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NANOFIBERS LOADED WITH NANOCHITOSAN OF FUNGAL ORIGIN: SYNTHESIS, CHARACTERIZATION, AND ANTIMICROBIAL ACTIVITY OF NANOCHITOSAN FROM *Aspergillus niger*

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ABSTRACT

Natural biopolymers are attracting the researcher's attention because of their magnificent properties and various biological activities. Among them, chitosan is the deacetylated form of chitin which is present in the fungal cell wall. In the present study, chitosan was extracted from *Aspergillus niger* on malt yeast broth (MYB) with yield 8%, degree of acetylation 69.5 % and molecular weight 2223.11 Da. Nano-chitosan was prepared through ionic gelation method then characterized through dynamic light scattering which revealed that the zeta potential was 37 mV and polydispersity index (PDI) reached 0.48 while transmission electron microscope (TEM) showed the spherically shaped prepared nanoparticles had particle size ranged from 1.77 to 8.17 nm. Thermoplastic Polyurethane (TPU) fibers loaded with chitosan and nano-chitosan were synthesized through electrospinning then morphologically characterized by scanning electron microscope (SEM) showing that chitosan loaded TPU fibers were comparatively rougher than that of nano-chitosan loaded TPU fibers which were quite smooth. The Limiting oxygen index (LOI) value of chitosan loaded TPU fibers was only 20.8% and the UL-94 resulted in V-1. However, the LOI value of nano-chitosan loaded TPU fibers increased up to 26.6% and the UL-94 result achieved V-0 rating. Moreover, the tensile strength of the chitosan loaded TPU fibers was 12.3 ± 0.2 MPa, while the nano-chitosan loaded TPU fibers was 17.9 ± 0.5 MPa. Finally, nano-chitosan loaded TPU fibers showed the maximum antibacterial activity with inhibition zone diameter reached 40 mm and MIC value 15.6 µg/mL.

INTRODUCTION

Chitin is the main precursor of chitosan which is a natural biodegradable biopolymer. Various types of applications had been monitored *e.g.* water engineering, food and nutrition, medical applications biotechnology and in gene therapy recently (**Thambiliyagodage *et al.*, 2023**). Due to seasonal and limited supply, processing challenges, particularly with the large amount of waste of concentrated alkaline solution causing environmental pollution, and inconsistent physicochemical properties, chitosan production commercially by crustacean chitin deacetylation with strong alkali seems to have a low acceptance for industrial potential. However, chitosan from fungi has been focused on in new studies. A larger possibility for more reliable products exists with the manufacture and purification of chitosan from the cell walls

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of fungus cultivated under controlled conditions **(Tayel *et al.,* 2011)**.

Nowadays, citric acid industrial scale production is almost exclusively accomplished by *Aspergillus niger*. Annual global production exceeds 600,000 metric ton (**de Oliveira *et al.,* 2022)**. Isolation of chitin and/or chitosan could be done by fermentation industries of fungi with their mycelia produced as a promising source **(Tayel *et al.,* 2011)**.

In our daily lives, synthetic polymeric materials are employed extensively. Despite this, chitosan has a poor microbial resistance and flammable upon exposing to a heat source (**Andrew and Dhakal, 2022)**, several additives have been employed to enhance the antimicrobial activity and eliminate flammability effect **(Qi *et al.,* 2022)**. Chitosan possesses the capacity of promoting the char formation of the matrix during combustion due to its carbon and nitrogen composition. Chitosan nanoparticles, being biocompatible, non-toxic, versatile, and biodegradable, attracted the attention of researchers in the biomedical field (**Ahmed *et al.,* 2021; Anderson *et al.,* 2022)**. **Mohamed (2022)** tested chitosan nanoparticles' different concentrations efficacy in enhancing the cold shelf life of kareish cheese against microbial contamination. It was reported that chitosan nanoparticles showed high antimicrobial effect in a dose dependent manner.

The present study aimed to synthesize Thermoplastic Polyurethane (TPU) nanofibers loaded with nano chitosan of fungal origin for biomedical applications.

