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RESEARCH ARTICLE

Chitosan Nanoparticles: An Approach to Sustainable Living

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ABSTRACT

Chitosan is a linear polymer extracted from sea waste; and shrimp shells. Chitosan shows fungicidal effects and can act as a defense mechanism in plant tissue; it has become a valuable and highly appreciated polymer as a naturally biodegradable high molecular polymer compound, a non-toxic and bioactive agent. Chitosan-based Nanoparticles are preferably used worldwide for various applications focusing on their biodegradability, high permeability, non-toxicity to humans, and cost-effectiveness. Green synthesis is a newly emerging field of nanobiotechnology that offers economic and environmental advantages. Chitosan Nanoparticles were synthesized using a plant-based method. Plant extracts of Neem leaves were used with chitosan for the synthesis of Neem based Chitosan Nanoparticles. The biosynthesized Neem based Chitosan Nanoparticles were scanned to detect the absorbance peak using a UV/Vis spectrophotometer between the wavelengths of 200 and 400 nm. FTIR and SEM analysis for nanoparticles was performed. These Neem based Chitosan Nanoparticles can efficiently release nutrients in the soil and can probably inhibit the fungal and bacterial contamination of soil. Resulting in increased the yield, and lower the cost of crops.

Keywords: Neem based chitosan nanoparticles, UV-Vis spectra, FTIR, SEM analysis, antibacterial and antifungal activity.

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INTRODUCTION

The study of molecules and particles with sizes between one and one hundred nanometers is the focus of nanoscience. The origins of nanoscience may be traced in the fifth century B.C., to the Greek scientists who contemplated, whether substance is continuous or composed of indivisible units, particularly which are now called atoms. Utilizing the principles of nanoscience, nanotechnology delivers useful applications by carefully applying the scientific process at the nanoscale (Chau et al., 2022; Narayanan et al., 2022a). When compared to the foundation material from which they originate, nanosized materials may exhibit enhanced or unexpected features. Numerous manufacturing methods (evaporation–condensation, top-down, laser ablation, microbial, fungal, etc.,) and potential applications (waste water treatments, electronics, textile industries, and medicinal, pharmaceutical, cosmetics, etc.,) (Sheng et al., 2022; Narayanan et al., 2022b; Prema et al., 2022; Ahmad et al., 2019) have been uncovered via extensive study on both inorganic and organic nanoparticles. Nevertheless, as of yet, it's important to note that there have been concerns raised about their impact on the environment and the human body. However, polysaccharide-based NPs are proven to be safe for the environment and have minimal relation to concerns about toxicity, biodegradability, or physiological stability. A dependable, environmentally responsible, and sustainable method of producing nanoparticles is through green synthesis (Tatarchuk et al., 2021; Youssef et al, 2017; El-Naggar et al 2022).

Chitosan is an amino derivative of the polysaccharide chitin, which is naturally bonded to the proteins in cellular structures such as fungal cell walls and the shells of invertebrates (Lodhi et al., 2011; Zhang et al 2021). The chitin is been purified through acidification and alkalization before being N-deacetylated to chitosan in an well-established controlled environment. Chitosan facilitates the opening of cellular epithelial tight junctions, which increases penetration and helps with both passive as well as active drug transport (Olecg et al., 2012).

The existing research indicates that the characteristics of chitosan nanoparticles (NPs) might range significantly based on the surface modification and preparation processes employed, thus opening up new application areas (Roy et al

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2010; Soni et al., 2013). The medical sector has undergone a great deal of scrutiny. Aside from the tremendous progress in medical over the last few decades, scientists have focused on a variety of uses, including wastewater treatment, agriculture, and cosmetics. Furthermore, chitosan nanoparticles (NPs) can be utilized as an additive for biodegradable plastics matrixes that require enhancement in their mechanical and barrier qualities. Possessing a positively charged surface, chitosan and chitosan-derived nanoparticles can attach to mucosal tissues, facilitating the continuous release of the therapeutic carrier (Duraisamy et al., 2022). Research conducted both in vitro and in vivo has confirmed that chitosan-based nanoparticles are biocompatible. These characteristics make them useful for treating disorders linked to digestion, treating cancer, treating pneumonic diseases, treating eye infections, and administering medications to the brain non-parenterally.

In light of the aforementioned assertions, we endeavoured in this study to create plant-based chitosan nanoparticles using fresh neem leaves. Our findings were subsequently validated by UV-VIS spectrophotometry and further identified through SEM analysis. FTIR analysis was also used to validate the functional groups.

