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Silver Nanoparticle Filled HPMC and Xanthan Films for Food Packaging and Safety

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Abstract

Majority of materials employed for food packaging are non-bio-degradable. This however does not meet escalate demands in society for sustainability and environmental safety. Many biopolymers have been exploited to develop biodegradable food packaging materials. Regardless, the usage of biopolymers has been limited due to the poor mechanical and barrier properties. To enhance these properties, Silver nanoparticles were synthesized by sodium borohydride using reduction method and are doped into bio-composite membrane of HPMC and Xanthum gum to form bio-nanocomposite membrane. SEM, TEM, FTIR, UV-VIS spectra and XRD can be done to have characteristic peaks of Nano-bio-composite membrane. This composite film is studied for its mechanical solubility, thermal, structural and antimicrobial property.

Keywords: Hydroxy Propyll Methyl Cellulose, Nano Bio Composites, Silver Nano Particles, Xanthangum

1. Introduction

The physical characteristics required in packaging depend on what item will be packaged as well as on the environment in which the package will be stored. The use of protective coating and suitable packaging by the food industry has become a topic of great interest because of its potential for increasing the shelf life of many food products. Cellulose derivatives such as hydroxypropyl methylcellulose (HPMC) are promising materials for edible coatings or films for packaging. HPMC is a water-soluble polymer used in the food industry as a gelling and stabilizing agent and xanthan gum is already present in food industry for gluten free product[1]. Xanthan gum is a natural polysaccharide and an important industrial biopolymer. It was discovered in the United States Department of Agriculture[2]. The xanthan gum (polysaccharide B1459) produced by the bacterium Xanthomonas campestris (NRRL B-1459) was extensively studied because of its properties that would allow it to supplement other known natural and synthetic water-soluble gums. The antibacterial activity of silver nanoparticles is influenced by the size of the particles. Nanosized fillers (less than 100 nm) have been used to enhance the performance of the biopolymers[3]. The nanofillers that are commonly studied for food packaging applications can be classified into few types which include nanoparticles.

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To the best of our knowledge, no study has been done to compare theproperties of the bio-nanocomposite materials prepared from different classification of nanofillers[4]. Researchers used different types of filler and biopolymer to produce bio-nanocomposite materials and they studied different properties of the produced bio-nanocomposite membrane for food packaging.

2. Structure of HPMC and Xanthan Gum

Hpmc (hydroxypropyl methylcellulose) semisynthetic, inert, viscoelastic polymer, whereas xanthan gum is Identical to that of cellulose. Trisaccharide side chains contain a D-glucuronic acid unit between two D-mannose