MATERIALS AND METHODS

Fungal Isolation and Identification

The fungal strain (*Aspergillus niger*) used in this study was isolated from soil and identified with GenBank Accession number MT597434.1 **(Abdelalatif *et al.,* 2023)**.

Cultivation Media and Culture Conditions

Malt yeast broth (MYB) was used for the cultivation of *Aspergillus niger*. The incubation period was 7 days at 28^{o}C to allow the formation of fungal mats (**George *et al.,* 2011).**

Chitosan Extraction and Purification

The fungal mycelia were harvested and 50 ml of 1N sodium hydroxide (NaOH) solution was added per g (dry weight) of mycelia and homogenized. The content was sterilized at 121°C for 20 minutes (alkali treatment). Centrifugation at 6000 rpm for 20 min was done to collect the alkali insoluble materials (AIM), AIM was then washed with distilled water until the pH was neutralized (pH 7) followed by dryness at 40°C. Dried AIMs were treated (1:30 *W/V*) with 2% acetic acid (chitosan solvent), under reflux conditions for 8 hours at 95°C. The insoluble part was separated by centrifugation at 6000 rpm for 15- 20 min while the supernatant (containing the chitosan) was collected and treated with 2N NaOH solution until the pH reached 10 to precipitate the fungal chitosan. The flocculated chitosan was then centrifuged at 6000 rpm, for 15 min. The isolated chitosan was washed four to five times with distilled water to neutralize it. After that, ethanol (96%) and acetone were employed to rinse the chitosan and then it was dried in a vacuum oven dryer at 60°C (**Chatterjee *et al.,* 2005)**. The crude chitosan yield was calculated from the following equation:

Chitosan yield (%) = [dry wt. of obtained chitosan/dry wt. of sample] x 100

Chitosan Characterization

Chitosan produced samples were characterized in KBr pellets by using FTIR (Model FTIR-6100) in the range of 400 to 4000 cm^{-1} (**George *et al.,* 2011)**. As well as the estimation of degree of deacetylation and chitosan molecular weight (**Pochanavanich and Suntornsuk, 2002)**.

Chitosan Nanoparticles Preparation

TPP solution in deionized water at a concentration of 1.0 mg/mL, pH 5.0 was prepared. In addition to chitosan (3.0 mg/mL) was mixed in diluted acetic acid (0.5%) and stirred at room temperature for 20 minutes. After bringing the pH down to 5.0, the solution was filtered using Gooch crucible (AG 1 x 3) vacuum filtration to remove any remaining insoluble particles. Under magnetic stirring at 600 rpm for 60 minutes, chitosan solutions were added dropwise to TPP solutions in a 3:1 ratio, creating chitosan nanoparticles. After adjusting the cycle and amplitude (using Hielscher Ultrasonics GmbH, Teltow, Germany), the mixture was sonicated for 5 minutes before being analyzed (**Hejjaji *et al.*, 2018).**

Characterization of Nano-chitosan Particles

Nano chitosan particles were characterized Using Transmission electron microscopy (JEM-100 CX Joel) (**Lee *et al.*, 2014)**, FTIR (**George *et al.*, 2011)**, zeta potential and poly-dispersity index (**Hejjaji *et al.*, 2018)**.

Preparation of Chitosan and Nano-chitosan Loaded TPU fibers

Melt mixing and hot compression molding were used to create samples of TPU composites. A micro twin-screw extruder (Wuhan Rayzong Ming Plastics Machinery Co., Ltd., China) at 40 rpm was used to melt and mix TPU and chitosan or nano-chitosan. The extrusion temperatures ranged from 170°C to 175°C to 180°C. For 20 minutes at 10 MPa and 175°C, the pelletized extrude was hot pressed in a molding machine. The sample was then subjected to 20 minutes of cold pressing at 20 MPa at room temperature (**Zhang *et al.*, 2018)**.

Characterization of Chitosan and Nano-chitosan Loaded TPU Fibers

Morphological characterization

Fiber morphology was observed with a scanning electronic microscope (SEM) (JSM-5600) at an accelerated voltage of 10 kV (**Huang *et al.*, 2011).**

Flammability test

The limiting oxygen index (LOI) values were determined by using a JF-3 instrument according to ASTM D2863-97. While the UL-94 vertical burning tests were conducted by using a CZF-3 instrument according to ASTM D3801 with a sample thickness of 3.2 mm (**Liu *et al.*, 2019)**.

