

Synthesis of Chitosan-Silver Nanocomposite Films through Green Method

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ABSTRACT: Today, the green methods of nanomaterial's production have developed greatly due to their biocompatibility. In this study chitosan-silver nanocomposite films were produced through silver photochemical reduction method in an acidic chitosan solution which is a novel, inexpensive, and quick way to produce chitosan films loaded with silver particles. In this method, chitosan polymer was used as a condenser and stabilizer substance for silver ions. The nature of nanocomposite was determined by using a Scanning Electron Microscope (SEM) and UV-VIS Spectrophotometry. These films can be utilized for medical purposes.

KEYWORDS: Green Method, Chitosan-silver Nanocomposite, Reductive, Film.

I. INTRODUCTION

Silver nanoparticles have been studied extensively due to their unique anti-microbial properties, catalytic activity, and good surface plasmon resonance. In recent years, the antimicrobial properties of silver nanoparticles against many pathogens have been assessed in various studies and excellent results have been achieved [1]. Silver nanoparticles affect various targets in bacteria cells. For instance, on the one hand, by bonding with sulfhydryl groups (SH), phosphate, imidazole, proton energy as well as proteins with negative surface charge they cause massive proton leakage and membrane destruction, and on the other hand, by bonding with a bacteria's proteins and enzymes they cause its transformation and destruction. Silver ions block the bacteria's respiratory chain in cytochrome oxidase and NADH-succinate dehydrogenase and can also enter the bacteria cell and bond to its DNA, preventing its proliferation [2].

Chitosan is a linear compound amino polysaccharide from the randomly scattered (1 -> 4) bonds of units D - glucosamine and N- Acetyl- D - glucosamine and is obtained from the shells of marine crustaceans such as shrimp and crab through deacetylation of alkaline chitin units. The antimicrobial action mechanism of chitosan involves chitosan's polycation nature interfering with the negative charge of macromolecules of cell surfaces, entering the bacterial cell body and preventing transcription, preventing lipid II synthesis and therefore preventing the transmission and bonding of cell wall peptidoglycan subunits, stimulating the K⁺ efflux pump and causing all vital potassium in bacteria's cytoplasm to move out [3].

Chitosan-silver nanocomposite possesses great antimicrobial properties due to containing both compounds [4] and through its multiple antimicrobial mechanism targets different parts of the bacteria's cell body, and bacterial resistance against it forms hardly. Besides its antimicrobial mechanism, chitosan-silver nanocomposite also possesses antifungal properties and used cutaneously [5]. In the chitosan-silver nanocomposite, silver nanoparticles bond with this biopolymer through amine chitosan groups. In fact, chitosan acts as a reductive agent on silver. In this study the production of chitosan-silver nanocomposite films was carried out in a green way through photochemical reduction reaction and using a chitosan acidic solution, without any chemical reductive agent.

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II. MATERIAL AND METHODS

50 milliliter of 1% Chitosan HMW (Sigma Aldrich, cas number: 9012-76-4) was prepared in a 1% acetic acid solution and was stirred for 10 minutes using a magnetic stirrer in a temperature of 70 ° C to dissolve chitosan completely, then it was placed in an electric oven in a temperature of 70 ° C for an hour. The flask containing the chitosan was placed on the magnetic stirrer and 100 mg of silver nitrate (Sigma Aldrich, cas number: 7761-88-8) was gradually added to it and then was placed in an open area under sunlight. A change of color from cream to dark brown indicates the formation of silver nanoparticles. Then, in order to prevent the aggregation of silver nanoparticles the flask was placed for 10 minutes in a 100 watt ultrasonic bath. Later on, all the flasks content was poured in the bottom of a square-shaped Pyrex glass container and placed in a dry-heat oven for 10 minutes until it completely dried. Then 50 ml of 1 molar NaOH was prepared and poured onto the dried film in the Pyrex container and was placed in dry-heat oven a second time. After separating the film from the container bottom, it was washed with distilled water three times and was cut into 5x5 pieces and was sterilized under UV light in a Petri dish for 20 minutes [6].

III. RESULTS & DISCUSSIONS

1. Sample Morphology

The morphology of the produced film was observed using a scanning electron microscope (SEM) (figure 1-a). Silver nanoparticles have been produced in a spherical shape and their average size was seen to range between 10 and 20 nm. The existence of glycosidic bonds in all straight-chain polysaccharides is notable as a characteristic. In the sample (figure 1-b), the overall surface of the nanocomposite was observed as a uniform structure which indicates the presence of chitosan, and silver nanoparticles were also observed on the nanocomposite surface.

