an encapsulation and composite respectively. The encapsulation was visibly observed in the TEM image. The synthesized luminescent perovskites were deposited on conducting substrate and used for photoelectrochemical water splitting.

8.2 Future scope

The synthesized materials can be further adapted for use in large scale synthesis and commercial applications. For example, black TiO_2 can be incorporated in mesh or sheets for repeated usability and easy recovery. Additionally, further studies can be performed for the degraded dye to confirm mineralization and its by-products after degradation. For the soot oxidation application, studying of the exhaust gases are important to realize the conversion of soot to oxides of C and N. Incorporation of the carbon material in supercapacitor devices will be helpful to establish the true applicability of high surface material for energy storage application. These materials can also be tested for possible biological applications. Furthermore, the synthesized perovskite needs further characterization and after optimization can be used for the photoelectrochemical reduction of CO_2.