Tensile strength

TPU fibers loaded with chitosan or nano-chitosan were tested for tensile strength in three different orientations: random, parallel, and perpendicular. All samples were the same size (30 mm x 10 mm), and the tests were run at room temperature (20°C) and humidity (65%) using a universal materials tester (H5 K-S, Hounsfield, UK) equipped with a 50 N load cell. For each sample, the cross-head speed was set at 10 mm/min (**Liu *et al.*, 2019)**.

Antibacterial Activity of Chitosan, Nano-chitosan, Chitosan Loaded TPU Fibers and Nano-chitosan Loaded TPU Fibers

Antibacterial activity was carried out using disc-diffusion method according to CLSI guidelines (**Abbey and Deak, 2019)**. By measuring the lowest inhibitory concentration (MIC), minimum bactericidal concentration (MBC) (**Elshaer *et al.*, 2022)**.

RESULTS

Chitosan Production and Characterization

The growth of *A. niger* on MYB was observed for 7 days. The chitosan yield was 18% while the molecular weight was 2223.11 Da and the degree of acetylation was 69.5%. Extracted chitosan structure was confirmed by FTIR analysis. In general, chitosan shows bands at 3000-3500 cm^{-1} attributed to O–H stretching and a significant band of amide I and amide II are located at 1653 cm^{-1} and 1436 cm^{-1} respectively. Finally, the C–N fingerprint band appears at the range of 800 - 810 cm^{-1} (Fig. 1).

Nano-chitosan Preparation and Characterization

The prepared nano-chitosan was characterized by TEM revealing that the particle size ranged from 1.77 – 8.17 nm (Fig. 2). Moreover, the zeta potential was 37 mV and the PDI was 0.48.

Preparation and Characterization of Chitosan and Nano-chitosan Loaded TPU Fibers

SEM of chitosan and nano-chitosan loaded TPU fibers

According to the results shown in Fig. 3, the surface of chitosan loaded TPU fibers was noticeably rougher than that of nano-chitosan loaded TPU fibers. We can show that nano-chitosan has the potential to increase the spinnability of polymer solutions by analyzing their surface morphologies.

Flammability test

Chitosan and nano-chitosan loaded TPU fibers' LOI and UL-94 findings are shown in Table 1. Chitosan-loaded TPU fibers only achieved a LOI of 21% and a UL-94 rating of V-1. The UL-94 result for nano-chitosan loaded TPU fibers, on the other hand, allows for a V-0 grade, which indicates a much higher LOI value (up to 26.6%). In general, nano-chitosan is more effective than chitosan for lowering TPU's flammability.

Tensile strength

The tensile strength of the chitosan loaded TPU fibers was 12.3 ± 0.2 MPa, while the nano-chitosan loaded TPU fibers was 17.9 ± 0.5 MPa (Table 2). Therefore, nano-chitosan enhances the characteristics of TPU by increasing the average tensile strength and showing better elasticity than the chitosan loaded TPU fibers.

Antibacterial Activity of Chitosan, Nano-chitosan, Chitosan Loaded TPU Fibers and Nano-chitosan Loaded TPU Fibers

Results in Table 3 reveal that the inhibition zone diameters (IZD), MIC and MBC of all tested samples ranged from 12.0 - 40.0 mm, 15.6 - 500 µg/ml and 31.2 - 1000 µg/ml, respectively. Nano-chitosan loaded TPU fibers has showed the highest IZ diameter and the lowest MIC value 40 mm and 15.6 µg/ml, respectively against *Escherichia coli* 25922 and *Klebsiella pneumonia* 13883. Therefore, nano-chitosan loaded TPU fibers has a potent antibacterial activity followed by chitosan loaded TPU fibers, nano-chitosan and chitosan.

