2026 S.T. Yau High School Science Award (Asia)

Research Report

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Anti-bacterial Bio-BandAIDeepSeek (Bio-bandAIDS)

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Anti-bacterial Bio-BandAIDeepSeek (Bio-bandAIDS)

Kin Cpheong YEUNG, Bohen ZHOU, Yan Lok Samuel CHONG

Abstract

Commercially available bandages such as hydrocolloid are neither biodegradable nor anti-bacterial. Both chitin and chitosan obtained from *Hermetia illucens* black soldier fly **BSF** and *Eriocheir sinensis* Chinese mitten crab are new eco-friendly material (Yong, 2022), bio-degradable, haemostatic (Periayah, 2012), anti-bacterial ability, high bio-compatibility, low toxicity, (Baharlouei, 2022) support cell attachment, proliferation, and migration and its potential for accelerating wound healing applications. (Vo, 2021) Chitin as the raw material of bandages has good water resistance and breathability. (Abdullah, 2020) (Zhu, 2019)

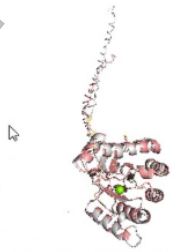
The seafood industry produces about 106 tonnes of waste per year and approximately 2000 tonnes of chitosan are processed per year, with most of the material coming from shrimp and crab shell remnants (Iber, 2021)

Chitin could be collected and extracted along different lifecycle stages of the Black Soldier Fly **BSF** (larvae, prepupae, pupae, flies, shedding & cocoons). (Soetemans, 2020) The chitin content in the collected biomass ranged between 8% and 24%, with shedding and cocoons being most rich in chitin, (Soetemans, 2020). Thus, black soldier fly **BSF** and crab are potential raw material alternatives of anti-bacterial bio-bandages and anti-bacterial bio-dressings.



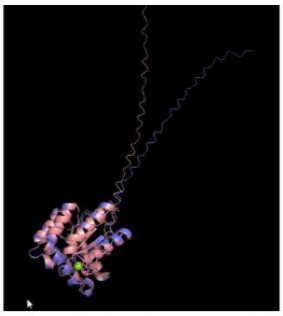
Anti-bacterial Bio-BandAIDS of crab chitin with *rouxii* chitosan of black soldier fly BSF as dressing

Figure 1 Anti-bacterial bio-BandAIDS of crab chitin with *rouxii* chitosan of black soldier fly BSF as dressing



A more water-soluble chitin deacetylase designed by AlphaFold 3 (AI deacetylase) with the best score

Figure 2



The pink one is the original chitin deacetylase
the blue one is the AI deacetylase with the best score

Figure 3

Results were as follows:

BandAIDS were anti-bacterial as Black soldier fly **BSF** chitin, **BSF** *rouxii* chitosan, crab chitin, crab *rouxii* chitosan, #roasted crab chitin, #roasted crab chitosan (16.7M NaOH), crab chitosan (16.7M NaOH) and pure chitosan

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were anti-bacterial, so they were suitable raw materials for making anti-bacterial bio-**BandAIDS** as there were fewer oral bacterial colonies. The commercial hydrocolloid of Nexcare was NOT anti-bacterial.

It took 24 days for Bio-**BandAIDS** of crab rouxii BSF dressing and 56 days for Bio-**BandAIDS** of crab rouxii dressing to be fully biodegraded in soil.

ALL Bio-**BandAIDS** of crab *rouxii* dressing, crab *rouxii* **BSF** dressing, crab chitosan (16.7M NaOH) only and #roasted crab chitosan (16.7M NaOH) only outperformed commercial hydrocolloid of Nexcare in the testing and certification based on IS 997. (IS997, 2004) Tensile strength of Bio-**BandAIDS** of crab chitosan (16.7M NaOH) only (>40N), #roasted chitosan (16.7M NaOH) only (21.0N), crab *rouxii* **BSF** dressing (28.3N) and crab *rouxii* dressing (23.0N) performed the best as their tension strength were the highest. (cf. commercial hydrocolloid of Nexcare: 4.3N only).

Besides, FSA Free Swell Absorptive Capacity based on SIST EN 13726-1 (SIST(EN)13726-1-2002) of bio-**BandAIDS** of crab *rouxii* dressing (11.68), crab *rouxii* **BSF** dressing (7.53) and *rouxii* **BSF** dressing only (10.88) were the highest. FSA of crab chitosan (16.7M NaOH) only (7.99) was also high. (cf. commercial hydrocolloid of Nexcare: 0.97)

Water resistance of bio-**BandAIDS** of crab chitin only (61%) , crab *rouxii* dressing (78%), roasted crab chitin (102%) and crab *rouxii* **BSF** dressing (74%) were the best (cf. Commercial hydrocolloid of Nexcare: (276%).

Percentage yield of chitosan from **BSF** chitin and crab chitin using deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* was increased from 3.7% to 16.9% and 18.3% to 22.1% when the temperature was increased from 30 °C to 50 °C in 6M urea showing that the optimum temperature for such deacetylase was 50°C. (cf. pure chitin 24.5% at 50 °C with chitin deacetylase expressed by *E. coli*) (cf. Using vinegar only at 50°C: 36.9% and 38.4%; *Mucor rouxii* in vinegar: 59.0% and 57.1% at 50°C; 16.7M NaOH: 22.1% and 48.3% at 80°C). Structural changes of BSF chitin and crab chitin to chitosan were confirmed using FTIR Spectrum II as DD% of *rouxii* chitosan of black soldier fly **BSF** obtained using a chitin deacetylase from *Mucor rouxii* (about 54% to 65%) were consistent with the DD% of pure chitosan (67.7%) and DD% of *rouxii* chitosan of Chinese mitten crab obtained using a chitin deacetylase from *Mucor rouxii* (about 57% to 63%) were consistent with the DD% of pure chitosan (67.7%)

A more water-soluble AI deacetylase designed by AlphaFold 3 and ProteinMPNN and the original deacetylase had similar shape. In doing so, the yield of chitosan would be drastically increased. The percentage yield of chitosan (from pure chitin) were 5.08% and 6.18% using AI designed deacetylase at 50°C (c.f. Original of deacetylase from *A. Nidulans* of 3.86%). Thus the use of AI designed deacetylase using ProteinMPNN, AlphaFold 3 etc could increase the percentage yield of chitosan from fermentation of chitin by 31.6% and 60.1% (purified AI deacetylase). DD% of chitosan of pure chitin obtained using an AI designed deacetylase (original: *A. nidulans*) expressed from *E. coli BL21* (about 76.5% to 75.5% from purified AI deacetylase) were consistent with the DD% of pure chitosan (67.7%).

