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Electro-spun nanofiber of carboxy methylcellulose-curcumin and its applications

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Abstract

Cellulose is a prominent scaffolding polysaccharide found in plants as micro fibrils which form the structurally strong framework in the cell walls. It has wide variety of uses such as attacking agent, emulsifier, stabilizer etc. Its use can be further enhanced by converting cellulose into cellulose derivatives. One of the most important cellulose derivatives is carboxy methyl cellulose (CMC). In the present study, cellulose is converted to CMC thereby preparing CMC – curcumin nanofiber by using electro spinning method. The functional groups identification was done by using UV Visible spectroscopy and FT-IR. Surface structure was analyzed by using Scanning Electron Microscopy. The antifungal activity was studied against *Aspergillus niger* and *Candida albicans*. . The antibacterial activities also studied for the samples against *E.coli*, *Klebsiella pneumonia, Streptococcus mutans and Staphylococcus aureus.*

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Introduction

Cellulose is the main constituent of cell walls of land plants including trees, shrubs and herbaceous plants. Chemically, cellulose is a polysaccharide made up of long, unbranched chains of glucose linked end to end making a very flat chain. Many cellulose chain associate sides by side to make a cellulose ribbon, or microfibril that has exceptional mechanical strength and chemical stability [1].

Cellulose chains have a strong tendency to aggregate and to form highly ordered structures and structural entities. The morphological structure of cellulose comprises a well-organized architecture of fibrillar elements. Morphology of the cellulose derivatives can be studied by electron microscopy techniques such as scanning (SEM) or transmission (TEM) electron microscopy. In the current study, SEM was widely used in the investigations of the morphological structures of the synthesized cellulose derivatives. Cellulose has found use in several industrial raw materials, food components, and house hold items. The most important use of pure cellulose include the production of paper and paper products, including news print, tissue paper, container board, packaging and related uses. Cellulose is also used for the manufacture of cotton products, such as items of clothing and industrial fabrics. Modified cellulose is also used as a filler in tablets. Banana fibers are rich in cellulose content. Banana fibers which are obtained from the dried stalk of banana trees, a waste product of banana cultivation, offer possibilities for engineering applications, including automotive [2]. Banana fiber possesses good specific strength properties comparable to those of conventional materials, like glass fibers. Furthermore, this material has a lower density than glass fibers. The main source of cellulose is from banana fiber. The chemical composition of banana fiber is cellulose, hemi cellulose and lignin. The noticeable characteristic is that it absorbs as well as releases moisture very fast. Moreover, it is biodegradable and has no negative effect on environment and hence considered as eco-friendly. Species such as Musa textiles are well known for their strong fiber qualities. Wild species like Musa balbisiana var. cola, Musa balbisiana var. andamanica existing in Andaman and Nicobar Islands are used for extracting fiber.

Pure cellulose additional treatment by HCL produced various cellulose derivatives. Based on solubility, cellulose derivatives are classified as (i) water soluble: hydroxyl propyl methyl cellulose, hydroxyethyl cellulose, hydroxypropyl cellulose (ii) water insoluble: ethyl cellulose, cellulose acetate phthalate. Based on chemical nature, cellulose derivatives are classified as (i) cellulose ester : cellulose acetate , cellulose triacetate , cellulose propionate, cellulose nitrate (ii) cellulose ether : methylcellulose , ethyl cellulose , carboxymethyl cellulose [3]. Among the cellulose derivatives, carboxymethyl cellulose (CMC) is the most widely used in the food packaging, food processing and pharmaceutical industries [4] due to its excellent film formability, biocompatibility, good gas barrier properties, hydrophilicity and stable internal network structure properties [5]. Carboxymethyl cellulose is a cellulose derivative that consists of the cellulose backbone made up of glucopyranose monomers and their hydroxyl groups bound to carboxymethyl groups. It is tackifier, at room temperature, it is

