Original Article

Journal of Pharmaceutical and Medicinal Chemistry
Volume 6 Number 1, January–June 2020
DOI: http://dx.doi.org/10.21088/jpmc.2395.6615.6120.1

Synthesis and Characterization of Chitosan Stabilised Zinc Oxide Nano Particles: An Efficient Nano Composite for Wastewater Treatment

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How to cite this article:
Anitta Antony, Ajil PA, Jaya T Varkey. Synthesis and Characterization of Chitosan Stabilised Zinc Oxide Nano Particles: An Efficient Nano Composite For Wastewater Treatment. J Pharmaceut Med Chem. 2020;6(1):5-8.

Abstract

Nano ZnO(Zinc oxide) as antibacterial agent received many versatile features because of its inexpensive, non toxic and has eco friendly nature. Zinc Oxide nano (ZnOnano) particles are commonly applied in pollutants removal and disinfectants, because of its high chemical stability and poison less characteristics. The addition of metal based particles into polymers is a versatile route to take advantage of their strong antimicrobial properties producing novel biocide materials and allowing a further extension of the range of applications. There are several useful features of Chitosan, such as non-toxicity, hydrophilicity, biocompatibility, biodegradability and antibacterial property which make it as a versatile material in many biomedical applications. The combining of polymer such as Chitosan and ZnOnano particles to form films or hydro gel materials have further advantages such as non aggregated nature and recyclablilty. The proposed approach can stabilise ZnOnano particles in Chitosan matrix by an alkaline solidification process. The fabricated ChitosannanoZnO composite has potential for many-sided applications such as bactericides, polluted water treatment andbiofouling.

Keywords: Chitosan, ZnOnano, composite, antibacterial, biodegradable

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Introduction

The uses of nano particles as antibacterial agents have been widely investigated.[1] The antibacterial impact of nano particles is due to the damage of DNA and the proteins found in the cell.[2-3] The nano particles tend to react with sulphur containing proteins and phosphorous containing DNA. It has been observed that metal oxide nano particles exhibit excellent biocide action against gram positive and gram negative bacteria[4] The toxicity depends on both the exposure method and the size of the metal nano particles. ZnO nano particles have been found to exhibit wide application in multiple fields. It has been found to exhibit interesting properties such as high surface reaction activity, high catalytic efficiency and strong adsorption ability that make them potential candidate for various applications. ZnO is an inorganic material with wide band gap semiconductor[5-6] so it has great potentials for many practical applications such as dye sensitised solar cells, piezoelectric transducers, UV light emitters, chemical and gas sensors and photo catalysis.[7] It also exhibits intense UV absorption and can potentially be utilised as UV shielding materials and as antibacterial agents.[8] ZnOnano particles with inexpensive and relatively less toxic property exhibit excellent biomedical applications, such as anticancer, drug delivery, antibacterial, and diabetes treatment.[9] ZnOnano particles have been employed as a powerful heterogeneous catalyst during several organic

transformations[10-15] because of their inexpensive, non toxicand eco friendly nature. Further more it also extensively used in textile industry and in various cosmetics or sunscreen lotions that protect human skin from dangerous UV rays. ZnOnano particles are commonly applied in pollutants removal and disinfectants, because of its high chemical stability and poison less characteristics.[16] The addition of metal based particles into polymers is a versatile route to take advantage of their strong antimicrobial properties producing novel biocide material and allowing a further extension of the range of applications. In this context metal nano particles emerge for the production of a broad range of polymer nano composites with a high release of metal ions and therefore antimicrobial behaviours. The combination of polymer and ZnOnano particles to form films or hydro gel materials have further advantages such as reusable non aggregated and recyclable. The proposed approach can stabilise ZnOnano particles in Chitosan matrix by an alkaline solidification process. The fabricated Chitosan ZnOnano composite has the potential for multifield applications such as bactericides, water pollutant treatment and others. Chitosan is a biopolymer and is hydrolysed derivative of chitin containing high amount of amino and hydroxyl functional groups and possessvery high adsorption ability of metal ions organic acids and pesticides.[17-19] There are several useful features of Chitosan such as non-toxicity hydrophilicity, biocompatibility, biodegradability and antibacterial property which make it as a versatile material in many biomedical applications.

Materials and methods

All reagents were provided by Sigma Aldrich Company. The FTIR spectra were recorded on a Bruker IFS-55 spectrometer using KBr pellets. The X- ray diffraction analysis (XRD) analysis was recorded on a Hitachi X-ray diffractometer using Cu Kα radiation.

