Chapter 5- Conclusions and future scope

5.1 Conclusions

In this study, advanced oxidation processes viz., sonocatalysis, photocatalysis, and sono-photocatalysis are investigated for water pollutant degradation. The chemical pollutant chosen for the study was RhB, a trace pollutant found in waste water discharges of colour industries. BFO is an active photocatalyst for the pollutant degradation process as it has a narrow band gap. However, for the getting of remarkable activity, the recombination rate of electrons and holes should be prevented. Making a composite of BFO with graphene-based materials not only reduce charge recombination rate but also enhance fast transportation of electron to the solid/liquid interface thus degradation efficiency increases. The parameters namely catalyst concentration, concentration of pollutant, pH, US power density and catalyst life cycle are also investigated. Based on the results and discussion presented in the previous chapter relevant findings of the study and the conclusions are as follows:

(i) Nitrogen-doped graphene oxide (N-rGO) was found best support material for RhB degradation process. XPS study reveals that three distinct N species such as pyrrolic N, pyridinic N, and graphitic N present in prepared N-rGO. A Chemical interaction developed between Bi of BFO and C of N-rGO as a result of the electronic transition which is due to $\pi - \pi^*$ transition of aromatic carbon and π band associated with p_z orbital of C to π^* band associated with p_z orbital of N, confirmed by DRS and XPS. The optimum parameters for photocatalytic degradation of RhB solution are considered to be the initial concentration of 10 ppm RhB, added amount of 30 mg. L^{-1} catalyst, and pH=2 within 120 min. Photocatalytic degradation experiments showed five-fold higher photocatalytic activity of BFO/N-rGO as compared to BFO. Trapping experiments revealed that $O_2^{\bullet-}$

were found to be the most active radicals responsible for RhB degradation compared to others.

(ii) Gd doped BFO based composite (BGFO/N-rGO) showed enhanced photocatalytic activity due to the synergistic effect of mainly two factors; photoinduced electron-hole pair separation and charge transfer resistance. Photoinduced electron-hole pair separation was successfully achieved by substitution of Gd in place of Bi that was confirmed by XRD and XPS. A chemical interaction between bismuth of BGFO and carbon of N-rGO, lead to high charge mobility, which was confirmed by DRS and XPS. A rapid transformation of electrons from BGFO to N-doped reduced graphene was observed due to the reduction in the charge transfer resistance and high electron mobility of N-rGO. This resulted in the suppression of the recombination of electron-hole pair as confirmed by EIS and PL. The support N-rGO increased the surface area of BGFO/N-rGO by 16 folds as compared with BFO leading to better adsorption of RhB. A synergistic effect of reduced photoinduced charge recombination, high charge mobility at the solid/solid interface of heterojunction, and high surface area resulted in the sufficient availability of electrons at the surface of the catalyst. Also, BGFO/N-rGO displayed high stability with 99 % recovery efficiency, even after five cycles of experiments.

(iii) Ultrasound assisted photocatalysis exhibits synergistic effect on RhB degradation compared to photocatalytic process. Like photocatalytic process, sonophotocatalytic degradation of pollutant also depend on various parameter viz. catalyst concentration, dye concentration, and pH of the solution. The optimum degradation conditions for RhB solution are considered to be the initial concentration of 20 ppm RhB, added amount of 40 mg. L^{-1} catalyst, output power density of 40 KW. L^{-1}, and pH=10 within 80 min. However, there is no convincing explanation available for the effect of pH which is mainly due to complexity of the processes sono-, photo- and sono-photocatalysis. The

sono-photocatalytic degradation improved the overall efficiency with a remarkable increase 28-fold and 2-fold of the kinetic rate constant with respect to the sonolytic and photocatalytic process alone, respectively. The study clearly proved the synergy of sono-photocatalysis and the advantages of coupling two AOPs. In summary, sonophotocatalysis can be used as an efficient AOP to remove chemical contaminants from water. Because it does not use toxic or harmful additives and is environmentally friendly, these methods increase the likelihood of safe reuse of water.

5.2 Future scope

In the present study rare earth metal doped photocatalyst were prepared which exhibited high activity. However, multi-elemental doping has been receiving much attention as a method for controlling the optical properties of BFO for solar energy harvesting and high activity. Here the photocatalytic degradation of RhB is studied and the study can be expanded for the degradation of other hazardous contamination of water and air. Effect of pH and temperature of wastewater also need to be investigated for industrial uses. The work can be extended for intermediate products identification for exact reaction mechanism. In sonophotocatalytic process, acoustic cavitation induces mechanical energy also play important role in degradation process thus it required proper study on it. Once scaled up, identifying optimal parameters, and developing suitable reactor equipment, this method can be considered an important process for providing clean drinking water to remote areas where water is scarce, especially in developing and underdeveloped countries.