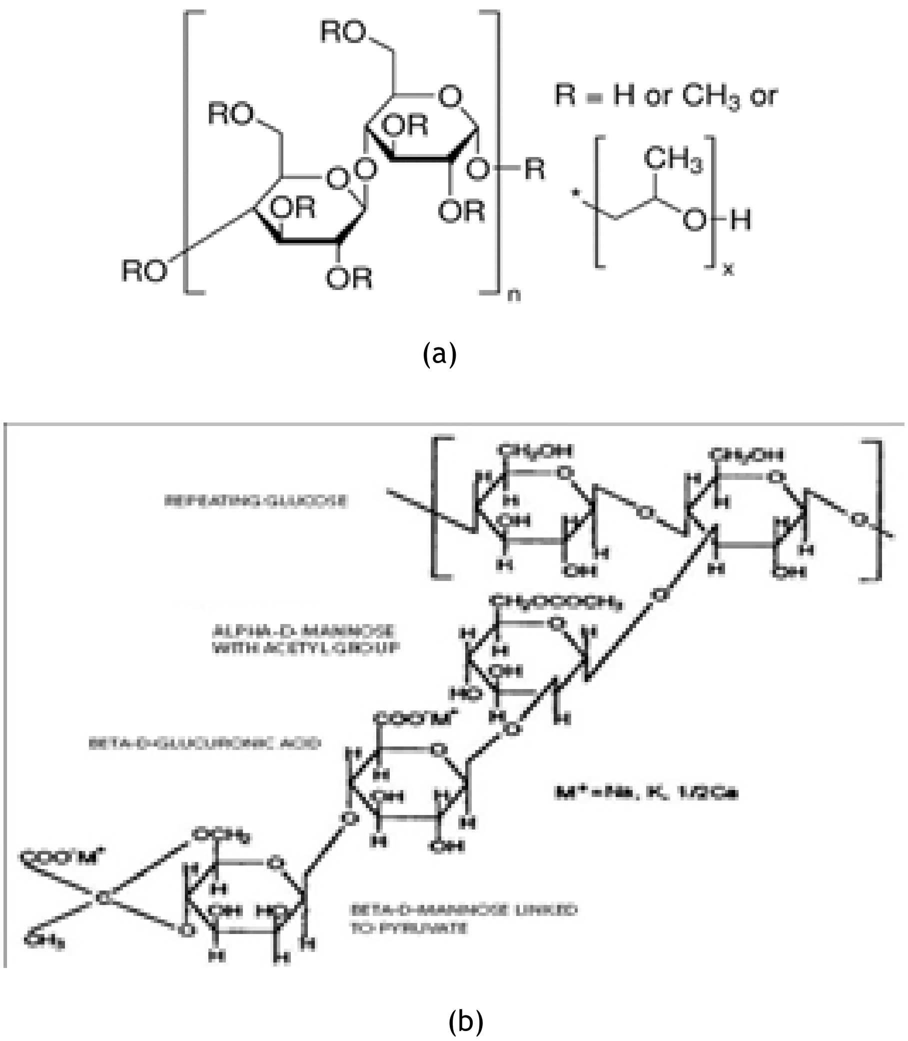


Figure 1. (a) HPMC (11) (b)Xanthan (12)

units linked at the O-3 position of every other glucose residue in the main chain (Figure 1).

3. Characterization

FTIR offers quantitative and qualitative analysis for organic and inorganic samples. Fourier Transform Infrared Spectroscopy (FTIR) identifies chemical bonds in a molecule by producing an infrared absorption spectrum. Fourier transform infrared (FTIR) spectra of HPMC, xanthan and different nanocomposite films were obtained using a Spectrum[5] in the range from 4,000 to 400 cm^{-1}. Optical properties and transmittance of the different nanoparticles-incorporated films were analyzed using a UV–Vis–NIR spectrometer. The structure and size of prepared particles were determined by X-ray diffractometer. Antibacterial activity was screened using Kirby– Bauer disk-diffusion method using Mueller–Hinton agar as a medium[6]. Statistical analysis can be done by the mean and standard deviations for the obtained results of antimicrobial activity and preservation studies were calculated from triplicate samples, and their corresponding error bars were obtained.

3.1 Film Thickness and Solubility

Digital micrometre is the instrument used for measuring the thickness of the film at five random-selected parts of the films. The water solubility of the prepared films was determined. The solubility and swelling property of the film at different PH can be determined by using spring scale. The properties such as improved quality, freshness, safety, and extended shelf life along with antimicrobial activity of nanoparticles-incorporated films for food preservation are explored in light of the textural and organoleptic levels of fruits such as grapes and plums.

3.2 Antibacterial Effect

Two selective food pathogenic bacterial isolates, namely Salmonella, Klebsiella, Bacillus, and Pseudomonas were obtained from Centre for Advanced Studies in Botany (Chennai, India) and maintained in suitable agar slants two. Antibacterial activity was screened using Kirby–Bauer disk-diffusion method (Kerch et al. 2011) using Mueller–Hinton agar as a medium. The prepared film samples were loaded into Petri plates and then incubated at 37^{O}C for 24 h. The loaded HPMC films were used as a control. After incubation, the inhibition zone around the film samples was measured with a transparent ruler.

3.3 Preservation Study

Fresh grapes and plums of equal size were used in this study. Five grapes and plums were randomly selected and washed with deionised sterile water and then dried. Out of these, few fruits of each having approximately equal size and shape were selected. All the selected fruits were wrapped and packed using different nanomaterials-doped XGHPM films. The packed fruits were stored in paper box in an air atmosphere at room temperature. These fruits were checked daily for sensory change. Initial weight (W0), Final weight(W) (Figure 4).

$$\text{Weight loss (\%)} = (W_o - W)/W_o \times 100$$

4. Methodology Used

Synthesis of nanoparticle is done by reduction method and hpmc and xanthan gum film are formed from ionic-gelation method. Doping of nanoparticles into bio composite membrane.

5. Experiment

5.1 Preparation of Silver Nanoparticles

The silver nanoparticles are formed from Tri-sodium citrate using chemical reduction method.

