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Chitosan – silver nanocomposite for biosensor application

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Abstract: Ecofriendly, biodegradable and biocompatible nanocomposites with good sensing capability have gained importance for use as biosensors. Chitosan–silver nanocomposite is one such system which possesses all the above mentioned qualities. Chitosan–silver nanocomposite was prepared by the chemical reduction method. The prepared nanocomposite was characterized using XRD and FTIR analysis. The XRD analysis confirms the presence of chitosan and silver in the nanocomposite. FTIR analysis has been used for the structural elucidation of the sample. The application of this composite as a sensor for sensing catechol was performed using a cyclic voltammeter.
Keywords- Biopolymer; Silver; nanocomposite; sensor.

Introduction

Materials that are not ecofriendly, non- biodegradable are a pre-eminent hazard to the environment. Hence it has become a vital thing to use compounds that are ecofriendly and biodegradable in all the fields. Chitosan – silver nanocomposite is one such material which apart from possessing the above mentioned properties has an additional advantage of being biocompatible [1]. It is this property of this composite which makes it useful in the field of medicine. This composite has a wide variety of applications which include its use as a pesticide, in food packaging, as a drug delivery carrier and in wound dressing [2]. The composite can also be used as a sensor for sensing impurities present in water out of which catechol sensing is done in this work.

Catechol is a phenolic compound detrimenting the availability of pure ground water. The presence of catechol in food and water causes various health issues. Catechol can be easily taken up by the cells while the eviction of catechol from the cells is a difficult task. Thus there is an accumulation of catechol taking place in the cell once it enters the body. Catechol is also a cancer causing agent.[3] As a consequence sensing catechol is an important task and this composite helps in the sensing of catechol and hence it is important as a sensor.

Experimental

The chitosan–silver nanocomposite was prepared using the chemical reduction method. A solution of chitosan was prepared by adding a solution of 2% acetic acid to the required amount of chitosan under stirring.

Silver nitrate solution was added dropwise to the chitosan solution under constant sonication and stirring. The amount of Silver nitrate was chosen such that the resulting composite would contain 5wt% of silver. A solution of $NaBH_4$ (whose concentration is 15 times the concentration of the $AgNO_3$ solution) was added dropwise to the above. The solution was then centrifuged to obtain the sample.

Results and discussion

Fig. 1 shows the XRD pattern of the prepared nanocomposite. The presence of chitosan, silver and the absence of impurity phases is evident from the XRD image [1,4]. The peaks of semi-crystalline chitosan at 2Ө values of ~10.9° and 20.8° are represented separately in the inset [5]. The peaks of silver were indexed to the face centered cubic structure which are in good agreement to the JCPDS card No.04-0783. The three silver peaks obtained belong to the (111), (200) and (220) reflections respectively. The average crystallite size of silver nanoparticles calculated using the Scherrer formula is about 8nm.
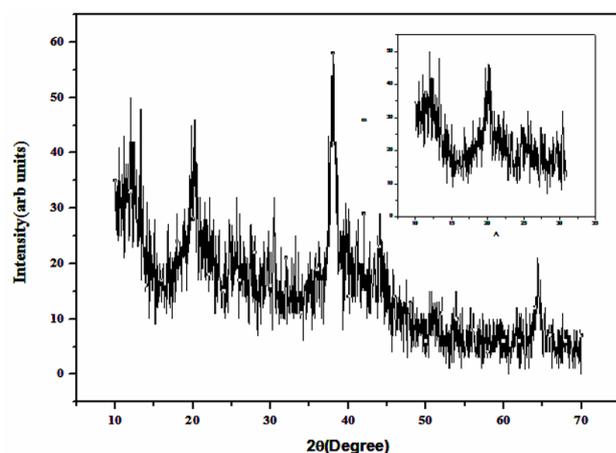

Figure 1. XRD pattern of chitosan–silver nanocomposite containing 5wt% Silver.
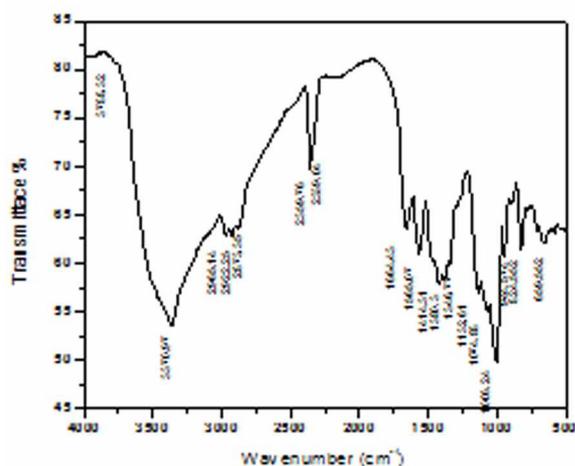

Figure 2. FTIR spectrum of chitosan–silver nanocomposite containing 5wt% silver.