As surface protein allergens were found to be absent in crab *rouxii* dressing, crab *rouxii* **BSF** dressing, #roasted chitin only and crab chitin only when tested using 3M ALLTEC C60, anti-bacterial bio-**BandAIDS** should be non-allergic. (ALLTEC, C60)

Obviously crab *rouxii* dressing and crab *rouxii* **BSF** dressing were the best raw materials to produce anti-bacterial bio-**BandAIDS** based on the testing and certification of bio-**BandAIDS** based on IS997 and SIST EN 13726-1-2002 and high water resistance. Anti-bacterial bio-**BandAIDS** should be eligible for marketing.

[#roasting done at 120°C for 30 mins (Ashenhurst, 2023)]

Keywords: *Mucor rouxii*, *Illucens hermetia, Eriocheir sinensis*, FTIR, anti-bacterial, chitosan, expression, *E. coli*, AlphaFold, proteinMPNN, multiple sequence alignment

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We would like to express our very great appreciation to our supervising teachers Dr. Tsz Yeung WONG for his valuable and constructive suggestions during the planning and development of this research work.

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We would like to thank Mr Conrad Young as the instructor on protein design and structural bioinformaticians.

AI was used in the development of this project. ProteinMPNN (v1.0.1) and AlphaFold 3 have been used to generate a more water-soluble deacetylase and to predict the physical structure of the deacetylase respectively. These two AI models were used when needed. See Appendix for more.

Timing: 2025 September

Frequency: two times, using MSA, ProteinMPNN and AlphaFold 3 to generate AI deacetylase and AI deacetylase without signal peptides

Declaration

This project was submitted to Shanghai International Youth Science & Technology Innovation Camp and "Science & Technology Stars of Tomorrow" Invitational Tournament in 2026, China Adolescents Science & Technology Innovation Contest (CASTIC) 2026, Hong Kong Youth Science and Technology Innovation Competition 2026, Hong Kong Chemistry Olympiad for Secondary Schools 2026 and Hong Kong Student Science Project Competition 2026.

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Commitments on Academic Honesty and Integrity

We hereby declare that we

1. are fully committed to the principle of honesty, integrity and fair play throughout the competition.
2. actually perform the research work ourselves and thus truly understand the content of the work.
3. observe the common standard of academic integrity adopted by most journals and degree theses.
4. have declared all the assistance and contribution we have received from any personnel, agency, institution, etc. for the research work.
5. undertake to avoid getting in touch with assessment panel members in a way that may lead to direct or indirect conflict of interest.
6. undertake to avoid any interaction with assessment panel members that would undermine the neutrality of the panel member and fairness of the assessment process.
7. observe the safety regulations of the laboratory(ies) where the we conduct the experiment(s), if applicable.
8. observe all rules and regulations of the competition.
9. agree that the decision of YHSA(Asia) is final in all matters related to the competition.

We understand and agree that failure to honour the above commitments may lead to disqualification from the competition and/or removal of reward, if applicable; that any unethical deeds, if found, will be disclosed to the school principal of team member(s) and relevant parties if deemed necessary; and that the decision of YHSA(Asia) is final and no appeal will be accepted.

(Signatures of full team below)

X

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Name of team member: Bohen ZHOU

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Name of team member: Yan Lok Samuel CHONG

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Name of supervising teacher: Dr Tsz Yeung WONG

Noted and endorsed by

(signature)

Name of school principal: Mr Wong Chun

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1.Theory

1.1 Anti-bacterial bio-BandAIDS

Anti-bacterial bio-**BandAIDS** are anti-bacterial bandages made of chitin with dressings that are anti-bacterial by using crab chitosan and black soldier fly **BSF** chitosan.

1.1.1 Chitin and chitosan

Crab chitosan and **BSF** chitosan can be obtained using the following ways:

- **Traditional method of using 16.7 M NaOH**
- **Green fermentation method using *Mucor rouxii***
- **Green fermentation method using AI to design other chitin deacetylase obtained by expression**

1.1.1.1 Chitin and chitosan as bio-degradable bandages and dressing

Chitin and chitosan are biodegradable biocompatible polymer. (Yanat, 2023) (Priyadarshi, 2020) Chitosan is derived from natural renewable resources with numerous applications such as edible film and coating. Both chitin and chitosan have antibacterial and antifungal properties which qualify them for bio-bandages.

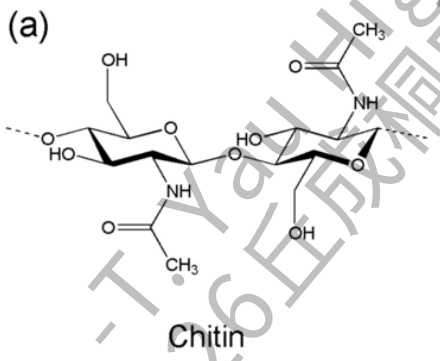


Figure 1.1.1.1.1 Structure of chitin (Hahn, 2020)

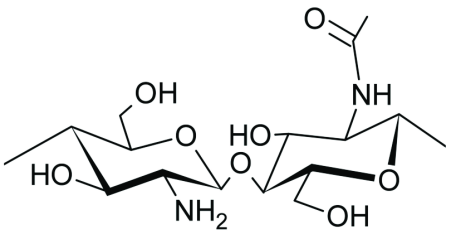


Figure 1.1.1.1.2 Structure of chitosan (Costa, 2021)

1.1.1.2 Chitin-rich natural sources

Chitin sources are not just from large crustaceans and crabs, but also insects and small crustaceans. As a new and promising raw material, Black Soldier Fly (*Hermetia illucens L.*), with its chitinous shell, is domesticated and liable to breeding representatives of invertebrate animals. Their shells are obtained a sufficiently high percentage chitin yield at 21.3% (1281.2 g per year per m^3 of a cage), almost complete absence of residual protein (C = 0.98 μg/ml) and high adsorption ability (X = 156.6 mg/g) of the extracted polysaccharide. (Antonov A., 2019)

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1.1.1.3 Productivity of chitin and chitosan obtained from BSF and Chinese mitten crab

The productivity of chitin obtained from the larvae of black soldier flies *H. illucens* was found to be approximately 5.00 ± 0.002%. These chitins were converted to chitosan by chemical treatment with a yield of about 93 ± 0.16%, and a deacetylation degree of 85.71 ± 0.24% was confirmed. Chitosan could be isolated and purified from larvae of black soldier flies (*Hermetia illucens*) which are rich in chitin. (Yong, 2022) The percentage by mass of chitin and chitosan that could be obtained from *Eriocheir sinensis* crab were as follows.