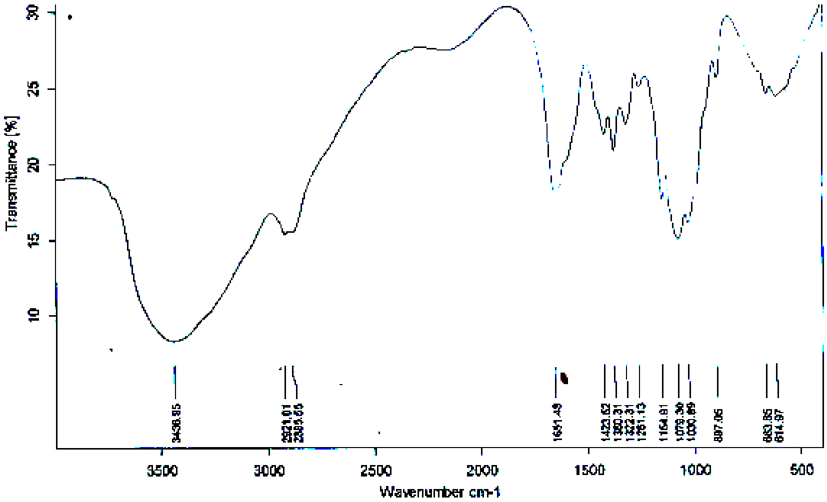


Fig. 1. FTIR of chitosan extracted from *Aspergillus niger* on MYB

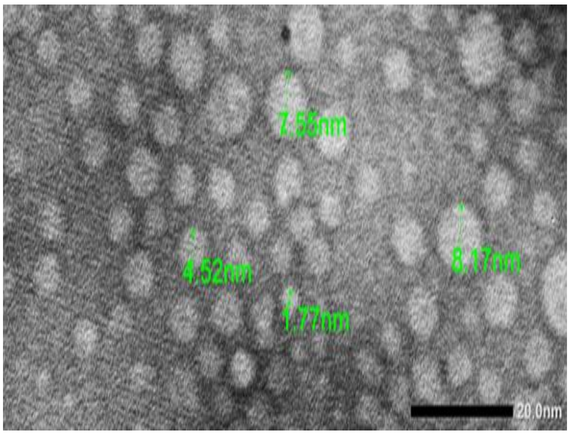
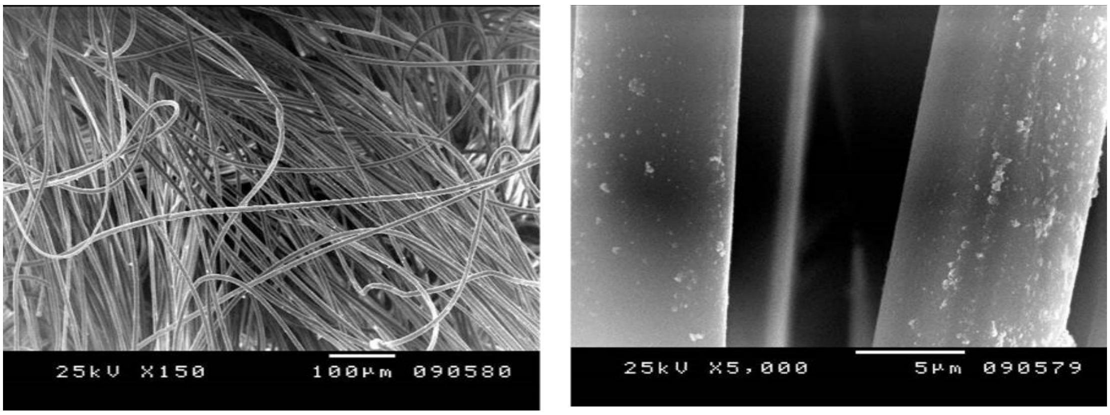
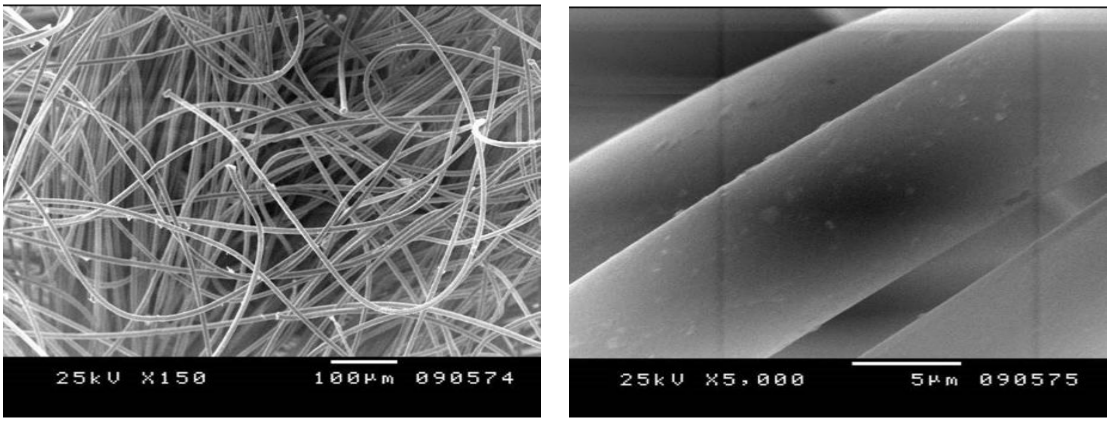