FTIR analysis was done for the structural elucidation of the prepared nanocomposite. The FTIR spectrum of the prepared composite shows C-Br stretch at 543.007 cm^{-1}, 588.025cm^{-1} and 659.552cm^{-1} due to the usage of KBr while making pellet. The spectrum shows C-H bending vibrations at 824.552 and 890.543 cm^{-1}, C-O-C bridge (glycosidic linkage) at 890.543 cm^{-1}, O-H bending vibration at 944.574 cm^{-1}, C-O stretching vibration at 1006.24cm^{-1}, C-O-C stretching vibration at 1074.88 cm^{-1}, C-C stretching vibration at 1132.61 cm^{-1}, C-N stretching vibration at 1346.77cm^{-1}, C-H bending vibration at 1380.3 cm^{-1}, O-H bending vibration at 1414.31 cm^{-1}, amide II band or chitosan hyroacetate at 1565.07 cm^{-1}, C=O stretch at 1664.43 cm^{-1}, C-H stretching at 2873.35, 2922.25, 2965.14 cm^{-1}, N-H stretching at 3370.97cm^{-1}and O-H bending at 788.32 cm^{-1} which is in perfect agreement with the literature [8].
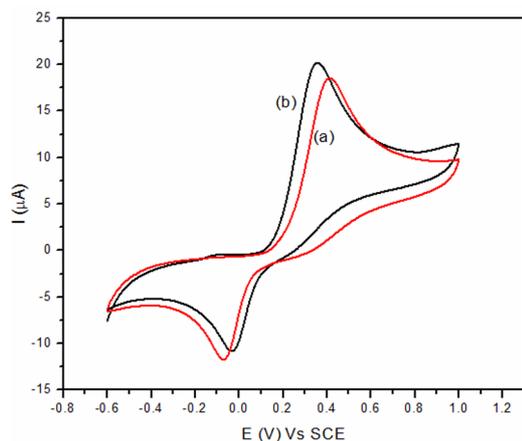
Figure 3. Cyclic voltammogram of catechol at
(a) bare glassy carbon electrode
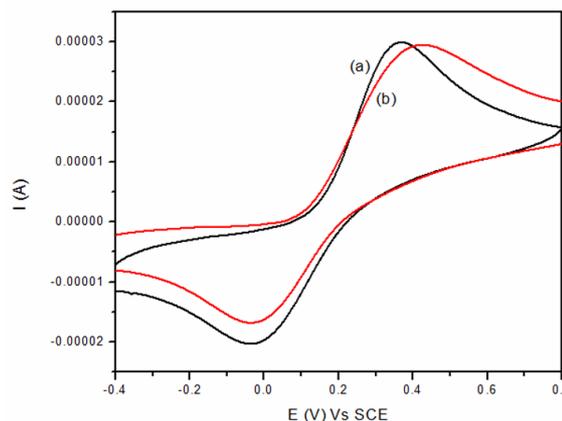(b) chitosan- silver/ Glassy carbon electrode.

Figure 4. Cyclic voltammogram of Ferrocyanide at
(a)bare glassy carbon electrode
b) chitosan- silver/ Glassy carbon electrode.

KCl was used as the background electrolyte for the measurements. It is evident from Fig.3 that the electrode modified with Chitosan –Silver (5wt%) can sense Catechol whereas it is evident from Fig.4 that using $Fe(CN)_6$ as a redox probe is not suitable .

Catechol adsorption is favored due to the formation of hydrogen bonds between Catechol and Chitosan present in the prepared sample. No such favorable phenomenon is seen to occur while using Ferro cyanide which is clearly seen from the observed behavior. Hence electrode modified with the prepared sample can be used for sensing catechol effectively.

Conclusion

Chitosan–Silver nanocomposite containing 5wt% Silver has been successfully synthesized and characterized using XRD, FTIR and FESEM. The XRD pattern confirms the formation of nanocomposite containing Chitosan and Silver, at the same time confirming the absence of any impurity phases. FTIR has been used for the elucidation of molecular structure. FESEM images clearly show that silver is embedded in a matrix of Chitosan. It also shows that the size of the Silver particles is in the nano range. The ability of the sample to detect catechol has been established using the cyclic voltammetry technique.

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