non-toxic, tasteless white flocculent powder. It is stable and soluble in water. The aqueous solution is neutral or alkaline transparent viscous liquid. It is insoluble in organic solvents such as ethanol. CMC is an important industrial polymer due to its high viscosity, non-toxic, non-allergenic, biodegradability as well as production at lower cost. Furthermore, it is a most important water soluble derivative with various applications in paper, food, detergents, cosmetics and textiles [6]. Curcumin is a polyphenolic molecule extracted from the turmeric which is derived from the rhizome of the plant curcuma longa, a yellow spice most commonly used as traditional ingredient of curry. The bright yellow-orange colour of turmeric comes mainly from fat-soluble polyphenolic pigments known as curcuminoids. Curcumin is soluble in ethanol and propylene glycol whereas insoluble in water and ether. For pH > 7, it is reddish brown in colour. For pH ~ 2.5, it is yellow in colour. It has melting point of 179 -182°C. Its chemical formula is C2H2006. Moreover, curcumin is hydrophobic in nature. It is also referred to as Indian saffron, yellow ginger etc. Several curcumin nano-formulations created a great impact on pharmaceutical applications and confirmed to have useful in the diagnosis of various human diseases [7]. Introduction of nanotechnology in curcumin provides and efficient solution in bio-availability and therapeutics. For one of the most dreadful disease 'Cancer', chemotherapy, radiation therapy and surgery are usually used which have harmful side effects. Therefore more safest and harmless treatment should be developed. Currently, the formulation of nanocurcumin enhanced the water solubility, bioavailability, systemic elimination, hence improved the specific tumour cell targeting to trigger the cancer tissues. Curcumin loaded chitosan nanoparticles helped to cure the infected animal with Plasmodium yoelii by blocking the synthesis of hemozoin. Curcumin loaded carboxy methyl cellulose has many biomedical applications. The curcumin loaded carboxy methyl cellulose nanofibers are synthesized by electrospinning technique. There are two ways in which nanofibers can be prepared by electrospinning technique- needle less and needle based. In needle- less electrospinning, the starting polymer solution is transferred to an open vessel where the fibers are generated from a stationary or rotating platform. But it has many disadvantages. In needle- based electrospinning, the spinning process starts when the solution is pumped at a constant flow rate and a specific voltage is applied to create an electric field between the needle tip and the collector. A charge accumulates at the liquid surface [8]. When the electrostatic repulsion is higher than the surface tension, the liquid meniscus is deformed into a conically shaped structure known as the Taylor cone. Advantages of needle-based technique include tightly controlled flow rate, number of jets and minimizing solution waste. These advantages of needle – based electrospinning have increased the popularity of this technique. This work focuses on the synthesis of cellulose from banana fiber and its subsequent conversion to CMC from which CMC-curcumin nanofibers are made.

Materials and Methods

Synthesis of CMC from banana fiber cellulose

Banana stem was obtained from local field of Thiruvananthapuram. The various chemicals used are of analytical grade. In the first step, Cellulose is extracted from plantain fiber. For that, 50g of banana fiber was taken and is heated for 30 min in a hot air oven. Then the fiber is treated with 50% NaOH, stirred and heated for 1.5 hours. After heating, the extract is washed with 50% alkali solution. The washings were repeated until the solution become completely neutral and it is dried in air oven at 70℃ for 2 h. After 2 hours, the extract is treated with oxalic acid solution and heated in a hot air oven at 60°C for 2 hours.

In the second step, 5g of cellulose is added to 150ml of isopropanol and is stirred well. 15ml (25%) NaOH added and stirred again for 1 hour. To the above solution, 6g MCA added and Stirred for 1.5 h. After complete stirring, the remaining extract is covered with an aluminium foil. It is then placed in an air oven and heated at 60°C for 3-5 hours. The slurry remained after heating is soaked in 100 ml of methanol and kept for one day. It is then neutralized with 90 % of acetic acid to pH 7 and filtered using Buchner funnel. The product is washed with 50 ml of ethanol and dried at 60 °C. The synthesized CMC is purified by dissolving 5g of CMC in hot 100 ml distilled water. The solution is stirred for 10 minutes. The solution is centrifuged for 1 minute (4000 rpm) and re-precipitated in 100 ml of acetone. Finally, the CMC was filtered and dried at 60 °C and kept in desiccator.

Electrospinning of CMC and Curcumin nanofibers

10 wt% solution of CMC in water, 10 wt% solution of PVA in water and 3.33 wt% solution of curcumin in chloroform/methanol were mixed by adding DMF. For spinning, the solution was loaded into a 5 mL standard polypropylene syringe attached to a 27 G bluntless stainless steel needle. The distance between the needle tip and the grounded collector (aluminium foil) is set at 20 cm. The solution is pumped at the rate of 1 mL/hour using syringe pump at 30 kV. Polymer droplet generated at the orifice of the needle were stretched and drawn into continuous nano fibers. Maintaining humidity and temperature at 22% and 25°C, nanofibers was collected on an aluminium foil and stored in dry containers.