Preparation of ZnO nanoparticles by calcination

ZnSO4 1.5 mol/L and NH4HCO3 (2.5 mol/L) were prepared in distilled water and 100 ml ZnSO4 solution was added to 126 ml NH_4HCO_3 solution while stirring and the reaction mixture was kept at 450 C. The slurry of basic $ZnCO_3$ in the form of white precipitate was obtained. It was then filtered, washed and dried. Finally ZnOnano particles were prepared by calcinating the precipitate at 5000 C for 1 hour.

Preparation of ZnOnano particles Chitosancomposite

Chitosan (0.2g~0.3g dissolved in 1% acetic acid solution, 7 ml) and zinc oxide nano particles (0.05g dried power) were mixed through constant stirring for 10 minutes to obtain the zinc oxide nano particle Chitosan mixture solution, which was then dropped into NaOH solution (20 wt%) by means of a motor pumped syringe. After 10 minutes ZnO nano particle Chitosan composite having a milk white colour was obtained. It was collected by centrifugation and washed twice with distilled water to remove any alkali.

Antibacterial study

An antimicrobial is a substance that kills or inhibits the growth of microorganisms such as bacteria, fungi, or protozoans as well as destroying viruses. The antibacterial studies were done by agar disc diffusion method against E. coli bacteria. The susceptibility of the bacteria E Coli, towards synthesised products were analysed by measuring the size of their zone of inhibition.

Characterisation

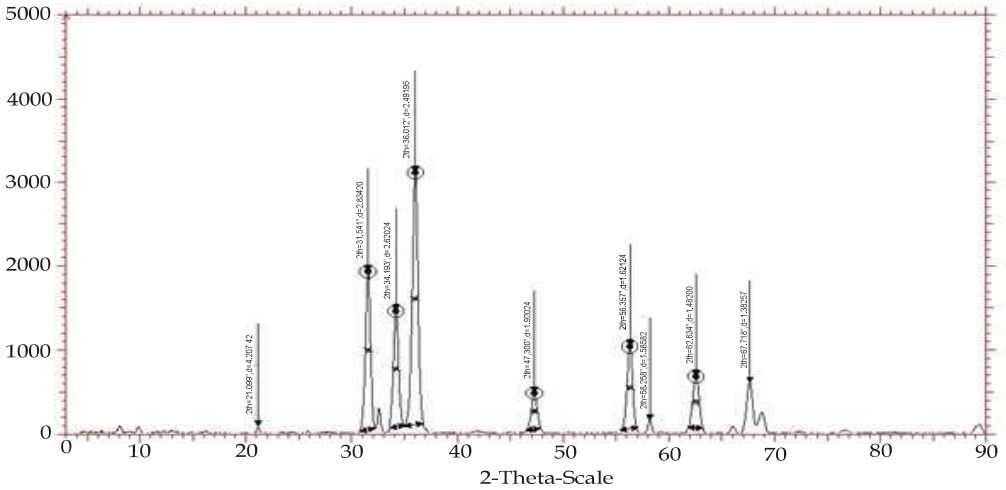
The prepared samples were characterised by X- ray diffraction analysis (XRD) and FTIR spectroscopy. Crystallographic study was carried out using Cu Kα radiations of wavelength 1.54 A 0. The FTIR spectra were recorded on a Bruker IFS-55 spectrometer using KBr pellets.

Results and Discussion

The antibacterial studies and results are shown in Image 1 and Table 1. The zone diameter of antibacterial activity of nanoZnO (ZN-1) is 19 mm. Chitosan (CH-2) shows no antibacterial activity against E coli. The nano Zinc oxide embedded Chitosan composite (CH-ZN 3) showed the zone diameter of 20 mm. Chitosan ZnO metal nano composite showed more antibacterial activity than nano ZnO. This could makeChitosanZnO metal nano composite find application in water purification.