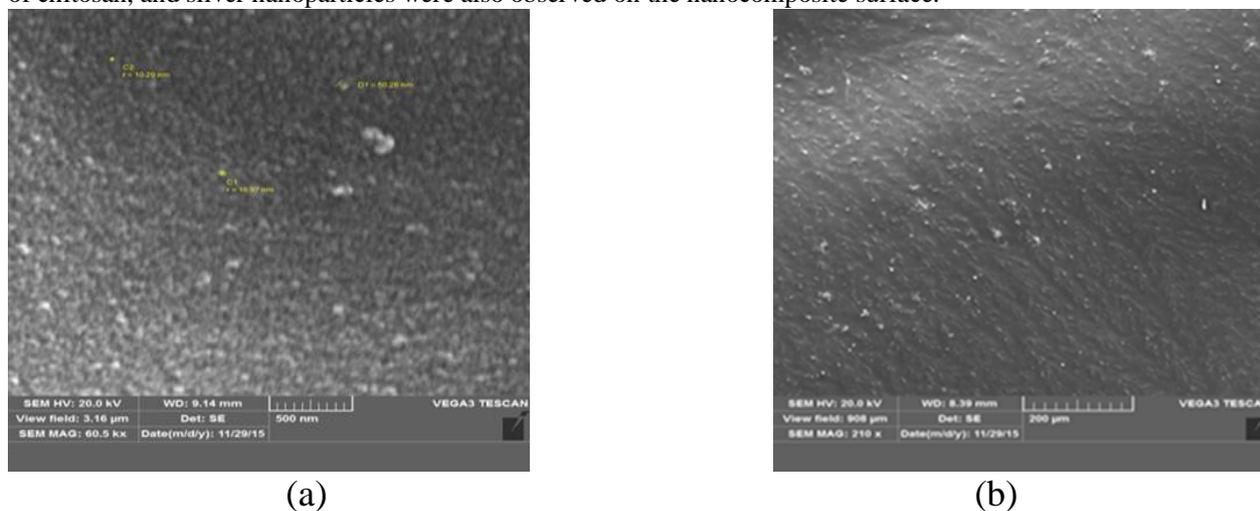


Fig 1: The SEM image of the chitosan nanocomposite film(a) 500 nm magnification displaying silver nanoparticles sized around 10-20 nm,(b) 200 μm magnification displaying the uniform nanocomposite surface structure

2. UV Spectrophotometry

Spectrophotometry results of chitosan-silver nanocomposite shows a peak at 400 nm which is indicative of the presence of silver nanoparticles and another peak exists at 320 nm which indicates the presence of chitosan (figure 2). The results of spectrophotometry fully confirm the SEM observations.

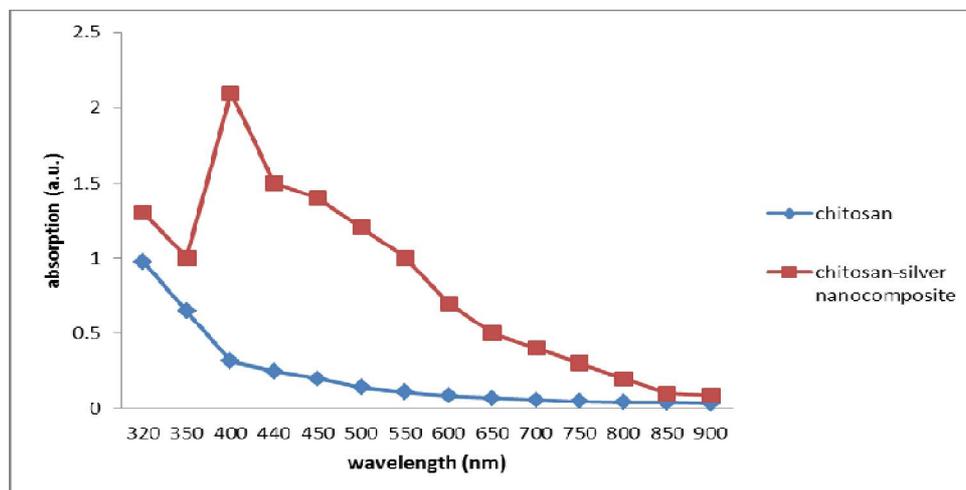


Fig 2: examining chitosan-silver nanocomposite and chitosan using UV spectrophotometry. Vertical axis shows absorption levels and horizontal axis shows wavelength in nanometers.

Kanikireddy Vimala et al. using the photochemical reduction method and were able to produce a chitosan-silver nanocomposite film by adding polyvinyl alcohol and glutaraldehyde, which its nanoparticles generally measured to be 16.5 nm in size [7], but the produced film cannot be classified as a green product due to the presence of polyvinyl alcohol and glutaraldehyde whereas the nanocomposite film produced with this study's method includes no chemicals and enjoys a green production method.

Nguyen Thi Ngoan et al. were able to reduce silver nanoparticles using curcumin and the chemical reductive of sodium borohydride (NaBH₄) and produced silver nanoparticles with curcumin coating and sizes of 20 nm and ranging generally between 10 and 50 nm [8], however the produced nanoparticles in this method, too, do not belong to the category of green products due to making use of chemicals.

Varsha Thomas et al. produced chitosan-silver nanocomposite films through photochemical reduction method and in a green way [9], but produced chitosan from chitin through deacetylation and therefore when exposed to sunlight, a one-hour period was needed for the color change and formation of silver nanoparticles. Due to the production of deacetylated chitosan 99% with high molecular weight, the nanocomposite produced in this study needs less than 5 minutes to change color and form nanoparticles.

In addition to the green production method, the nanocomposite produced through the method introduced in this paper also has other advantages such as saving time in comparison to the other green synthesis methods like nanoparticle production using bacterial and fungal extracts which require a period of several days, also the price of this nanocomposite is lower than the products made through chemical methods since there will be no need to use expensive chemical reductives.

IV. CONCLUSION

The chitosan-silver nanocomposite in this study was produced using no chemical reductive substance and can be used for medical purposes due to its antimicrobial properties. The results obtained from SEM observation and spectrophotometry indicate the presence silver nanoparticles with sizes of about 10-20 nm and the general size of below 50 nm in this nanocomposite.

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