Fig. 2. Nano-chitosan particles under transmission electron microscope



(a) (b)



(c) (d)

Fig. 3. SEM of chitosan (a & b) and nano-chitosan (c & d) loaded TPU nanofibers

Table 1. Flammability test of chitosan and nano-chitosan loaded TPU fibers

Sample	LOI (%)	UL-94
Chitosan loaded TPU fibers	21.0 ± 0.1	V-1
Nano-chitosan loaded TPU fibers	29.9 ± 0.3	V-0

Table 2. Tensile strength of chitosan and nano-chitosan loaded TPU fibers

Sample	Average tensile strength (MPa)
Chitosan loaded TPU fibers	12.3 ± 0.2
Nano-chitosan loaded TPU fibers	17.9 ± 0.5

Table 3. Antibacterial activity of chitosan, nano-chitosan, chitosan loaded TPU fibers and nano-chitosan loaded TPU fibers

Sample / Pathogen	Chitosan			Nano-Chitosan			Chitosan loaded TPU fibers			Nano-chitosan loaded TPU fibers		
	IZD (mm)	MIC (µg/ml)	MBC (µg/ml)	IZD (mm)	MIC (µg/ml)	MBC (µg/ml)	IZD (mm)	MIC (µg/ml)	MBC (µg/ml)	IZD (mm)	MIC (µg/ml)	MBC (µg/ml)
Escherichia coli **25922**	18 ± 0.3	125	250	25 ± 0.1	75	150	27 ± 0.4	50	100	40 ± 0.1	15.6	31.2
Proteus mirabilis **35659**	14 ± 0.2	250	750	22 ± 0.4	100	300	26 ± 0.5	75	150	35 ± 0.3	62.4	125
Staphylococcus aureus **25923**	17 ± 0.6	125	375	21 ± 0.2	150	450	27 ± 0.3	75	225	35 ± 0.2	31.2	93.6
Klebsiella pneumonia **13883**	12 ± 0.2	500	1000	20 ± 0.3	150	300	26 ± 0.2	100	200	40 ± 0.1	22	44

DISCUSSION

Because of its high levels of biocompatibility, biodegradability, and antibacterial characteristics (**Yang *et al.*, 2021)**, chitosan-based materials have garnered a lot of interest for usage in biomedical settings. Since chitin and chitosan are found in the cell walls of many fungi, including *Aspergillus niger*, their mycelium has been investigated as potential sources (**Ke *et al.*, 2022)**. Similar results were found by **Ghormade *et al.* (2017)** who reported that the yield of chitosan isolated from *A. niger* was 10%, the degree of acetylation was 64-90%, and the molecular weight was 2.7 x 10^3 Da. Also, compared to solid state fermentation, biomass production doubles during submerged fermentation (**Crognale *et al.*, 2022)**. Another research found that the *A. niger* chitosan production was 11.64 percent, with an acetylation level of 86.4 percent.