Raw material	Mass (g)		Yield (%)	
	Shrimp	Crab	Shrimp	Crab
	396.00	204.00	-	-
Chitin	162.00	114.24	41.00	56.00
Chitosan	87.12	81.60	22.00	40.00

Figure 1.1.1.3.1 Table (Andrade, 2012)

1.1.1.4 Removal of calcium carbonate by demineralization of carbonates using 2M HNO_3

$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$

1.1.1.5 Deproteinization through deacetylation of chitin to chitosan

Deacetylation could be done by using NaOH room temperature (RT), 363 and 393 K, hydroxide concentration (2.0 or 10.0 M) and time (3 and 24 h) on shrimp chitin deacetylation. (Pires, 2014)

Chitin is extracted from crab shell from which chitosan is made by N-deacetylation

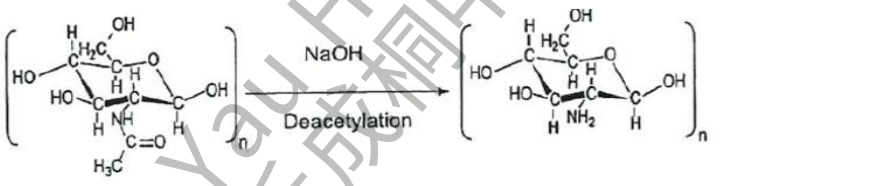
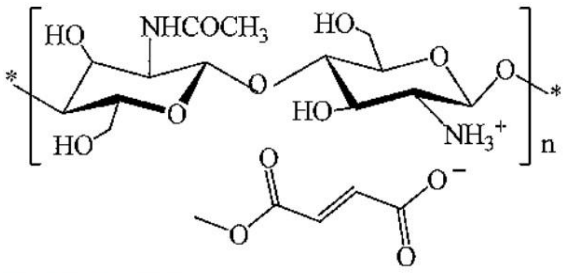


Figure 1.1.1.5.1 Conversion of chitin to chitosan by deacetylation (Okoya, 2016)

1.1.1.6 Water absorption of hydrogel, the salt of chitosan

Chitosan is able to form a gel, all by itself, without the need of any additive. The process is based on the neutralization of chitosan amino groups and thus the inhibition of the repulsion between chitosan chains. The formation of the hydrogel then occurs via hydrogen bonds, (Croisier, 2013)

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Chemical structure of MF-chitosan salt.
https://www.researchgate.net/figure/Chemical-structure-of-MF-chitosan-salt_fig3_269711737

Figure 1.1.1.6.1 Chemical structure of MF-chitosan salt

Hydrogels, a special form of SAPs, exhibit water absorption capacity in the vicinity of 100%, swell in water and retain a significant fraction of water (>20%) within their structure without dissolving (Graham, 1998)

1.1.2 Fermentation of chitin to chitosan using a chitin deacetylase

A deacetylation degree of 55–70% is defined as a low deacetylated degree of chitosan, which is almost completely insoluble in water. A deacetylation degree of 70–85% is the middle deacetylation degree of chitosan, which may be partly dissolved in water. Finally, 85–95% is a high deacetylation degree of chitosan, which has good solubility in water. (Lv, 2016) Chitin became soluble in dilute acetic acid at the DD of ca. 28% or over (i.e. DA of about 72% or below) and soluble in water at the DD of ca. 49% (i.e. DA of about 51%). Some hydrogen bonds existing in raw alpha-chitin were found to be missing at a DD of ca. 49%. (Cho, 2000)

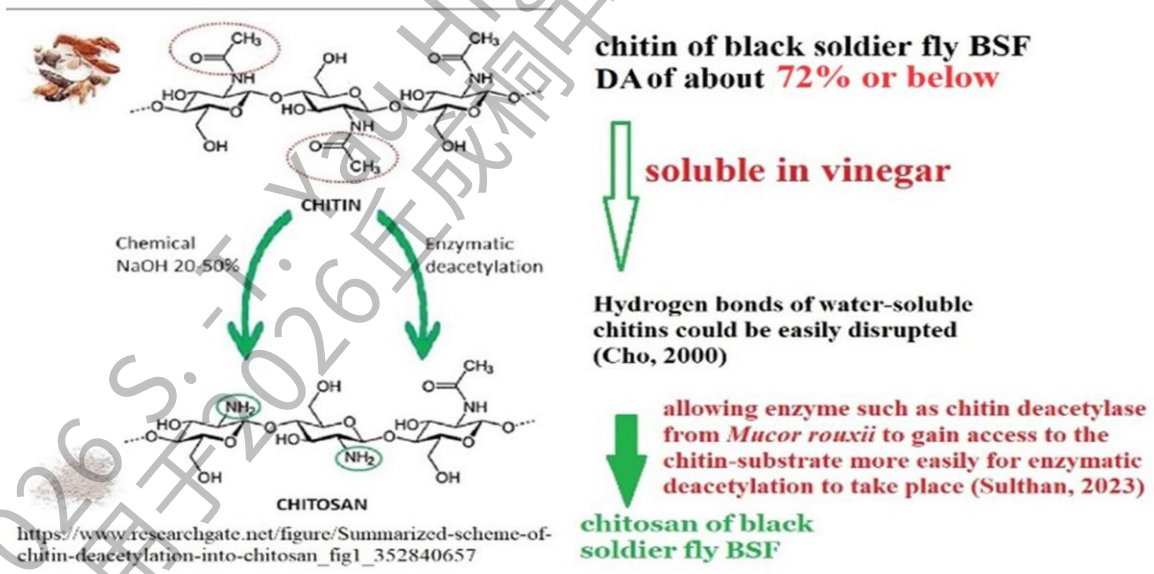


Figure 1.2.3 Schematic diagram of fermentation of chitin to chitosan by fermentation using a chitin deacetylase (Cho, 2000)

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1.1.2.1 Fermentation using *Mucor rouxii*

A chitin deacetylase could be isolated from *Mucor rouxii* ((Martinou, 1993) which could be used to produce gamma-linolenic acid (GLA) by a filamentous fungus, *Mucor racemosus*, using fermentation Douchi. (Lu, 2010)

1.1.2.2 Expression of chitin deacetylase using *E. coli*

1.1.2.2.1 Recombinant DNA technology

Expression is a kind of recombinant DNA technology. It involves the cutting of DNA molecules from different sources and joining them together. The resultant DNA is called recombinant DNA.

In this technology, a DNA fragment containing a gene of interest is inserted into a plasmid, which is a small ring of extrachromosomal DNA found naturally in bacteria such as *E. coli*.

