CHAPTER - 7

The Conclusion and the Future Prospects of the Work
The underlying motivation of this thesis was to fabricate hybrid nanocomposites from chitosan, alginate and agarose (from the family of biopolymers) by integrating nanomaterials of diverse forms; metal nanoparticles and carbon dots. These hybrid nanocomposites showed unique and interesting attributes contributing to varied applications like drug delivery, sensing and catalysis.

The thesis introduced two green precursors of carbon dots (CD); chitosan gel and tea (Chapter 2), the first report in the family of carbon dots precursors. The carbon dots showed pH dependent photoluminescence properties and metal enhanced fluorescence as well. The chitosan carbons dots were used as a suitable nanomaterial to form hybrid nanocomposites with other biopolymers of the group, alginate and agarose. With alginate, the carbon dots formed highly stable calcium alginate beads which showed low pH drug delivery applications with tetracycline and tetracycline:β-cyclodextrin as model drug systems (Chapter 3). Also, the chitosan carbon dots, on mixing with agarose, resulted in hybrid Agr/CD nanocomposite film (Chapter 4) which showed an amazing colorimetric detection of quintet metal ions, Cr$^{6+}$$\rightarrow$yellow, Cu$^{2+}$$\rightarrow$blue, Fe$^{3+}$$\rightarrow$brown, Pb$^{2+}$$\rightarrow$white, and Mn$^{2+}$$\rightarrow$tan brown with optical detection limits 1 pM (Cr$^{6+}$), 0.5 nM (Fe$^{3+}$, Pb$^{2+}$, Mn$^{2+}$) and 0.5 μM (Cu$^{2+}$). In addition, the metal nanocomposites of these biopolymers were fabricated. A hybrid nanocomposite film of agarose and gold nanoparticles (Au NPs) was fabricated which served as the perfect platform for thiols to process the non-conventional fragmentation of supported Au NPs (Chapter 5 (A)). Such thiols fragmented film; thiols-Au@Agr showed an extraordinary rapid catalysis of the
red concentration reaction of p-nitrophenol (p-NP) with rate constant, $1.6 \times 10^{-1}$ s$^{-1}$. Another such nanocomposite film was prepared from chitosan and silver nanoparticles (Ag NPs) (Chapter 5 (B)), which showed interesting storage/release property of Ag NPs making the nanocomposite as the store house of Ag NPs suitable for catalysis of p-NP reduction. At variance from the polysaccharide based nanocomposites, we also synthesised CDs in organic medium (tetrahydrofuran (THF) & Olelyamine (Oam)) using deoxycholic acid hydrazone based organogel as a potential precursor (Chapter 6). The as-synthesised $O_gTOam$-CD$_{org}$ showed the amazing aggregation-induced emission enhancement (AIEE) property with maximum emission at 40/60 (v/v (%)) of THF/Water mixture along with the characteristic excitation based PL emission. This AIEE property made $O_gTOam$-CD$_{org}$ an excellent fluorescence turn-on sensor of cholesterol with its “enzyme-free” detection in human blood serum upto a limit of detection (LOD) = 0.36 μM.

**7.1 The Future Prospective of the Work**

The findings in the thesis were an attempt to contribute in the development of hybrid functional nanocomposites and, thus its future prospects revolve around its application to the areas other than showed in the thesis. It would be interesting to investigate the integration of chitosan CDs, tea CDs and CD$_{non-aq}$ with other important materials. This would conclusively lead to a wider application field. All the applications shown in the thesis involve showing “proof of the concept”. The applications especially as fluorescent sensors and as colorimetric sensors can be extended with development of prototype devices. There are not many report of CD$_{org}$ (carbon dots prepared in organic medium), and thus hybrid nanocomposites with CD$_{org}$ are not explored yet. As the
development of hybrid functional biopolymer nanocomposites are answers to modern
day requirement of advanced smart material, the thesis holds a great future prospect in
material nanoscience.