A Facile Synthesis of Chitosan/MWCNT Nanocomposite

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Abstract- **Chitosan/multiwalled carbon nanotube nanocomposite has been successfully synthesized by the chemical method. The prepared nanocomposite was characterized using XRD, FTIR and HRTEM. The XRD pattern of the nanocomposite shows the presence of planes corresponding to both chitosan and MWCNT and the absence of impurity phases. The semi-crystalline nature of chitosan is also evident from the obtained pattern. Shift in the vibration and a change in the intensity of NH_2 and NH_3^+ modes shows the formation of the nanocomposite by the binding of MWCNT to the NH_2 group of Chitosan. HRTEM images show the even distribution of MWCNT in a matrix of chitosan. Further work would be to study the use of the nanocomposite as a drug delivery vehicle.**

Keywords- chitosan; MWCNT; nanocomposite

I. INTRODUCTION

Nanotubes are potential candidates for drug delivery due to their vantage over other systems like protecting entrapped drug molecules against denaturation or degradation over the delivery process. They have large inner volumes that can allow for loading more than one therapeutic agent so that targeting molecules, contrast agents, drugs or reporter molecules can be used at the same time. Of these, Carbon nanotubes have unique electronic, mechanical, and structural properties as well as chemical stability, which make them ideal nanomaterials for drug delivery carriers[1]. However intratracheal administration of unfunctionalized CNTs aggregated in the lungs and led to pulmonary toxicity and inflammation. But this aggregation was seen to be less in the case of well dispersed nanotubes. Hence, to promote and optimize the use of CNT in biotechnology, it is necessary to functionalize CNT with biomaterials including biomolecules, biopolymers and other bio-nanostructures[2].

Chitosan (CS) is one such biopolymer synthesized by the deacetylation of chitin, a natural polymer found in the exoskeleton of crustaceans. It possesses properties like being biocompatible, biodegradable, non-toxic and ecofriendly. It has active sites for the chelation of drugs and other molecules[3, 4] which make it even more interesting for use in biomedicine, packaging, wastewater treatment, cosmetics,etc[5, 6]. Moreover, CS can be made to possess amphiphilic properties giving it a unique capacity to solubilize hydrophobic CNTs in aqueous solution thus making it a suitable one for the functionalization of CNT. Furthermore, the combination of chitosan with carbon nanotube would mean the existence of properties of both in addition to unique properties which render it suitable for a wide range of applications ranging from their use as sensors to targeted drug delivery. Here we present the synthesis of chitosan/MWCNT nanocomposite by a simple chemical method and its characterization.

II. MATERIALS AND METHODS

A. Materials

Chitosan with the degree of deacetylation of 85% from Sigma Aldrich and multiwalled carbon nanotube from Sigma Aldrich were used for synthesis. All experiments were carried out using double distilled water.

B. Method

Chitosan was dissolved in 2% acetic acid to obtain a polymer solution at a concentration of 0.34% (w/v). The solution was then filtered and used further. Amount of MWCNT was chosen such that the composite would

contain 5% (w/w) MWCNT i.e. the amount of CNT would be 5% of the weight of chitosan. The calculated quantity of MWCNT was added to the chitosan solution kept under simultaneous stirring and sonication. The pH of the solution was found to be ~2to 3. MWCNT was allowed to swell and disperse in the chitosan solution for about 5 hrs after which the solution was centrifuged and the particles were collected and characterized.

The X-Ray diffraction analysis of the prepared sample was done using GE X-ray diffraction system-XRD 3003 TT with CuKα1 radiation of wavelength 1.5406 Å. HRTEM was carried out using Tecnai instrument operating at 200 kV. The FTIR spectrum was recorded using Perkin-Elmer FTIR system.

III. RESULTS AND DISCUSSION

A. Structural Investigation

The XRD pattern of CS/MWCNT nanocomposite is shown in figure 1. The XRD pattern shows the presence of peaks corresponding to both chitosan and carbon nanotube. Three peaks at 2Θ ~ 11º, 23º and 44.4º are observed of which the peak at 11º corresponds to CS and the peak at 44.4º corresponds to carbon nanotube. The broad peak at 23º was deconvoluted into two peaks as shown in figure and the first peak centered at ~ 20.9º belongs to CS and the other peak centered at ~ 24.8º belongs to the carbon nanotube[7, 8]. So the XRD pattern shows the formation of nanocomposite. Absence of secondary phases confirms the purity of the nanocomposite.

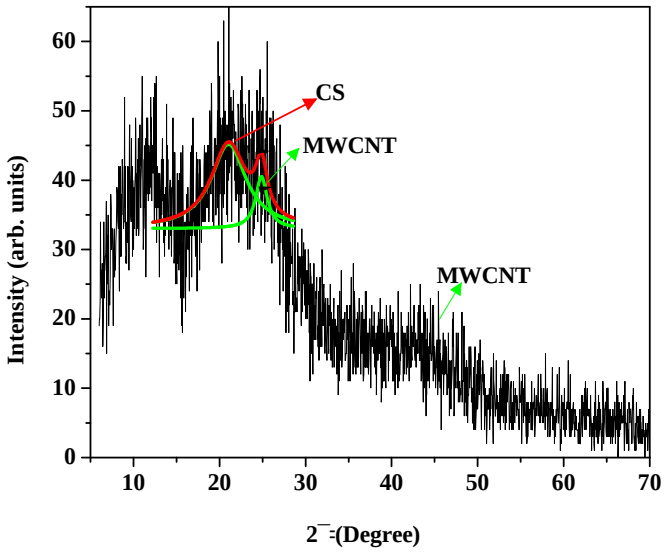

Figure 1: XRD pattern of CS/MWCNT nanocomposite.