1.1.2.2.2 Industrial uses of expression

Enzymes for industrial uses can also be produced using recombinant DNA technology. Genes for the enzymes such as chitin deacetylase are introduced into bacteria such as *E. coli*, and the enzymes produced by the bacteria can be extracted for use such as deacetylation of chitin of black soldier fly **BSF** to chitosan.

1.1.3 Determination of Degree acetylation DA% in chitin and degree of deacetylation DD% in chitosan using FTIR

The following is FTIR Spectrum Two.



Figure 1.1.3 FTIR Spectrum Two

Spectrum Two FT-IR spectrometers feature:

- Standard, high-performance, room-temperature $LiTaO_3$ (lithium tantalate) MIR (mid infra-red) detector with a SNR (signal to noice ratio) of 9,300:1

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- Optional temperature-stabilized, high-performance DTGS (deuterated triglycine sulfate) MIR detector with a SNR of 14,500:1. Ideal for low-light, high throughput applications
- Standard optical system with KBr windows for data collection over a spectral range of 8,300 – 350 cm^{-1} at a best resolution of 0.5 cm^{-1}

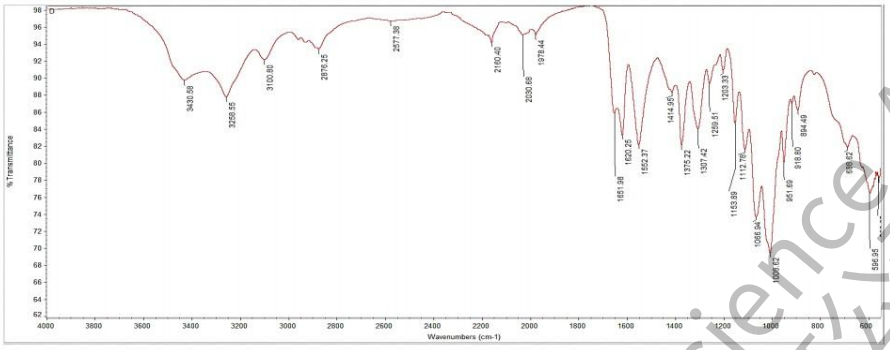


Fig. 3: FTIR spectrogram of the chitin sample 1.

G. Interpretation of FTIR spectra

The interpretation of FTIR analysis of the samples is done for the possible presence of functional groups and the details are given in table 2. The basis of interpretation is the FTIR of standard chitin is reported in literature.

Table 2: Interpretation of FTIR analysis

Sr. No	Standard chitin wavelength in cm^{-1}	Crab chitin wavelength in cm^{-1}		Group
		Sample- 1	Sample -2	
1	3448	3430	3431	OH
2	3300-3250	3258, 3100	3257, 3101	N-H stretching
3	2891	2876	2880	C-H stretching
4	1680-1660	1651, 1620	1619	C=O stretching
5	1560-1530	1552	1552	Amide II band amide II band
6	1340	1375, 1307	1374, 1307	Methyl CH stretch, Amide III
7	1152-1156	1153, 1112	1153, 1112	Glycosidic linkage, C-H stretch
8	1072	1066, 1008	1067, 1008	C-O-C
9	952	951	951	Amide III
10	750-650	688	688	N-H

http://ijsetr.org/wp-content/uploads/2016/05/IJSETR-VOL-5-ISSUE-5-1378-1383.pdf

Figure 1.1.3.1 (Pandharipande, 2016)

Like in the NMR spectroscopy, also in the FTIR spectroscopy, several procedures and equations are described in literature for calculation of degree of deacetylation. (Biskup, 2012)

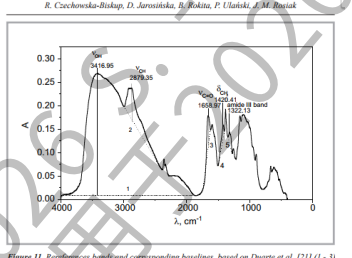


Figure 11. Rereferences bands and corresponding baselines, based on Duarte et al. [21] (1 - 3) and Brugaretto et al. [22] (4 - 5) for FTIR spectrum of chitosan sample S2.

(Biskup, 2012)

Figure 11. Rereferences bands and corresponding baselines, based on Duarte et al. [21] (1 - 3) and Brugaretto et al. [22] (4 - 5) for FTIR spectrum of chitosan sample S2.

$$DA\ [\%] = \frac{A_{1655}}{A_{3450}} \times 100/1{,}33\ [17, 23] \quad (15)$$

$$DA\ [\%] = \frac{A_{1655}}{A_{2870}} \times 100/1{,}33\ [23] \quad (16)$$

$$DA\ [\%] = \frac{A_{1655}}{A_{3450}} \times 115\ [17] \quad (17)$$

$$DA\ [\%] = \left(\frac{A_{1320}}{A_{1420}} - 0{,}03822\right)/0{,}03133\ [22] \quad (18)$$

where: A_{3450}, A_{2870}, A_{1655}, A_{1420}, A_{1320}, are values of absorbance from baseline 1, 2, 3, 4, 5 to maximum, respectively. In ***Figure 11***, on the basis IR spectrum of chitosan S2, baseline settings and individual bands ascribed for characteristic groups in chitosan are presented.

(Biskup, 2012)

Samples	50	60	70	80	90	100
Mussel shell	77.21	83.31	85.75	91	93.22	96.51
Oyster shell	69.68	73.98	80	85.62	90.44	93.27
Prawns shell	40.17	45.78	48.59	51.61	54.22	60.56
Crab shell	54.1	56.49	63.7	69.4	74.16	74.57
Pang scale	50.11	52.58	56.89	62.35	65.77	69.12
Silver scale	47.59	49.16	52.18	56.12	60.1	65.85

Table 4 Degree of acetylation (DA) (%) of chitin samples from sea waste at varied temperature (°C)

https://www.semanticscholar.org/paper/Biopolymer-(Chitin)-from-Various-Marine-Seashell-Alabaraoye-Achilonu/2c78c6353508c9cb7328347e7c7abf533c3a0d02/figure/6

(Alabaraoye, 2018)

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1.1.4 Water resistance and breathability of chitin

Chitin is inherently water-repellent and highly insoluble in water due to strong hydrogen bonding between chitin polymers and hydrophobic properties, making it resistant to swelling and improving water barrier properties. (Abdullah, 2020) It can also be turned into films which are found to be breathable. (Zhu, 2019)

