Chapter 2

Scope and objectives

Polymer nanocomposites have been the materials of intense industrial and academic research for the past twenty years. Amongst the entire potential nanocomposite precursors, those based on metal and carbon nanotubes/graphene have been more widely investigated. Further, development of polymer nanocomposite materials depends largely on our understanding of the fundamentals in relation to their formation, processing, property prediction and design. In the present dissertation, development, characterization and applications of new bionanocomposite systems are described. Bionanocomposites are an emerging class of hybrid materials derived from naturally occurring polymers and inorganic solids interacting at the nanometric scale. The objectives of this investigation are as follow:

The introductory Chapter 1 addresses some of the basic concepts of biodegradable polymers and their nanocomposites and it also contains a comprehensive review of the literature on the biomedical applications of biomaterials. Of particular relevance from applications point of view of bionanocomposites, it should be taken into consideration that biopolymers are biocompatible as well as biodegradable compounds and hence their composites are of interest for advanced biomaterials, as for instance tissue engineering, artificial bones or gene therapy, for better healthcare products and bio-medical materials. This chapter also covers the biomedical applications of nanoparticles for instance gold and silver nanoparticles, carbon nanotubes, graphene and biopolymer mesoporous composites as elegant biomaterials.

Chapter 2 consider the scope and objectives of present study.

The objective of Chapter 3 is to prepare the chitosan silver nanocomposite films and scaffolds via solution casting and freeze-drying method for drug release and cytotoxicity behaviour, respectively. However, gelatin was also used as a cell adhesive protein of chitosan-silver-gelatin nanocomposites. The effect of Ag nanoparticles in nanocomposite films and scaffolds on physical properties was also taken in account.
Graphene/polymer (bio) nanohybrids and their biomedical applications were not investigated in details due to lack of high solubility problem of graphene in several solvents. Therefore, the objective of Chapter 4 is to enhance the solubility of graphene after functionalized with chitosan for biomedical applications. The presence of organic groups will be confirmed by X-ray photoelectron spectroscopy and thermogravimetric analysis. Restoration of SP² carbon network and exfoliation of graphene sheets will be confirmed by Raman Spectroscopy, UV-vis Spectroscopy and Wide Angle X-ray Diffraction (WAXD) etc. Further objective of this work will consider the effect of chitosan graphene nanohybrid on biomedical applications for example, controlled release behavior of two drug molecules, i.e. ibuprofen (IBU) and 5-fluorouracil (5-FU).

Well defined interconnected mesoporous polymer/silica composites with a large specific surface area and pore volume are vital for the ideal delivery system and must be highly biocompatible in order to be promising materials for biomedical applications. Polymer mesoporous matrix has not been extensively used for biomedical applications. Chapter 5 will describe a facile, dual-template method for the synthesis of hierarchical mesoporous bio-polymer/silica composite materials with bimodal mesopores for biomedical applications.

On-the-spot rapid detection of trace chemical vapors with portable chemical sensors is in high demand for environmental protection, industrial pollution control, biomedical systems and public safety guarantees. Polymers and their nanocomposites are used widely in chemical sensing, and their sorptive properties have been examined in detail. Objective of Chapter 6 is to synthesize chitosan grafted and chitosan-co-polycaprolactone grafted multiwalled carbon nanotubes for volatile organic and toluene vapor sensing applications. Vapor sensitive transducer films consisting of chitosan grafted (CNT-CS) and chitosan-co-polycaprolactone grafted (CNT-CS-PCL) multiwalled carbon nanotubes have been prepared by using spray layer-by-layer technique. Further, this work will focus to study the biocompatibility of synthesized CNT-CS and CNT-CS-PCL that might be useful for future biosensing applications.

On the other hand, periodic mesoporous organosilica (PMOs) are known for their excellent properties such as chemical sensing and nano-material fabrication, adsorption of heavy metal-ions and in controlled drug delivery systems. Using the relevant organic
moieties, the surface of PMOs can be modified to improve the adsorption capacity through surface hydrophobicity for the removal of heavy metal-ions. Therefore, objective of this work mainly focus on to introduce a silica precursor 1,1’,1”-(1,3,5-triazine-2,4,6-triyl)tris(3-(triethoxysilyl)propyl)urea) (TTPU) to prepare periodic mesoporous organosilica (MPMOs). Melamine has been used as a key backbone molecule to synthesize the organosilica precursor. The detail discussion has been done in Chapter 6. Though this chapter is not directly related to the biomedical application but can be considered as an extension of chapter 5 which deals with non-biomedical application on metal adsorption.

Finally, Chapter 8 will summarize the important conclusions of the present investigation.