50 ml of 0.001M AgNO3 was heated to boil (Figure 2). To this solution 5ml of 1% trisodium citrate was added

drop by drop. The solution is mixed vigorously and heated until change of color was seen(pale yellow). After this sample was removed from the heating device and stirred until it get cooled to room temperature[7].

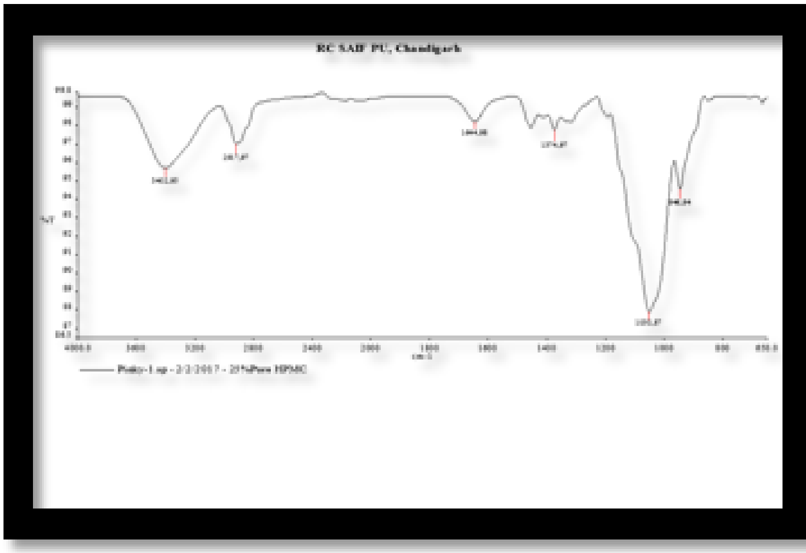
5.2 Synthesis and Casting of Film

Hydroxypropyl methylcellulose (HPMC) and Xanthan gum (XG) was dissolved in distilled water (100 ml) under magnetic stirring for 12 h at different ratio. The test films were obtained by adding HPMC and Xanthan gum in 100 ml of the prepared nanoparticle solution with 1 wt.% of dopant under weight of the dry matter (Figure 3). This gel is then casted into cell culture disk and dried into room temperature.

6. Results

Figure 2. Silver nanoparticles solution.

(a)



(b)

Figure 3. Bio composite membrane(hpmc+xanthan).

6.1 Ftir Results of Pure Hpmc

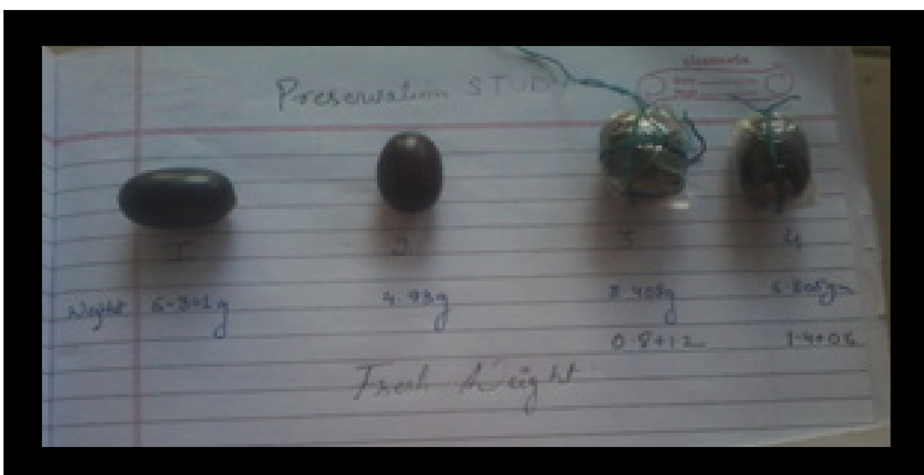


Figure 4. Preservation study of fresh grapes.

7. Conclusion

Silver nanoparticles are synthesized via crosslinking with Trisodium citrate by ionic gelation method. To the 2 wt% of Xanthan-HPMC films. Ag of equal ratio is added and casted into films. The preservation study carried out on selected fruits reveals that the shelf life of the grape fruit preserved using the silver nanoparticle and silver, Xanthan-HPMC films is extended for 5 days with good sensory and textural qualities compared with others. Thus, the nanocomposite HPMC and Xanthan gum films incorporated with Ag show better solubility, increased mechanical and thermal properties, good antibacterial properties, and reduced decay index.

8. Acknowledgement

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