Characterization of CMC and CMC - Curcumin blend nanofibers

The electronic spectra was done using Shimadzu CORP80282(Serial no. A16354) UV-Visible spectrophotometer. The functional groups in cellulose, synthesized CMC and CMC-Curcumin electron spun mats were determined using Perkin Elmer Fourier Transform Infrared Spectrophotometer. The surface morphology of the synthesized CM*C /* curcumin blend nanofibers was analyzed using an electron scanning microscope JEOL JSM-brand 5600LV under an accelerating voltage of 20kV. The antifungal activity of CMC / curcumin blend nanofibers was tested by Agar- well diffusion method. In this method, Potato Dextrose Agar medium (1L), Clotrimazole (standard antifungal agent, concentration: 10 mg/ ml) were used. Culture of test organisms and growth of culture were adjusted according to McFarland standard. 0.5 % *Aspergillus niger (*ATCC 16404) and *Candida albicans* (ATCC 10231) were used for antifungal studies. Culture medium was prepared by dissolving 39 g of the commercially available Potato Dextrose Agar Medium (HiMedia) in 1000 ml of distilled water. For

antibacterial studies, *E.coli* (ATCC 25922), *Staphylococcus aureus* (ATCC *2*59223), *Klebsiella pneumoniae* (ATCC 13883), *Streptococcus mutans* (MTCC 890) were used. The medium was prepared by dissolving 33.8 g of the commercially available Muller Hilton Agar Medium (MHI Agar Media) in 1000mL of distilled water. The dissolved medium was autoclaved at 15 lbs pressure at 121°C for 15 minutes. The autoclaved medium was mixed well and poured onto 100 mm petri plates (25-30 ml/plate) while still molten. Plates were prepared and allow overnight growth of fungal and bacterial species. Wells of approximately 10mm was bored using a well cutter and samples of different concentrations 250µg/ml, 500µg/ml, 1000 µg/ml were added. The zone of inhibition was measured after overnight incubation at room temperature and compared with that of standard anti-mycotic (Clotrimazole and Streptomycin).

Results and Discussion

UV-VISIBLE Spectra

The UV spectra of curcumin is shown in **Fig 01**. From the values in **Table 01**, the absorbance at 429.50 nm confirmed the Π-Π* transition. This is in agreement with previous work showing maximum absorption at 418 nm by Ashwinder Singh [9].

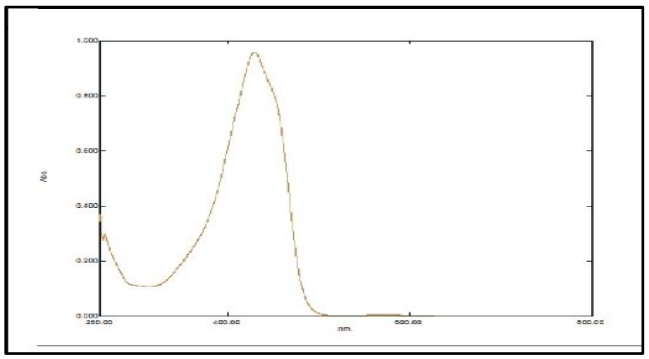

Fig 01: UV spectra of curcumin

Table 01: UV spectra of Curcumin

No.	Wavelength nm.	Abs.
1	429.50	0.958
2	251.50	4.000
3	209.50	2.173
4	518.50	0.001
5	311.50	0.105
6	218.00	-4.000
7	205.00	-4.000

Anna Masek [10] depicts the absorption spectra of curcumin recorded in acetonitrile. The UV spectrum shows a strong and intense absorption band in the range of 350- 480 nm. The absorption spectrum at 350-480 nm is very broad, and the presence of more than one shoulder indicates the possible presence of more than one isomeric form in the ground state. Another work by Prasad Vijay Kadam reported that Curcumin was found to be soluble in methanol and the λ_{max} of methanolic extract of curcumin was found to be 422 nm [11].

Holkar [12] used UV Spectrophotometric method to determine of Curcumin in bulk and pharmaceutical dosage. The solvent used is methanol and the wavelength corresponding to maximum absorbance of the drug was found at 421 nm. The absorbance values can be used for the routine analysis of Curcumin in bulk and pharmaceutical formulation.

Fourier Transform Infrared Spectroscopy

IR Spectrum of Cellulose is shown in **Fig. 02**.