Peaks in the FTIR spectrum of chitosan were observed at 3406 cm^{-1} (-OH stretch), 2920 cm^{-1} (C-H stretch), 1651 cm^{-1} and 1635 cm^{-1} (N-H bend), and 1068 cm^{-1} (C-O stretch) **(Tayel *et al.*, 2011)**. Nano-chitosan particles display a wide peak at 3419-3467 cm^{-1} due to -OH and water stretching vibrations, which is consistent with the findings of **Calderón *et al.* (2013)**, who reported that the size of nano-chitosan particles varied from 30-300 nm with PDI 0.5 and zeta potential +35 mV. C-H stretching vibrations caused peaks between 2870 and 2937 cm^{-1}. Furthermore, research has shown that the size of nano-chitosan particles is between 200 and 2500 nm (**Sreekumar *et al.*, 2018)**.

Zhang *et al.* (2018) reported that Nano-chitosan loaded TPU achieved LOI of 28.6% and UL-94 V-0, whereas results for neat TPU were 20.8% and no rating in the UL-94 test. Additionally, TPU and nano-chitosan loaded TPU demonstrated tensile strengths of 15.5 and 19.2 MPa, respectively. In contrast to the control, the morphological characteristics of the TPU surface loaded with fungal chitosan showed no evidence of agglomerated particles, suggesting uniform distribution of the fungal chitosan in the coating layer and the absence of undesirable agglomeration during coating formation **(Tayel *et al.*, 2011)**. Chitosan and nano-chitosan were shown to be more effective against Gram-negative (*E. coli*) than Gram-positive (*S. aureus*) bacteria in terms of their antibacterial properties. Gram-positive bacteria, in contrast, have a peptidoglycan cell wall that is both thicker and stiffer. Therefore, Gram-positive bacteria are less susceptible to antibacterial effects (**Shirvan *et al.*, 2014)**. Both fungal chitosan loaded TPU and nano-chitosan loaded TPU were shown to have MICs of 2.25 mg/ml and 1.75 mg/ml against *E. coli*, respectively, in a different investigation **(Tayel *et al.*, 2011)**.

Conclusions

A. niger produces high yield of chitosan with high molecular weight. Therefore, the synthesized nano-chitosan had stable and small particle size. Nano-chitosan has improved the properties of the TPU fibers by making it smother, improve spinnability of polymer solution, reduce the flammability, increase the average tensile strength, and increase the antibacterial activity.

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REFERENCES

Abbey, T.C. and Deak, E. (2019). What's new from the CLSI subcommittee on antimicrobial susceptibility testing M100. Clinical Microbiol. Newsletter, 41(23), 203-209.

Abdelalatif, A.M.; Elwakil, B.H.; Mohamed, M.Z.; Hagar, M. and Olama, Z.A. (2023). Fungal secondary metabolites / dicationic pyridinium iodide combinations in combat against multi-drug resistant microorganisms. Molec., 28(6): 2434.

Ahmed, S.B.; Mohamed, H.I.; Al-Subaie, A.M.; Al-Ohali, A.I. and Mahmoud, N.M. (2021). Investigation of the antimicrobial activity and hematological pattern of nano-chitosan and its nano-copper composite. Scient. Reports, 11 (1): 1-9.

Anderson, A.S.; Mkabayi, L.; Malgas, S.; Kango, N. and Pletschke, B.I. (2022). Covalent Immobilisation of an *Aspergillus niger* derived endo-1, 4-β-mannanase, man26a, on glutaraldehyde-activated chitosan nanoparticles for the effective production of prebiotic MOS from soybean meal. Agron., 12(12): 2993.

Andrew, J.J. and Dhakal, H.N. (2022). Sustainable biobased composites for advanced applications: recent trends and future opportunities–A critical review. Composites Part C : Open Access, 7: 100220.

Calderón, L.; Harris, R.; Cordoba-Diaz, M.; Elorza, M.; Elorza, B.; Lenoir, J. and Cordoba-Diaz, D. (2013). Nano and microparticulate chitosan-based systems for antiviral topical delivery. Europ. J. Pharm. Sci., 48(1-2), 216-222.

Chatterjee, S.; Adhya, M.; Guha, A.K. and Chatterjee, B.P. (2005). Chitosan from Mucor rouxii: production and physico-chemical characterization. Proc. Biochem., 40 (1): 395-400.