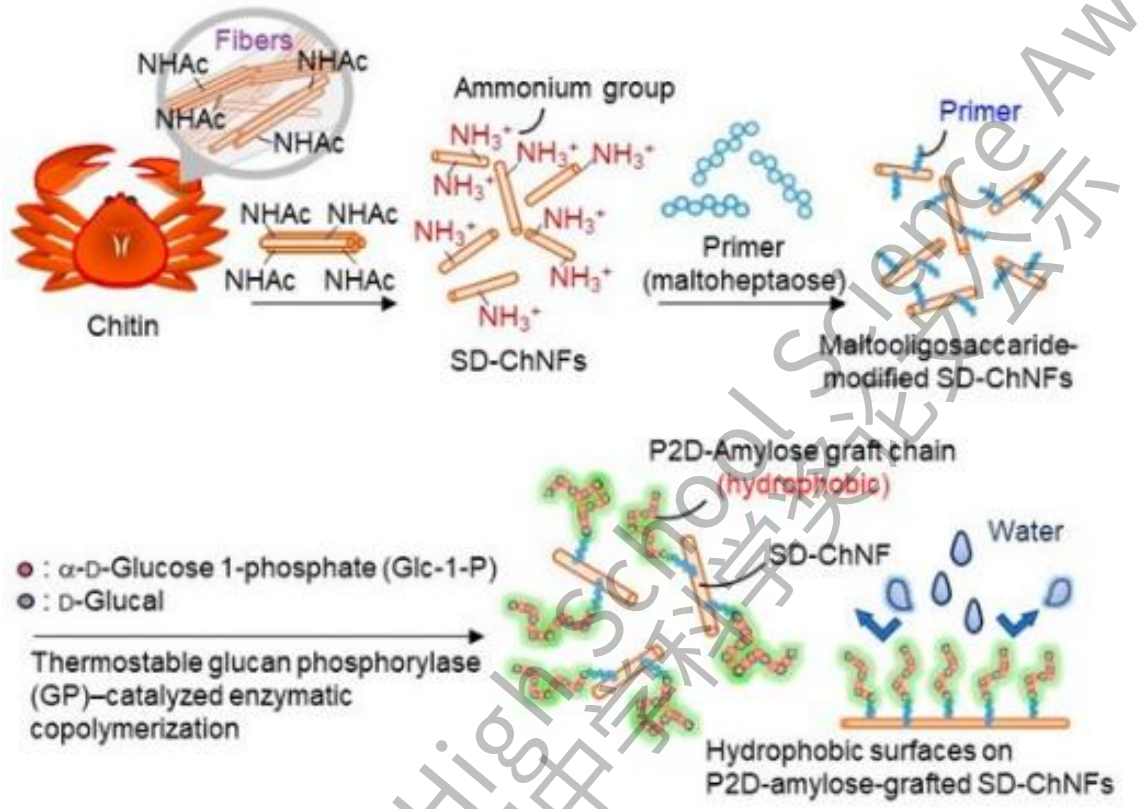


Figure 1.1.4 Schematic illustration of enzymatic grafting of partially 2-deoxygenated (P2D-) amylose on scale-down chitin nanofibers (SD-ChNFs) by thermostable glucan phosphorylase (GP) catalysis, as the concept of this study showing the hydrophobicity of chitin (Yamamoto, 2025)

1.1.5 Chitosan as hemostatic agents

Hemostatic mechanism usually involves the body's multifaceted response to bleeding by coagulation when platelets quickly adhere onto the injured endothelium. A blood clot is a colloidal composite formed spontaneously and gives response for bleeding. As a hemostatic agent, chitosan, which has high biocompatibility, low toxicity, inherent antimicrobial ability and favorable hemostatic performance that facilitates the formation of blood clot. (Zhang, 2024)

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1.2 Testing and Certification of the performance of anti-bacterial bio-BandAIDS as bandages based on IS997 and SIST EN 13726-1

1.2.1 Testing and Certification of the performance of anti-bacterial bio-BandAIDS as bandages based on IS997

SSI 997 (2004)

203. BANDAGE CHARACTERISTICS

In the tests described in Table 3 bandage characteristics will be as detailed in the table

Table 3

Serial No.	Bandage Characteristics	The requirement				Test After
		W&W 18	W&W 20	W&W 24	W&W 27	
3	Load per unit of area (gr/m^2) min.					
	- bandage with fringes	24	27	32	36	Para. 305
	- bandage without fringes	29	31.5	36	40	
4	Tension strength in the wrap direction (Newton) min. Of bandage type 103.1.2	50	60	60	67	IS 915 A
4a	Tension strength in wet condition in the wrap direction (Newton) min. Of bandage type 103.1.2	50	60	60	67	Para. 306
5	pH	4.5 - 8				
6	Absorption ability: sedimentation time (seconds), max.	10				

204. OVERALL COUNT OF MICRO-ORGANISMS

The bandage is tested as described in European Pharmacopoeia, updated edition.

The number of micro-organisms as described in European Pharmacopoeia, updated edition, for products destined for application to skin.

306. TENSION STRENGTH IN WET CONDITIONS IN THE WRAP DIRECTION OF A GAUZE BANDAGE MADE OF RAYON-VISCOSE (TYPE 103.1.2)

Tension strength testing under wet conditions in the wrap direction is tested as described in the Israeli Standard IS 915 in the paragraph that deals with the tension, with the following additions:
The samples are laid on a surface of distilled water or water free of ions at a temperature of 17ºC to 30ºC until they will sink by themselves, however if the time required for them to sink is longer than 2 hours, they should be forced to sink for an additional hour, at least.
If it becomes necessary to impregnate the samples, full impregnation of those that are generally immune to impregnation, the use of a watery solution that contains non ionic moisturizing material in an amount not exceeding 1 gr./litre instead of water is permitted.

Figure 1.2.1.1 IS997

1.2.2 Testing and certification of the performance of bio-BandAIDS based on SIST EN 13726-1

SIST EN 13726-1 - Aspects of Absorbency

https://cdn.standards.iteh.ai/samples/9445/f3ea1058a29a440a99a50051409b979d/SIST-EN-13726-1-2002.pdf

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The majority of wound dressings are applied to remove excess wound fluid (exudate) from the immediate vicinity of the wound. This standard contains a series of test methods which assess absorbency, fluid handling capacity and dispersion characteristics:

Section 3.2 Free-Swell Absorptive Capacity
This test is intended to measure the absorbency of fibre-type wound dressings such as alginates (e.g. Kaltostat, Sorbsan etc.) and gelling fibres (e.g. Aquacel, Durafibre etc.) which are used on moderate to heavily exuding wounds where total absorptive capacity is an important feature.
Dressings are sectioned into 5x5cm samples, weighed and then incubated in artificial exudate at 37°C. The free-swell absorbency following 30 minutes incubation is subsequently calculated.
This test is only appropriate for dressings which remain physically intact and which reach their absorptive capacity within 30 minutes under the test conditions.
As the dressings need to be sectioned prior to testing, this test method is not appropriate for super-absorbent containing wound dressings (SMTL have alternative test methods for super-absorbent wound dressings which are outlined in SMTL TM-404 and TM-414).
Similarly, wound dressings which have duel action of handling exudate via absorbency and moisture vapour transmission are not appropriate for this test, and should be tested for Fluid Handling Capacity.