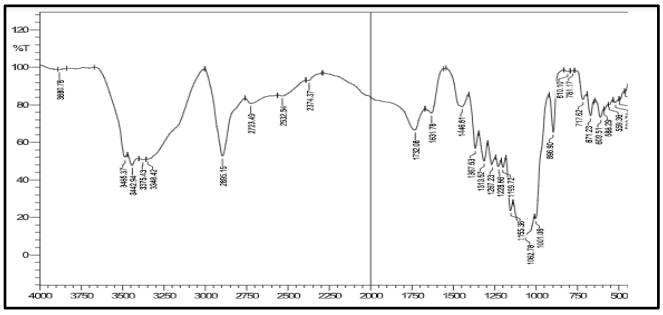

Fig 02: IR spectrum of cellulose

For cellulose fiber, the peaks obtained at 3485.37 cm^{-1} (OH bending), 3442.94 cm^{-1}(OH stretching), 2895.15 cm^{-1} (CH), 1732.08 cm^{-1} (C=0), 1631.78 cm^{-1} (C=C), 1313.52 cm^{-1} (OH bending), 1267.23 cm^{-1} (C- O) and 717.52 cm^{-1} (aromatic CH). The band centered at 3485.37 cm^{-1} is attributed to the OH bending. The bands around 3442.94 cm^{-1} are assigned to OH stretching vibration as well as inter and intra molecular hydrogen bonds in cellulose molecules. The peak at 2895.15 cm^{-1} is attributed to aromatic CH stretching vibration. The vibration peak at1732.08 cm^{-1} was assigned to C=0 stretching and the peak at 1631.78 cm^{-1} is due to C=C plane symmetrical stretching vibration. In addition, the peak at 1313.52 cm^{-1} corresponds to OH bending of the absorbed water. The peak at1267.23 cm^{-1} was assigned to C- O out of plane stretching vibration. The bands around 717.52 cm^{-1} are assigned to aromatic CH bending. Similar peaks were observed in a work involving the characterization of cellulose from banana pseudo-stem. This work clearly describes that the band around 3600-3000 cm^{-1} denotes the presence of OH group. The peak centered at 2902 cm^{-1} was attributed to CH stretching vibration [9]. Also, the observed result is in close accordance with the FTIR Spectra of cellulose from Kepok banana peel. The result showed that FTIR spectra of cellulose from Kepok banana peel were similar with FTIR spectra of standard cellulose [13].

IR Spectrum of CMC is depicted in Fig 03.

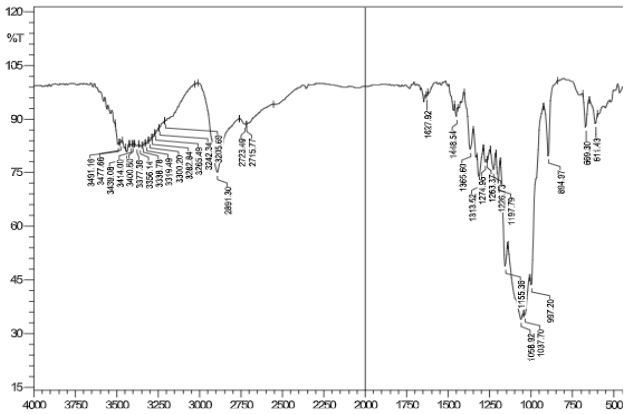

Fig 03: IR spectrum of CMC

The prominent peaks found are 1448.54 cm^{-1}(CMC substituent), 1313.52 cm^{-1}(OH bending), 669.30 cm^{-1}, 2891.30 cm^{-1} (CH). The peak at 1448.54 cm^{-1} indicates the presence of carboxymethyl substituent. The peak at 1313.52 cm^{-1} is assigned to OH bending vibration. The peaks at 669.30 cm^{-1} and 2891.30 cm^{-1} correspond to aromatic CH bending vibration and aromatic CH stretching vibration respectively.

On comparing the spectrum of cellulose and CMC, an additional peak obtained at 1448.54 cm^{-1} denotes the presence of carboxymethyl substituent. Cellulose and carboxy methyl cellulose have similar functional groups with same absorption bands in FTIR (-OH stretching) at 3200–3600 cm^{-1}, hydrocarbon groups (-CH_2 scissoring) at 1450 cm^{-1}, carbonyl groups (C=O stretching) at 1600 cm^{-1} and ether groups (-0-) at 1000 – 1200 cm^{-1}, also -CH stretching vibration at 3000 cm^{-1} [14].