Conclusion

In the present study, synthesis, characterisation and antibacterial activities of nano ZnO embedded Chitosan composite were investigated. The prepared samples were characterised by XRD



Graph 1: XRD spectrum of ZnOnano particle

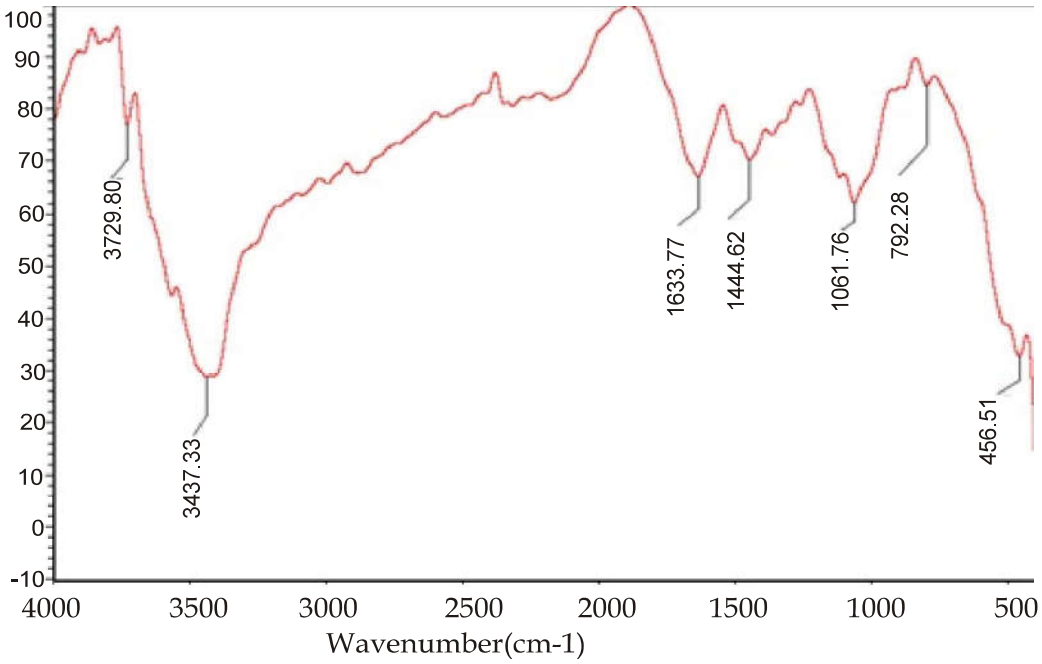


Fig. 1: FTIR spectrum ofChitosannano Zinc oxide composite

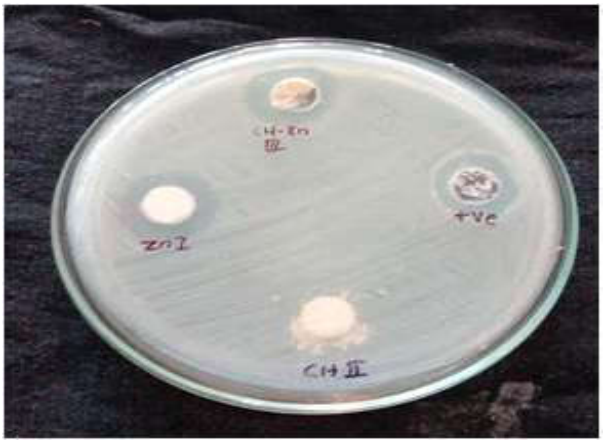


Image 1: Zone of inhibition against E.coli bacteria

Table 1: Antibacterial activity

Sample	Organism	Zone size	Positive control
ZN – 1	E.coli	19 mm	10mm
CH-2	E.coli	-	10mm
CH-ZN 3	E.coli	20 mm	10 mm

and FTIR spectroscopy. The antibacterial studies were done by agar disc diffusion method against E colibacteria. ZnO nanoparticles embedded Chitosan composite exhibit strong antibacterial activity against E Coli and the nano ZnO was assumed to be responsible for the high antibacterial performance of this composite. ZnO nano particles

initiating disorganisation of the cell membrane and damage them embrane by releasing the zinc ions and producing reactive oxygen species. Chitosan is a cationic polysaccharide having positive surface charges. It is attracted towards the negatively charged cell membrane of the bacteria and increased the attachment of nano ZnO embedded Chitosan and bacteria. This enhanced attachment results in greater exposure of nano ZnO with bacteria and hence exhibited strong antibacterial activity. This could make Zn Onano embedded Chitosan find applications in water purification by removing pathogenic E Coli bacteria. This property also assisted it to be used as a coating for reducing marine biofouling. These results demonstrate the potential for synthesized ZnO nano embedded Chitosan composites for use to clean contaminated drinking water.

Acknowledgement

We acknowledge the Department of chemistry, St. Albert's college (Autonomous), Ernakulamand the Department of chemistry, St. Teresa's college (Autonomous), Ernakulam for providing us the academic support and laboratory facilities. One of the authors, Anitta Antony acknowledges CSIR India for the financial support.

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