Crognale, S.; Russo, C.; Petruccioli, M. and D'annibale, A. (2022). Chitosan production by fungi: current state of knowledge, future opportunities and constraints. Ferment., 8 (2): 76.

de Oliveira, P.Z.; de Souza Vandenberghe, L.P.; Rodrigues, C.; de Melo Pereira, G.V. and Soccol, C.R. (2022). Exploring cocoa pod husks as a potential substrate for citric acid production by solid-state fermentation using *Aspergillus niger* mutant strain. Proc. Biochem., 113: 107-112.

Elshaer, E.E.; Elwakil, B.H.; Eskandrani, A.; Elshewemi, S.S. and Olama, Z.A. (2022). Novel Clotrimazole and *Vitis vinifera* loaded chitosan nanoparticles: Antifungal and wound healing efficiencies. Saudi J. Biol. Sci., 29 (3): 1832-1841.

George, T.S.; Guru, K.S.; Vasanthi, N.S. and Kannan, K.P. (2011). Extraction, purification and characterization of chitosan from endophytic fungi isolated from medicinal plants. World J. Sci. and Technol., 1(4): 43-48.

Ghormade, V.; Pathan, E.K. and Deshpande, M.V. (2017). Can fungi compete with marine sources for chitosan production? Int. J. Biol. Macromolec., 104: 1415-1421.

Hejjaji, E.M.A.; Smith, A.M. and Morris, G.A. (2018). Evaluation of the mucoadhesive properties of chitosan nanoparticles prepared using different chitosan to tripolyphosphate (CS:TPP) ratios. Int. J. Biol. Macromolec., 120, 1610 – 1617.

Huang, C.; Chen, R.; Ke, Q.; Morsi, Y.; Zhang, K. and Mo, X. (2011). Electrospun collagen chitosan TPU nanofibrous scaffolds for tissue engineered tubular grafts. Colloids and Surfaces B: Biointerfaces, 82(2), 307–315.

Ke, Y.; Ding, B.; Zhang, M.; Dong, T.; Fu, Y.; Lv, Q. and Wang, X. (2022).

Study on inhibitory activity and mechanism of chitosan oligosaccharides on *Aspergillus flavus* and *Aspergillus fumigatus*. Carbohydrate Polymers, 275: 118673.

Lee, D.S.; Eom, S.H.; Kim, Y.M.; Kim, Y.S.; Yim, M.J.; Lee, S.H.; Kim, D.H.; and Je, J.Y. (2014). Antibacterial and synergic effects of gallic acid-grafted-chitosan with lactams against methicillin-resistant *Staphylococcus aureus* (MRSA). Can. J. Microbiol., 60: 629–638.

Liu, X.; Sun, J.; Zhang, S.; Guo, J.; Tang, W.; Li, H. and Gu, X. (2019). Effects of carboxymethyl chitosan microencapsulated melamine polyphosphate on the flame retardancy and water resistance of thermoplastic polyurethane. Polymer Degradation and Stability, 160, 168–176.

Mohamed, S. (2022). Antimicrobial activity of Chitosan nano particles against *Escherichia coli* and *Aspergillus flavus* strain in kareish cheese. Benha Vet. Med. J., 42 (2): 134-137.

Pochanavanich, P. and Suntornsuk, W. (2002). Fungal chitosan production and its characterization. Letters in Appl. Microbiol., 35 (1): 17-21.

Qi, P.; Wang, S.; Wang, W.; Sun, J.; Yuan, H. and Zhang, S. (2022). Chitosan / sodium polyborate based micro-nano coating with high flame retardancy and superhydrophobicity for cotton fabric. Int. J. Biol. Macromolec., 205, 261-273.

Shirvan, A.R.; Nejad, N.H. and Bashari, A. (2014). Antibacterial finishing of cotton fabric *via* the chitosan/TPP self-assembled nano layers. Fibers and Polymers, 15 (9), 1908-1914.

Sreekumar, S.; Goycoolea, F.M.; Moerschbacher, B.M. and Rivera-Rodriguez, G.R. (2018). Parameters influencing the size of chitosan-TPP nano and microparticles. Scient. Reports, 8 (1): 1-11.