Free-Swell Absorbency (FSA)
Pre-weighed dressings were soaked in ionic solution at 37°C for 30 min and weighed after removing the excess. Absorbency was calculated as follows:
Absorbency (g/dressing) = wet weight – dry weight

1.3 Anti-bacterial property of chitin and chitosan

Both Chitin and chitosan are anti-bacterial. (Srinivasan, 2023)

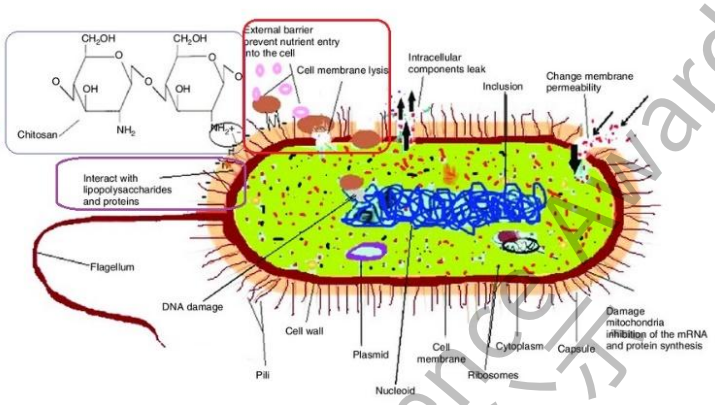
Both chitin and chitosan caused They concluded that chitin and chitosan had bacteriostatic activity and caused the bacteria to flocculate and die through lack of nutrients and oxygen. (Benhabiles, 2012) (Mohammed, 2013)
However, chitin's antimicrobial properties are generally less potent than those of its derivative, chitosan. (Kucharska, 2019)

Chitosan is a versatile material with proved antimicrobial activity. Three antibacterial mechanisms have been proposed: i) the ionic surface interaction resulting in wall cell leakage; ii) the inhibition of the mRNA and protein synthesis via the penetration of chitosan into the nuclei of the microorganisms; and iii) the formation of an external barrier, chelating metals and provoking the suppression of essential nutrients to microbial growth. It is likely that all events occur simultaneously but at different intensities (Goy, 2009)

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Three antibacterial mechanisms have been proposed:
i) the ionic surface interaction resulting in wall cell leakage;
ii) the inhibition of the mRNA and protein synthesis via the penetration of chitosan into the nuclei of the microorganisms; and
iii) the formation of an external barrier, chelating metals and provoking the suppression of essential nutrients to microbial growth. (Goy, 2009)

https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-14282009000300013



https://www.researchgate.net/figure/Various-antimicrobial-mechanisms-of-chitosan_fig3_327108512

Figure 1.3.1 Various antibacterial mechanisms of chitosan

1.4 Invertebrate allergen

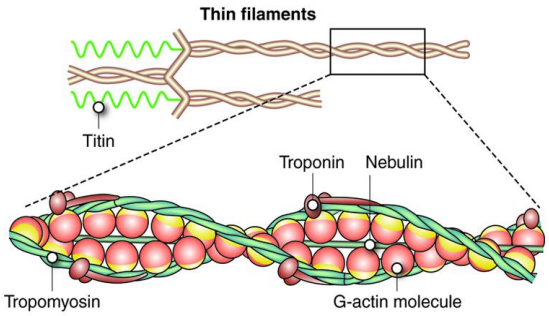
The major allergen has been identified as the muscle protein tropomyosin. This molecule belongs to a family of highly conserved proteins with multiple isoforms found in both muscle and nonmuscle cells of all species of vertebrates and invertebrates. Its native structure consists of two parallel alpha-helical tropomyosin molecules that are wound around each other forming a coiled-coil dimer. Allergenic tropomyosins are found in invertebrates such as crustaceans (shrimp, lobster, crab, crawfish), arachnids (house dust mites), insects (cockroaches), and mollusks (e.g. squid) (G Reese, 1999)

As only shells of black soldier fly were used in the production of anti-bacterial bio-bandages, the bio-bandages obtained would be non-allergic.

(Muscular Levels of Organization | Anatomy and Physiology I | | Course Hero)

Protein test using protein test strip. If protein is absent, so does allergens such as tropomyosin.

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https://www.coursehero.com/study-guides/cuny-csi-ap-1/muscular-levels-of-organization/

Figure 1.4.1
(Muscular Levels of Organization | Anatomy and Physiology I | | Course Hero)
Protein test using protein test strip. If protein is absent, so does allergens such as tropomyosin.



Figure 1.4.2 3M ALLTEC60 Clean-Trace protein test strip

1.5 Bio-degradability

Lysozyme-Induced Degradation of Chitosan involves physical dissolution of chitosan and lysozyme cleavage of glycoside bond. (Lončarević, 2017)

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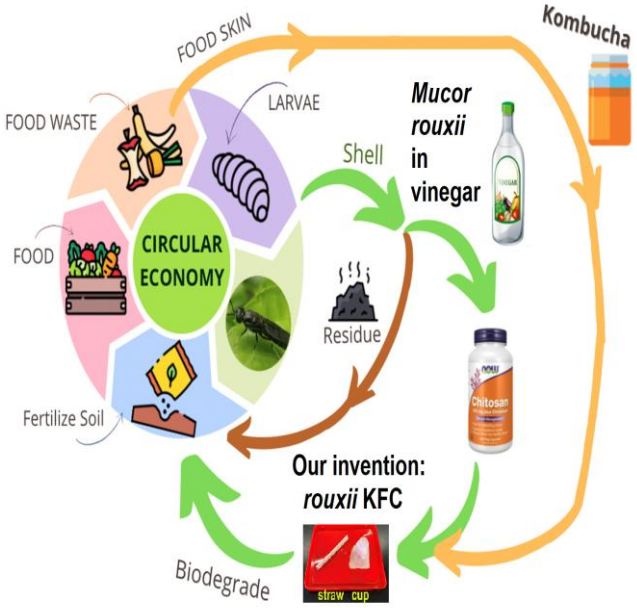


Figure 1.5.1: Microstructure of chitosan cross section (left) and surface (right) after four weeks of incubation in different lysozyme solutions.