B. Morphological study

The HRTEM image of CS/MWCNT nanocomposite is shown in figure 2. The HRTEM image shows the embedment of carbon nanotubes in a matrix of chitosan. In other words the HRTEM image shows the formation of a polymer matrix nanocomposite structure with chitosan as the matrix phase and carbon nanotube as the filler phase. Bundling of MWCNT is not seen which makes the prepared nanocomposite a suitable one for use in various applications.

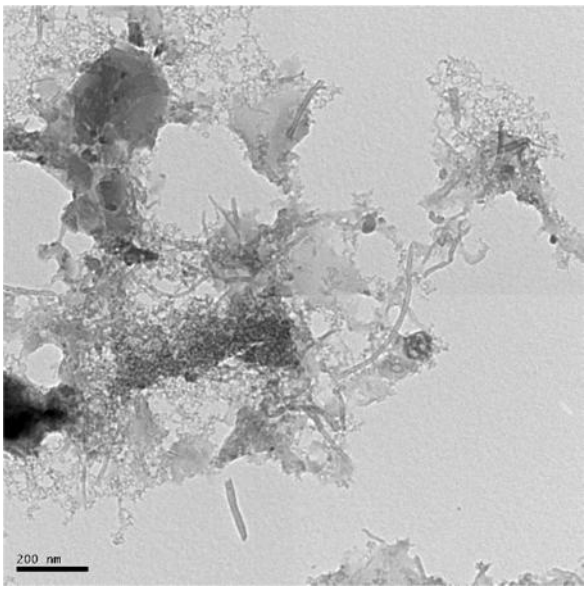

Figure 2: HRTEM image of CS/ MWCNT nanocomposite

C. FTIR Analysis

The FTIR spectrum of CS/MWCNT nanocomposite is shown in figure 3. The peaks in the FTIR spectrum of CS/ MWCNT nanocomposite were seen to match mostly with the peaks obtainrd for pure chitosan.

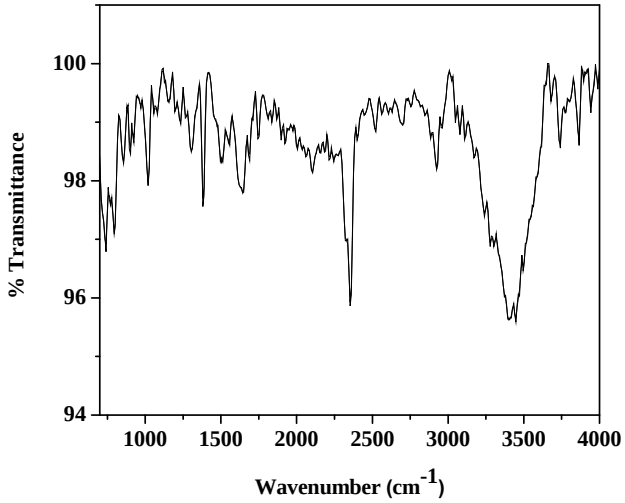

Figure 3: FTIR spectrum of CS/MWCNT nanocomposite.

The peaks corresponding to C-O stretching, C-O-C stretching, C-N stretching, C-H bending and OH and NH stretching were observed at 1070 cm^{-1} , 1240 cm^{-1}, 1318 cm^{-1}, 1382 cm^{-1} and 3427 cm^{-1} respectively. The only difference between the FTIR obtained for the nanocomposite from that of pure chitosan is the shift in peaks corresponding to NH_3^+ and the NH stretching peaks to lower wavenumbers in the composite when compared to pure chitosan. The NH_3^+ and the NH were observed for pure chitosan at 1508 cm^{-1} and 1650 cm^{-1} respectively for pure chitosan whereas for the nanocomposite these were observed at 1494 cm^{-1} and 1636 cm^{-1} which is indicative of the binding of MWCNT to the NH groups of chitosan[9].

IV. CONCLUSION

Chitosan/MWCNt nanocomposite was successfully synthesized by a simple chemical method. The XRD pattern of the nanocomposite system shows the semicrystalline nature of chitosan and the presence of the peaks corresponding to both the moeties which is indicative of the formation of the nanocomposite. The HRTEM image shows the dispersion of carbon nanotubes in a matrix of chitosan and a shift in the peaks observed in the FTIR spectrum shows that the formation of nanocomposite is probably by the binding of MWCNT to the NH groups of chitosan. Further work can be done on the use of this nanocomposite as a drug delivery carrier.

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