7.1. Summary of the thesis

The inspiration for the whole work compiled in the thesis is to develop new bio-hybrid materials using polysaccharide based natural polymers like chitosan, alginate, cellulose etc. combining the advantages of new age nanomaterials like carbon dots, metal oxides and graphene based nanomaterials. These bio-hybrid nanocomposite materials possess many interesting properties and have the potential to be used in many advanced applications.

The thesis introduces a new biopolymeric hydrogel material for fabrication of films and patches. For fabrication of films, a novel gel casting technique was used and the soft and smooth self-standing films were obtained by utilizing the self-healing ability of the polymeric hydrogel (Chapter 2A and Chapter 5). Carbon dots (CDs) synthesized from Assam CTC tea was used for the first time in polymeric systems. Tea CDs were found to be a very efficient multipurpose additive for both chitosan hydrogel and alginate films (Chapter 2). Tea CDs not only improved the mechanical and thermal properties of the biopolymeric nanocomposite films, but also it could add UV-blocking ability to such films. A study on property relationship of alginate films using 5 different types of divalent and trivalent cross-linker ions was also carried out. Tea CDs were also use for the reduction of graphene oxides (GO) and these reduced GOs decorated with the tea CDs were found as an efficient conducting coating material for fabrication of a conducting textile (Chapter 3). The surface conductivity of such cotton based tea CDs reduced GO coated conducting fabric was found to be ~623 S/m which is comparable to that of the already reported advanced carbon based conducting textile materials.
Then fabrication of alginate fibers just by using the laboratory micropipette (Chapter 4) was reported. This particular technique eliminates the use of any sophisticated spinning machines for fabrication of such hydrogel fibers. The fibers were made magnetic by incorporation of magnetic iron oxide nanoparticles and such small magnetic hydrogel fibers were used for adsorption separation of antibiotic ciprofloxacin hydrochloride. A composite nanomaterial of graphene oxide coated with iron oxide magnetic composite nanomaterials was synthesized and incorporated in a chitosan hydrogel film (Chapter 5). The films showed improved mechanical and thermal properties compared to that of the bare chitosan hydrogel films. Along with that the films exhibited a new interesting property i.e. antimicrobial activity. This type of films has high potential to use as a wound dressing material.

But the problem with these biopolymeric materials for their practical use as a wound dressing materials is the mechanical property. Most of the bio-polymeric systems loses their mechanical strength whenever they are exposed to aqueous medium. So, realizing this drawback with the biopolymeric system, endeavor was made to fabricate a system which can retain their mechanical properties even in presence of water. This goal was accomplished by fabricating a polymeric hydrogel coated cotton patch where a slice of fibrous cotton wool was coated with a chitosan hydrogel system and then made it compact by compression (Chapter 6). Such compact cotton patch not only remain stable in water, but also acts a smart bandage material by providing the means to load any drug or nanomaterial in it. The patch was demonstrated as a bandage material by incorporating graphene oxide and curcumin as model drug and was further tested in animal model. Graphene oxide and curcumin loaded bandage patch showed the best result and complete wound healing within twenty-one days of observation period.

7.2. Future scope

The whole idea of the thesis is to develop new hybrid biomaterials which can enjoy inherent biodegradability and biocompatibility of the biopolymers as well as amazing and interesting properties of nanomaterials. Combination of biopolymers and the nanomaterials produces new group of nanocomposite hybrid materials which have a great potential to use
in many advanced biomedical applications. The thesis is a demonstration of the “proof of concept” of the ideas which has scope to study further to develop prototype or to proceed to the pilot scale. The thesis demonstrates the fabrication of a type of soft but tough biopolymeric films from the chitosan hydrogel which can further be developed to make it suitable for many other applications. The demonstration of the fabrication of alginate hydrogel fibers using only the laboratory micropipette will help many researchers to work on such fibers even in absence of any sophisticated spinning machines. The compact cotton patch has the high possibility to have a commercial value as a smart bandage material. Since nanocomposite fabrication is the most efficient and fruitful solution for extending the application of biopolymers to develop advance materials, so this thesis holds a great future prospect in material science and sustainable development.