According to the literature, the weight loss of porous chitosan depends on the initial concentration of chitosan solution, degree of deacetylation, distribution of molecular weight and swelling properties. Chitosan materials with very high deacetylation degree (95 – 98%) would show a lower weight loss due to the low sensitivity of amine groups to lysozyme. (Lončarević, 2017)

1.6 Expression of chitin deacetylase using *E. coli*

1.6.1 Plasmid design

The plasmid we designed contains an insert of deacetylase ligated with the pET plasmid. The pET plasmid contains kanamycin resistance gene, SUMO-tag, 6-His tag and a Multiple Cloning Site. In our design, sumo-tag would be removed.

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Figure 2(a): initial location of sumo

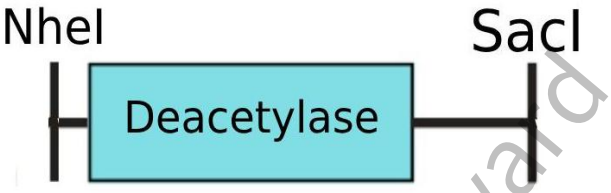
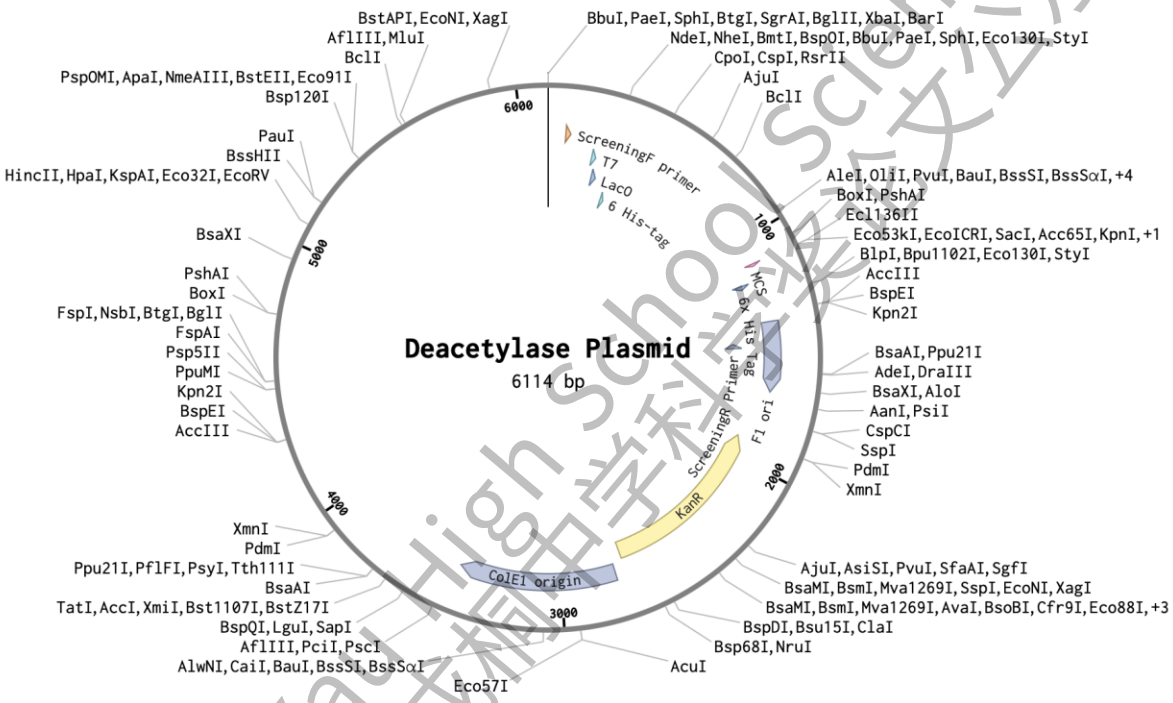


Figure 2(b): ACPs insert design



Overview of plasmid design

1.6.2 Amplification of plasmid

Amplification of plasmid DNA is a technique in molecular biology and biotechnology that serves several important purposes, including gene cloning, protein expression, genetic engineering, gene therapy, and vaccine development. By inserting a gene of interest into a plasmid and then amplifying that plasmid within a host organism, researchers can produce large quantities of specific DNA sequences. This process enables the large-scale production of proteins, including therapeutic proteins like insulin, and facilitates the creation of genetically modified organisms (GMOs) with desirable traits. Additionally, amplified plasmids can be used as vectors for delivering therapeutic genes in

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gene therapy and for developing vaccines by encoding antigens from pathogens. Overall, plasmid amplification plays a vital role in advancing scientific research and developing new biotechnological applications.

1.6.3 Digest and ligate with restriction enzyme and ligase

Digest and ligation are techniques in molecular biology used for manipulating and cloning DNA. Digestion involves using restriction enzymes to cut DNA at specific sequences, generating fragments with compatible ends that can be easily joined. This process is crucial for preparing DNA fragments for cloning and constructing recombinant DNA. Ligation follows digestion and involves the enzyme DNA ligase, which joins the digested DNA fragments (e.g., a plasmid vector and an insert) to form a stable recombinant DNA molecule. Together, these processes enable gene cloning, genetic engineering, and the creation of transgenic organisms, making them fundamental tools in genetic research, biotechnology, and therapeutic development.

1.6.4 PCR screening for determining peptides/proteins

PCR means polymerase chain reaction. It's a test to detect genetic material from a specific organism, such as a virus. The test detects the presence of a gene of interest if you have the gene of interest at the time of the test. The test could also detect fragments of the gene of interest even after you are no longer infected.

1.6.5 Designing a chitin deacetylase using AI

A more water soluble chitin deacetylase could be designed using AlphaFold 3 (Abramson, 2024), ProteinMPNN (Sumida, 2024) (Dauparas, 2022) to eliminate the use of solvents such as 6M urea.

The Nobel Prize in Chemistry 2024 is about proteins, life's ingenious chemical tools. David Baker has succeeded with the almost impossible feat of building entirely new kinds of proteins. Demis Hassabis and John Jumper have developed an AI model which is Alphafold 3 to solve a 50-year-old problem: predicting proteins' complex structures. These discoveries hold enormous potential.