IR Spectrum of Curcumin is shown in **Fig 04**.

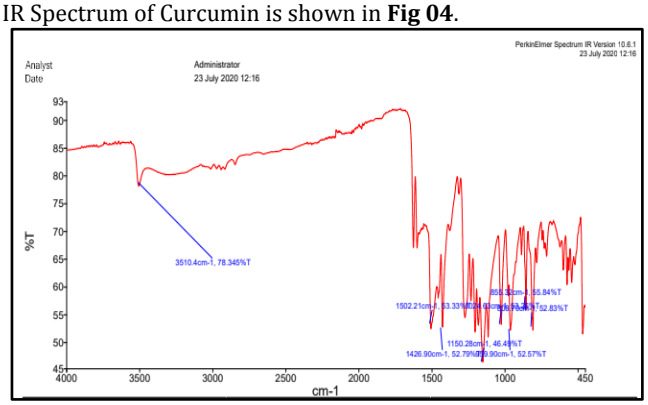

Fig 4: IR spectrum of Curcumin

The characteristic peaks observed were 3510.4 cm^{-1} (OH), 1502.21 cm^{-1} (NO), 1426.90 cm^{-1} (OH), 855.32 cm^{-1} (CH), 855.32 cm^{-1} (CH) and 1273 cm^{-1} (CO). The peak at 3510.4 cm^{-1} is attributed to the OH stretching vibration of phenol. The bands around 1502.21 cm^{-1} is assigned to NO stretching vibration. The peak at 1426.90 cm^{-1} is attributed to OH bending vibration. The peak centered at 855.32 cm^{-1} refers to aromatic CH bending because the bands around 680 - 860 cm^{-1} corresponds to aromatic CH bending. The peak found at 1273 cm^{-1} refers to CO stretching frequency. The above observed peaks can be seen in the IR spectrum of curcumin obtained by Siregar and his co-workers [15]. This work reported that the clear and board peak at 3200 cm^{-1} corresponded to the stretching vibration of hydrogen bonded (OH) present in the curcuminoid. Conjugated carbonyl group was observed at 1655 cm^{-1}. The IR spectra of curcumin shows stretching vibrations at 1628 cm^{-1} attributed predominantly to the overlapping stretching vibrations of alkenes (C=C) and carbonyl character. Infrared of curcumin ligand show stretching vibration at 3200 – 3500 cm^{-1} due to OH groups, C = C aromatic stretching vibration at 1427 cm^{-1} and a significant intense band 1227 cm^{-1} attributed to the bending vibration of the v (-CO) phenolic bond [16].

Fig 05 indicates IR Spectrum of CMC- Curcumin nanofiber.

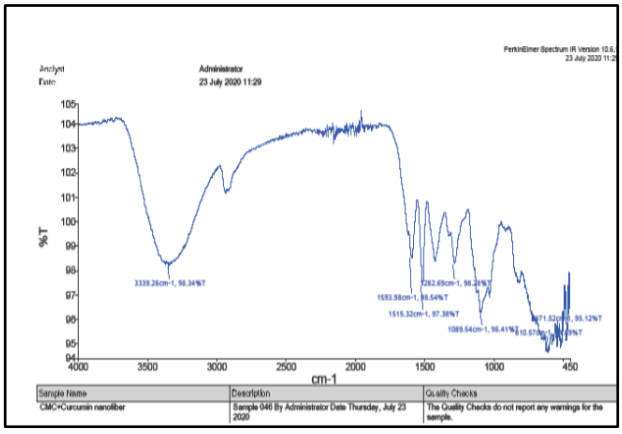

Fig 5: IR Spectrum of CMC- Curcumin nanofiber

The main peaks observed are 3329.26 cm^{-1} (NH), 1515.32 cm^{-1} (NO), 1282. 69 cm^{-1} (CO) and 1089.54cm^{-1} (CO). The peak centered at 3329.26 cm^{-1} refers to NH stretching of amine group. The bands around 1515.32 cm^{-1} assigned to asymmetric NO stretching. The peak observed at 1282.69 cm^{-1} attributed to CO stretching of aromatic ester. The bands around 1089.54 cm^{-1} refers to alkoxy CO stretching.