MATERIALS AND METHODS

Preparation of neem leaves extract:

300 mg of fresh *Azadirachta indica*, or neem, leaves were gathered, and each leaf was carefully cleaned with tap water. Afterwards, these leaves were once again washed with distilled water, and a mortar and pestle were used to make a thin paste. After the paste was formed, 100 milliliters of D/W was combined with it and heated to 60^{o}C for twenty minutes. Muslin cloth was used to filter this mixture, and it was centrifuged for 20 minutes at 1000 rpm. The supernatant was collected and kept for further use.

Preparation of chitosan nanoparticles

The plant extract and 1% chitosan solution were combined in test tubes in a 1:1 ratio making total volume of 50ml. For twenty-four hours, the tubes were stored in a dark environment. the resultant solution was centrifuged for 15 minutes at 5000 rpm. The nanoparticle pellet was collected and five times washed with deionized water. Later, UV-VIS spectroscopy was employed to characterize it. Here plant extract was kept as a control.

UV-VIS spectroscopic analysis of plant-based chitosan nanoparticles

The purified nanoparticles were exposed to analysis of UV-VIS spectroscopy in the range 200nm to 800nm wavelength using UV-VIS spectrophotometer make. And the spectra was analysed.

FTIR analysis of plant-based chitosan nanoparticles

For this analysis the nanoparticles were analysed in the range of 6000cm^{-1} -800 cm^{-1} wavenumber. Here chitosan was used as control to compare with that of plant based chitosan nanoparticles.

SEM analysis of plant-based chitosan nanoparticles

The powdered sample of chitosan nanoparticles was sent for SEM analysis to Instrumentation analysis section, SPPU, Pune.

RESULTS AND DISCUSSION

Preparation of Plant based chitosan nanoparticles

The neem plant extract was added in 1% of chitosan solution in 1:1 ration and kept at dark for 24 hours. Later it was observed that the color of the solution changed from light green to dark brown indicating the formation of chitosan nanoparticles. Nigam et al (2022), also performed similar experiment of formation of chitosan nanoparticles using leaves, stem and roots of *Clitoria ternatea* leaves. They obtained pale yellow, greenish and brownish color nanoparticles. This indicates that the color of the chitosan nanoparticles prepared using plant based vary with the use of extract.

UV-VIS spectroscopic analysis of plant-based chitosan nanoparticles

Using UV-VIS spectroscopy, the pure chitosan nanoparticles were examined, and the sample was scanned between 200 and 800 nm in length. The absorbance peak at 235 nm in Figure 1 is indicative of the chitosan nanoparticle production. The chitosan absorption peak was found to be at 295 nm, suggesting a shift in the position of peak. the result of present finding was in accordance with the peak at 250 nm found by Thamilarasan et al. (2018). According to Rai et al. (2017), 320 nm is the absorption peak of chitosan nanoparticles. According to reports, the presence of the group CO has caused the chitosan nanoparticles' UV–visible spectrum to vary between 200 and 322 nm (Duraisamy et al., 2022).

FTIR analysis of Plant based chitosan nanoparticles

FTIR analysis the spectra of chitosan nanoparticles were compared with the standard chitosan. In the Figure 2 representing the standard chitosan, exhibits characteristic vibrational bands at 3333.43 cm which is associated to O-H stretching which is a primary functional group of chitosan, 1636 cm peak corresponds to C=O stretching of amide (Varun et al., 2017), 1419.38 cm is associated to C-H bending and 1278.48 cm corresponds to C-OH vibrations (Hong et.al., 2021; Fernanades et al., 2014). On contrary to this when the FTIR spectra of neem based chitosan nanoparticles was studied (Figure 3), multiple peaks other that the chitosan were observed. The peaks at 3412.72, 3204.98 and 3047.01 shows the stretching vibrations of amino and -OH groups. The peak at 2377 is related to symmetric stretching of C-H, 1628.77 is due to stretching of amide I group, 1328.23 is for -NH2 bending. And the peaks between 1200 to 850 represents stretching of amid III. The results of current findings are parallel to the FTIR results obtained by Dursaisamy et al., (2022) and Abdallah et al., (2020), plant materials for synthesis of chitosan nanoparticles. These findings imply that the most effective chemicals in M. annua's ethanol extract are those that can convert chitosan from its natural form into chitosan nanoparticles. The reduction, capping, and stability of chitosan

