Nanocomposites offer unique combinations of property and design, a major limitation in the conventional microcomposites. In this class, hybrid functional bionanocomposites have been introduced as an advanced and versatile generation providing miniaturisation as well as hybridisation between organic and inorganic functions. Be it applications like drug delivery, sensing or catalysis, these hybrid bionanocomposites on par have proved their excellence.

In the thesis, these studies laid the grounds framing the main objective to investigate the feasibility of three different polysaccharides, viz., chitosan, alginate and agarose to form hybrid bionanocomposites which are variedly functional. The initial work introduces chitosan gel and tea as two new precursors for the synthesis of carbon dots (CD) having particle size less than 10 nm. The CDs from both the sources showed bright blue fluorescence under UV lamp with sharp peaks in their photoluminescence (PL) spectra. The unique property variance between these two carbon dots was observed in their net surface charge with chitosan gel CDs showing positive value (ζ= +27.8 mV), and tea CDs showing negative value (ζ= −39.2 mV). In addition, the photoluminescent properties of chitosan CDs at different pH conditions and on incorporation of silver and gold nanoparticles were examined. Interestingly, when chitosan carbon dots combined with calcium alginate (CA) beads formed a protective coat on the beads. These carbon dots coated alginate beads (CA-CD) showed exceptional stability at room temperature (even after 60 days) and also at higher temperature. The CA-CD beads showed their proficiency as a pH dependent drug delivery vehicle taking tetracycline (TC) and tetracycline:β-cyclodextrin (β-TC) as model drug systems. The TC loading was 35% for CA and 77% for CA-CD, and β-TC loading was 48% for CA and 90% for CA-CD. A maximum drug release at pH 1 was obtained with 70% for CA-CD and 37% CA at 96 h. However, in case of β-TC loading the delivery rates were slower showing 61% release for CA-CD and 22% for CA at pH 1 after 96 h. Thus, CA-CD can be suitably used as an effective drug delivery vehicle at low pH, and β-cyclodextrin:drug inclusion complex deals with slow and long-term drug administration. Next, the chitosan carbon dots were
rooted into agarose hydrogel to form a hybrid hydrogel film (Agr/CD). The film showed instant colorimetric detection of the quintet metal ions; $\text{Cr}^{6+} \rightarrow \text{yellow}$, $\text{Cu}^{2+} \rightarrow \text{blue}$, $\text{Fe}^{3+} \rightarrow \text{brown}$, $\text{Pb}^{2+} \rightarrow \text{white}$, $\text{Mn}^{2+} \rightarrow \text{tan brown}$, exclusively. The optical detection of these metal ions were found to be 1 pM for $\text{Cr}^{6+}$, 0.5 μM for $\text{Cu}^{2+}$, and 0.5 nM for $\text{Fe}^{3+}$, $\text{Pb}^{2+}$, $\text{Mn}^{2+}$. The Agr/CD also showed its potential in separation of these quintet metal ions. Thus, the Agr/CD can act as an excellent hybrid solid sensing platform to employ as an on-site operational, portable, cheap colorimetric-optical detector of heavy metal ion with potential skill in their separation.

Another comprehensive study was done on the feasibility of selective thiols to fragment supported gold nanoparticles@agarose film. Thioglycolic acid (TGA), cysteine (CS), 2-mercaptoethanol (ME), L-methionine (MET) were found to successfully fragment 60 nm Au NPs to 20~30 nm Au NPs. Such thiol-Au@Agr film showed a great catalytic property for the reduction of p-nitrophenol (p-NP) to p-aminophenol (p-AP) within 20~30 s with pseudo-first order rate constant $1.6 \times 10^{-1}$ s$^{-1}$. The role of synergy between thiol and Au@Agr could be credited to such successful catalysis. In addition, a hybrid nanocomposite of chitosan-silver nanoparticles were investigated for its property study on the storage/release of Ag NPs. The chitosan hydrogel was found to act as a store house of Ag NPs, when ex-situ incorporation of Ag NPs was done. This also facilitated the application of chitosan-Ag-ex-situ (CH-Ag-E) nanocomposite for the reduction catalysis of p-NP to p-AP.

To extend the horizon of this thesis, an investigation on the synthesis of carbon dots in organic medium was also investigated. Here, the carbon dots were synthesised in tetrahydrofuran (THF) and oleyamine (Oam) using organogel as the precursor. Also, the as-synthesised $\text{CD}_{\text{org}}$ showed the amazing newfound aggregation-induced emission enhancement (AIEE) at 40/60 (%) of THF/Water mixture. This AIEE attribute of $\text{CD}_{\text{org}}$ made it an exciting candidate for the “enzyme-free” detection of cholesterol in human blood through turn-on in its PL intensity. Therefore, $\text{CD}_{\text{org}}$ has the potential to broaden the application fields of CDs, which are still limited to aqueous medium.

Hence, the findings in this thesis assert the development of stimuli responsive hybrid nanocomposites showing diverse applications like drug delivery, sensing and catalysis. It also offers a decent platform for the application of CDs beyond aqueous medium, thereby widening its scope.