According to Ismail [17], the FTIR results showed that there was no significant change in the functional groups of the composite film (CMC and curcumin) as compared to the CMC film, indicating that the chemical structure of the CMC was not changed after incorporation of curcumin. A similar peak pattern with a slightly higher or lower intensity was obtained. The gelatin/CMC/chitosan composite films exhibited amino groups that shifted from 1542 to 1548 cm^{-1} while NH or OH groups shifted from 3384 to 3288 cm^{-1}. Blending CMC with gelatin and chitosan showed a decreased intensity of -COO group peak [18]. The FTIR spectra of the CMC-Curcumin encapsulated with Montmorillonite (MMT) nano layers displayed peaks at 3350cm^{-1} due to phenolic stretching vibration. Additionally, sharp peaks at 1508cm^{-1} and 1423cm^{-1} are due to stretching vibration of C=C of benzene rings and olefinic bending vibrations of C–H bound to the benzene rings of curcumin. The peak at 820 cm^{-1} relates to the stretching vibrations of C-O groups present in curcumin [19].

SEM (Scanning Electron Microscope) Analysis

CMC-curcumin nanofiber mats were evaluated by JEOLJSM-brand 5600LV electron microscope at an accelerating voltage of 20 kV. The surface view of fibers was taken at a resolution of 7000x. The micrograph images depict randomly interconnected structures. From **Fig 06**, it is clear that the sample has a thickness of 5000 nm. No aggregates and defects are seen in the interconnected fibers which indicate successful incorporation of curcumin onto the CMC nanofibers.

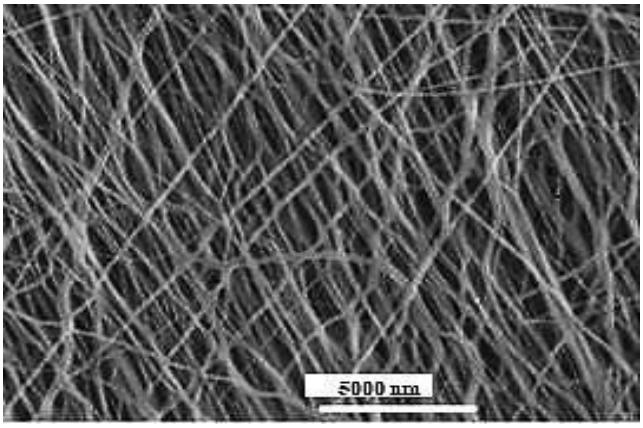

Fig 6: SEM of CMC-Crcumin nanofiber

According to Suwantong [22], cross sectionally round fibers were obtained for SEM images of e-spun fibers from curcumin loaded cellulose acetate (CA) solutions and no presence of any kind of curcumin aggregates was observed on these fibers, implying that the as-loaded curcumin was perfectly incorporated well within the fibers. The average diameter of the neat CA fibers was ~ 300 nm, while those of the curcumin - loaded ones were in the range of ~ 314 to ~340 nm.

The SEM image of CMC-curcumin composite film was intact and smooth surfaced without any apparent defects. The surface of the composite film was somewhat rougher than the neat CMC film. Moreover, SEM images of the cross section of the CMC

based composite film showed that no voids were present in the nanocomposite films [17]

Tavares [20] took the cross-section of starch films and showed that no starch granules remained after the gelatinization process. The blends presented a dense and compact structure and the micro cracks observed in the fractures of the neat films decreased after the addition of CMC, which shows a good interaction among their constituents, making it possible to obtain a compact film. No interruption of the starch/ CMC interface was observed, which shows that there was good interfacial adhesion between its constituents. The surface morphology of the different CMC/CNC composite films was characterized by SEM to explore the dispersion of CNC in CMC matrix and the compatibility between CMC and CNC. The surface of pure CMC was smooth and homogeneous without crack or hole and air bubbles. The CMC/CNC composite films still maintained smooth and homogenous surfaces until the addition content of CNC was up to 5 wt%. These observations indicated that the CNC was well distributed in the continuous CMC matrix and had good compatibility with CMC [21]. In this work, curcumin is loaded to the nanofiber in the place of CNC. Curcumin is also well dispersed on the surface of CMC nanofiber. The surface of curcumin loaded CMC nanofiber is smooth and does not contain any aggregates or defects.

Antimicrobial studies

Antifungal and Antibacterial Activity

The antifungal activity of the CMC curcumin nano fiber I shown on **Fig 07**.