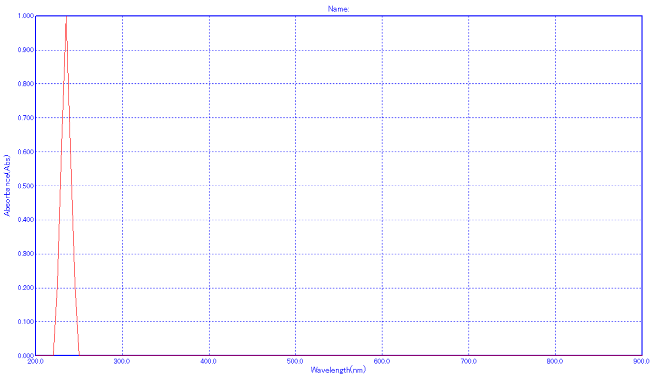

Figure 1: UV-Vis Spectroscopic analysis of Plant based chitosan nanoparticles

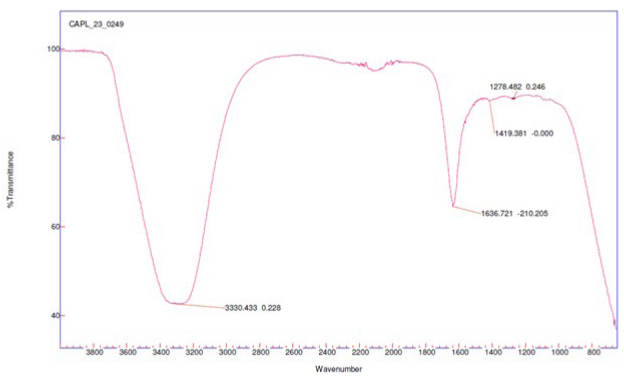

Figure 2: FTIR spectra of Standard Chitosan

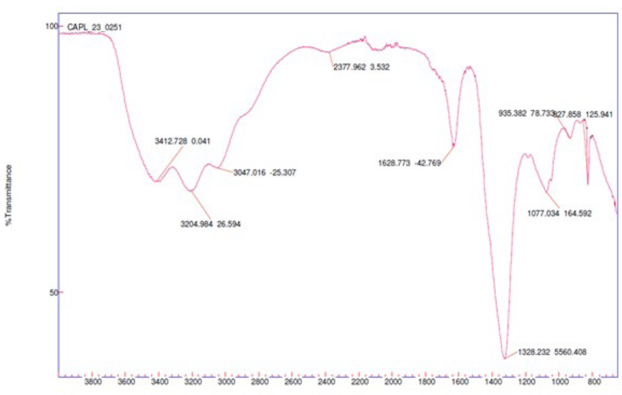

Figure 3: FTIR spectra of Neem based chitosan nanoparticles

nanoparticles are facilitated by the presence of terpenoids, polyphenols, and flavonoids as important functional groups (Singh et al., 2018).

SEM analysis of plant-based chitosan nanoparticles

SEM analysis of the chitosan nanoparticles was done from Instrumentation analysis section in SPPU, Pune. Figure 4, exhibits the structure of nanoparticles, which are spherical shape and particles size was in the range of 13 to 25 mm. Manne et al. (2020) stated that *Pterocarpus marsupium* heartwood extract was used to create spherical-shaped CNPs, which ranged in size from 90 to 110 nm. According to Shetta et al.

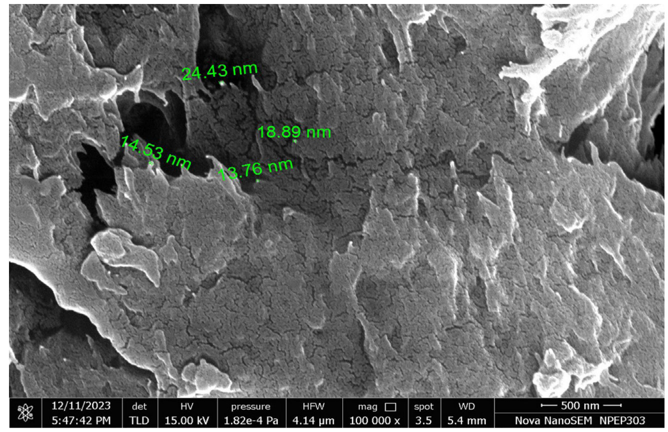

Figure 4: SEM analysis of plant-based chitosan nanoparticles

(2019), the pure and original chitosan particle size was typically up to 350 nm. Similarly, plant extracts were used to create 200–350 nm-sized spherical-shaped CNPs, according to Ilk et al. (2017). The concentration utilized and the synthesizing parameters (such as reaction time) followed for the manufacture of MA-CNPs determine the size and form of the resulting particles (Garavand et al., 2022).

CONCLUSIONS

Owing to multiple advantages of chitosan, in current study an attempt was made for plant-based synthesis of chitosan nanoparticles for which fresh neem leaves were selected. Later, the formed chitosan nanoparticles were confirmed using UV-Vis Spectroscopy and SEM analysis revealed that the nanoparticles were spherical in shape and range in 13mm-25mm size. FTIR analysis was used to confirm the different functional groups attached to chitosan nanoparticles. From this study it is suggested that, plant based nanoparticles if made form fresh leaves gives small sized nanoparticles which are very stable in nature.

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