Tayel, A.A.; Moussa, S.H.; El-Tras, W.F.; Elguindy, N.M. and Opwis, K. (2011). Antimicrobial textile treated with chitosan from *Aspergillus niger mycelial* waste. Int. J. Biol. Macromolec., 49 (2): 241–245.

Thambiliyagodage, C.; Jayanetti, M.; Mendis, A.; Ekanayake, G., Liyanaarachchi, H. and Vigneswaran, S. (2023). Recent Advances in Chitosan-Based Applications- A Review. Materials, 16 (5): 2073.

Yang, J.; Shen, M.; Luo, Y.; Wu, T.; Chen, X.; Wang, Y. and Xie, J. (2021). Advanced applications of chitosan-based hydrogels: From biosensors to intelligent food packaging system. Trends in Food Sci. and Technol., 110: 822-832.

Zhang, S.; Liu, X.; Jin, X.; Li, H.; Sun, J. and Gu, X. (2018). The novel application of chitosan: Effects of cross-linked chitosan on the fire performance of thermoplastic polyurethane. Carbohydrate Polymers, 189: 313–321.

الملخص العربي

ألياف نانوية محملة بنانو شيتوزان من أصل فطري: التخليق والتوصيف والنشاط المضاد للبكتيريا للشيتوزان النانومتري من فطر *Aspergillus niger*

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٢. قسم النبات والأحياء الدقيقة، كلية العلوم، جامعة الإسكندرية، الإسكندرية، مصر.
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لقد جذبت البوليمرات الحيوية الطبيعية انتباه الباحثين بسبب خصائصها الرائعة ونشاطها البيولوجي المتنوع. من بينها، الشيتوزان وهو الشيتين المنزوع الأسيتيل الموجود في جدر الخلايا الفطرية. في هذه الدراسة تم استخلاص الشيتوزان من *Aspergillus niger* على بيئة خميرة الشعير (MYB) بإنتاجية ٨% ودرجة أستيل ٦٩,٥% ووزن جزيئي ٢٢٢٣,١١ دالتون. تم تحضير الشيتوزان النانومتري بطريقة الهلام الأيوني ثم تم تمييزه من خلال تشتت الضوء الديناميكي الذي أظهر أن جهد زيتا كان ٣٧ مللي فولت ووصل PDI إلى ٠,٤٨ بينما أظهر مجهر الإلكترون النافذ (TEM) أن الجسيمات النانومترية المحضرة كانت كروية بحجم جسيم يتراوح من ١,٧٧ إلى ٨,١٧ نانومتر. تم تصنيع ألياف البولي يوريثين بالحرارة (TPU) المحملة بالشيتوزان والنانو شيتوزان من خلال الغزل الكهربائي ثم تم تمييزها شكليًا عن طريق المجهر الإلكتروني الماسح (SEM) مما وضح أن ألياف TPU المحملة بالشيتوزان كانت أكثر خشونة نسبيًا من ألياف TPU المحملة بالنانو الشيتوزان والتي كانت ناعمة تمامًا. كانت قيمة مؤشر الأكسجين المحدد (LOI) لألياف TPU المحملة بالشيتوزان ٢٠,٨% فقط وأدى UL-٩٤ إلى V-١. ومع ذلك، زادت قيمة LOI لألياف TPU المحملة بالنانو الشيتوزان بنسبة تصل إلى ٢٦,٦% وحققت نتيجة UL-٩٤ تصنيف V-٠. علاوة على ذلك، كانت مقاومة الشد لألياف TPU المحملة بالشيتوزان ١٢,٣ ± ٠,٢ ميجا باسكال، بينما كانت ألياف TPU المحملة بالنانو الشيتوزان ١٧,٩ ± ٠,٥ ميجا باسكال. أخيرًا، أظهرت ألياف TPU المحملة بالنانو الشيتوزان أقصى نشاط مضاد للبكتريا الممرضة مع قطر منطقة التثبيط بلغ ٤٠ مم وقيمة MIC ١٥,٦ ميكروغرام/مل.

الكلمات الإسترشادية: الشيتوزان الفطري، الجسيمات النانوية، ألياف نانوية، الخصائص الفيزيائية، نشاط مضادات الميكروبات.

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