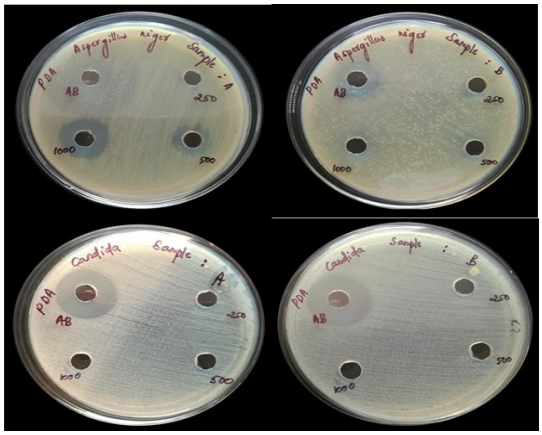

Fig 07: antifungal activity of the CMC curcumin nano fiber

Table 02: shows the inhibition zone of antifungal activity of the used sample against two fungal strains namely *Aspergillus niger* and *Candida albicans* on comparison with standard Clotrimazole (100µg).

Table 02: Antifungal activity of the CMC curcumin nano fiber

Sample	Concentration (µg/mL)	Zone of inhibition(mm) of different organism	
		Aspergillus niger	Candida albicans
A	Clotrimazole (100 µg)	28	25
	250	Nil	11
	500	11	13
	1000	18	16

Fig 08: shows the anti-bacterial activity of CMC curcumin nanofiber against Gram positive bacteria *Escherichia coli* and *Klebsiella pneumoniae*.

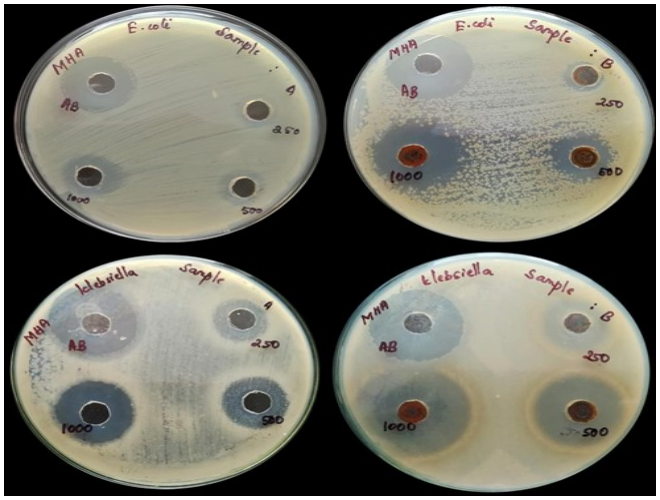

Fig 08: anti-bacterial activity of CMC curcumin nanofiber

Table 03: Anti-bacterial activity of CMC curcumin nanofiber against gram positive bacteria.

Sample	Concentration(µg/mL)	Zone of inhibition (mm) for different organism	
		E.coli	Klebsiella pneumonia
A	Streptomycin (100µg)	20	25
	250	Nil	18
	500	12	20
	1000	18	21

The values in **Table 03** shows the antibacterial activity of two organisms namely *E.coli* and *Klebsiella pneumonia*e for a particular concentration with respect to a standard Streptomycin (100µg). **Fig 09** shows the anti-bacterial activity of CMC curcumin nanofiber against Gram negative bacteria *Staphylococcus aeurus* and *Streptococcus mutans*.

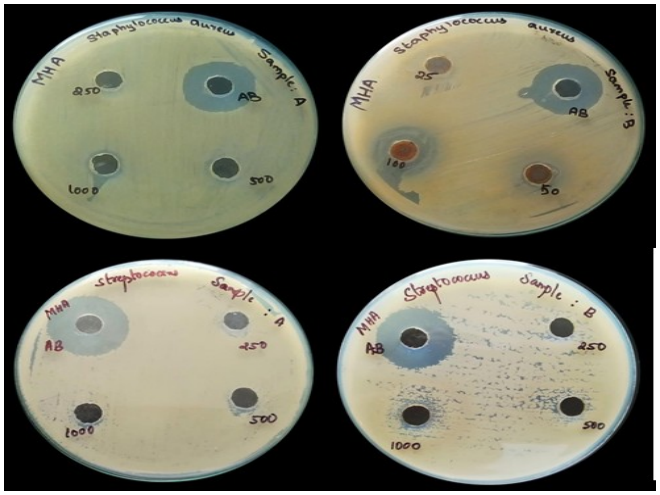

Fig 09: anti-bacterial activity of CMC curcumin nanofiber

Table 4: Anti-bacterial activity of CMC curcumin nanofiber against Gram negative bacteria

Sample	Concentration (µg/mL)	Zone of inhibition (mm) for different organisms	
		Staphylococcus auerus	Streptococcus mutans
A	Streptomycin(100µg)	22	25
	250	Nil	Nil
	500	Nil	Nil
	1000	12	Nil

The values in **Table 4** confirms the antibacterial activity of two organisms namely *Staphylococcus aeurus* and *Streptococcus mutans* with respect to the standard Streptomycin (100µg). The absence of inhibition zone indicates the absence of antimicrobial activity of the given sample for both bacteria – *Staphylococcus auerus* and *Streptococcus mutans*. But 1000 µg/ml concentration sample shows an inhibition zone for *Staphyloccus auerus*.

Niamsa [16] investigated the antibacterial activity of curcuma longa aqeous extract against various bacteria. The results show that the extract showed antimicrobial activity against *E.coli, Staphylococcus aureus, Kleibsella pneumonia and Staphylococcus epidermis* at low concentration.

X**.** Zhang shows that the antibacterial activity of chitosan can be attributed to the electrostatic interaction between the positively charged amino groups on the surface of chitosan and the negatively charged microbial cell membrane. This interaction increased the permeability of the bacterial cell membrane, leading to the inhibition of bacterial growth. The antimicrobial activity of curcumin can be attributed to its ability to inhibit the polymerization of Ftsz (filamentous temperature-sensitive protein Z), a protein which is necessary for cell division and bacterial sustainability [23]. In the present work, CMC nanofiber also shows antimicrobial activity due to the incorporation of curcumin into the electrospun CMC nanofiber because the presence of curcumin in the CMC fiber inhibit the cell division and sustainability of different bacteria like *E.coli, Kleibsella pneumonia, Streptocoocus mutans and Staphylococcus aureus.*

Hualin Wang [24] founds that the zein-CUR fibers made from zein (extract form maize) and curcumin showed good antibacterial activity towards *S. aureus* and *E. coli*, and the inhibition efficiency increased with the increase of curcumin contents. Due to the different cell membrane constituent and structure, the antibacterial activity towards *S. aureus* was better than that towards *E. coli*. The study displayed that the zein-CUR fibers might have potential as a promising material for antimicrobial applications to inhibit bacterial growth and propagation in food packaging.

Conclusion

Cellulose is the most abundant polymer on earth, which makes it most common organic compound. Plant synthesizes 102 tons cellulose annually. Recently, cellulose has been in the public eye due to its possible use in the production of biofuels. Nowadays, cellulose can be chemically modified to yield cellulose derivatives which had wide variety of application in various industrial sectors including sources for commodity goods. One of the most important cellulose derivatives is carboxymethyl cellulose.

Cellulose was successfully extracted from banana pseudo stem through alkali treatment. The cellulose was then converted to CMC by treating with sodium hydroxide (NaOH) followed by etherification with monochloro acetic acid. The IR spectrum confirmed the change of cellulose to carboxymethyl cellulose by the presence of carboxyl, C=O group at 1732.08 cm^{-1}. The presence of carboxyl methyl substituent made shift in the peaks obtained in the FTIR spectra of cellulose. Remaining functional groups in cellulose, Carboxymethyl cellulose (CMC) and curcumin loaded- CMC fibers are confirmed using IR spectroscopic method. The UV spectra of curcumin showed highest absorbance at 429.5 nm indicating Π-Π* transition. The surface morphology of nanofiber was analyzed using SEM technique. It is noted that the diameter of CMC- curcumin nanofiber obtained has been 5000 nm. The resulting nanofiber shows antifungal and antimicrobial activity which was confirmed by the presence of inhibition zone. Antifungal activity was determined against two fungal strains namely *Aspergillus niger* and *Candida albicans* on comparison with standard Clotrimazole (100µg). Antifungal activity was shown by sample against both fungal strains. Antibacterial activity was done in gram negative bacteria namely *E.coli, Klebsiella pneumoniae, and for gram positive bacteria namely Staphylococcus auerus* and *Streptococcus mutans*. The sample showed antimicrobial activity for *E.coli* and *Klebsiella pneumonia.* The sample shows antibacterial activity towards *Staphylococcus auerus* at higher concentrations and it does not show any antibacterial activity against *Streptococcus mutans*.

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Conflict of Interest

There is no conflict of interest between the authors.

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