In 2020, **Demis Hassabis** and **John Jumper** presented an AI model called AlphaFold2. (Jumper, 2021)With its help, they have been able to predict the structure of virtually all the 200 million proteins that researchers have identified. Since their breakthrough, AlphaFold2 has been used by more than two million people from 190 countries. Among a myriad of scientific applications, researchers can now better understand antibiotic resistance and create images of enzymes that can decompose plastic.

The new AI model AlphaFold 3 invented by Google DeepMind AlphaFold team is capable of high-accuracy prediction of complexes containing nearly all molecular types present in the Protein Data Bank achieved by a substantial evolution of the AlphaFold2 architecture and training procedure. (Accurate structure prediction of biomolecular interactions with AlphaFold 3, https://doi.org/10.1038/s41586-024-07487-w)

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Multiple sequence alignment MSA Multiple sequence alignment (MSA) is the process or the result of sequence alignment of three or more biological sequences, generally protein, DNA, or RNA. Alignments are used to assess sequence conservation. (Bonatesta, 2025)

HHblits: lightning-fast iterative protein sequence searching by HMM-HMM alignment was an open-source, general-purpose tool that represents both query and database sequences by profile hidden Markov models (HMMs): 'HMM-HMM–based lightning-fast iterative sequence search' (HHblits; http://toolkit.genzentrum.lmu.de/hhblits/). (Remmert, 2012)

ProteinMPNN sequence design improves TEV protease expression by fixed residue selection of highly conserved residues. Highly conserved residues were determined with multiple sequence alignment MSA. To generate the MSA, HHblits were performed. (Sumida, 2024)

2.Methodology

2.1 Comparing different method in obtaining anti-bacterial dressing of chitosan BSF from chitin BSF

Here are the samples under investigation (**Figure 2.1.1**):



Hermetia illucens, black soldier fly (**BSF**)

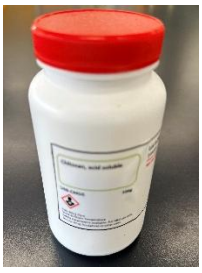


Eriocheir sinensis **(Chinese mitten crab)**



Commercial hydrocolloid









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Pure chitin Pure chitosan *Mucor rouxii* vinegar

Figure 2.1.1 Samples under investigation

Chitosan was obtained by deacetylation of chitin **BSF** and crab chitin by several methods. Chitosan **BSF** and crab chitosan obtained were dissolved in vinegar and dried to form a chitosan **BSF** dressing and crab chitosan dressing..

2.1.1 Percentage yield of *rouxii* chitosan BSF from chitin BSF using fermentation with a chitin deacetylase obtained from *Mucor rouxii*.

1. 0.1g of chitin **BSF** was weighed and added to 10cm^3 of vinegar in each tube.

2. 0.05g of chitin deacetylase obtained from *Mucor rouxii* in added

3. Each tube of sample was put into incubators at different temperature (30°C, 40°C, 50°C, 60°C) for 1 day.

4. The above were repeated for crab chitin.



Figure 2.1.1.1 Samples of chitin **BSF** and crab chitin in vinegar and *Mucor rouxii*



Figure 2.1.1.2 incubator



Figure 2.1.1.3 chitin BSF left



Figure 2.1.1.4 crab chitin left

4. ***rouxii*** chitosan formed were dissolved in vinegar and dried. Mass of ***rouxii*** chitosan **BSF** and rouxii crab chitosan formed were measured

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2.1.2 Obtaining Chitosan BSF and crab chitosan using fermentation, vinegar only and 16.7 M NaOH

1. 0.1 g of chitin of **BSF** were weighed and added to 10 cm^3 vinegar. (vinegar only method)

2. Step 1 was repeated. 0.05g *Mucor rouxii* was added and the mixture was put into an incubator at 50°C for 1 day. (fermentation method)

3. 10 g of chitin **BSF** were heated with 2 dm^3 16.7 M NaOH at 80°C for 6 hours. (traditional chemical method)

4. Chitosan **BSF** obtained were weighed.

5. The above were repeated with crab chitin.

2.2 Testing and certifications different anti-bacterial Bio-BandAIDS based on IS997(2004) and SIST EN 13726-1

2.2.1 Testing and certification of different anti-bacterial Bio-BandAIDS based on IS997(2004)

1. Load per unit area of the samples were calculated by dividing the mass of samples by the surface area.
2. Tension strength of the samples were found using Newton balance.
3. Tension strength in wet condition (soaking the samples in distilled water for 3 hours) of the samples were found using Newton balance.
4. pH of the wet the samples were measured using pH paper.
5. Overall count of micro-organism were calculated by counting the bacterial colonies developed after spreading drinking water with oral bacteria soaked with the samples for 24 hours over agar with culture solution.



Figure 2.2.1 Testing of tension strength based on IS997 (2004)

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2.2.2 Testing and certification of different anti-bacterial Bio-BandAIDS based on SIST EN 13726-1

1. Mass of samples of dry dressings of 5 cm x 5 cm were weighed.
2. Samples of dressings were allowed to absorb excess synthetic blood for 30 minutes.
3. Mass of the wet samples were weighed.

FSA = weight of wet samples – weight of the dry samples (g per 5cm x 5cm dressing)+



Figure 2.2.2 Testing Free swell absorbancy FSA using synthetic blood

2.3 Testing of the anti-bacterial ability of crab *rouxii* dressing and crab *rouxii* BSF dressing, roasted chitin only and crab chitin only and commercial hydrocolloid

1. Oral bacteria were collected from drinking bottle.

2. Crab *rouxii* dressing and crab *rouxii* **BSF** dressing, roasted chitin only and crab chitin only and commercial hydrocolloid were soaked in 1 ml of oral bacteria solution for a day.

3. 100 microlitre of bacterial solution were spread over the agar plate.

4. The agar plate was incubated in shake incubator in 37°C for 24 hours.

5. Number of bacterial colonies on each plate were counted.

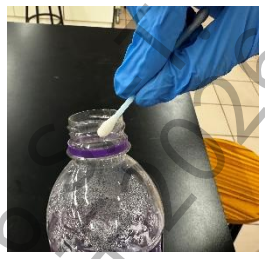


Figure 2.3.2.1.1 obtaining oral bacteria from drinking bottles



Figure 2.3.2.1.2 Serial dilution



Figure 2.3.2.1.3 Spreading oral bacteria on agar plates

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2.4 Testing of surface protein allergen level on anti-bacterial bio-BandAIDS



Figure 2.4 3M Clean-Trace ALLTEC60

3M Clean-Trace ALLTCE60 was used to detect the presence of surface protein allergens on anti-bacterial bio-**BandAIDS.**

2.5 Comparing the biodegradability of different bio-BandAIDS and commercial hydrocolloid



Figure 2.5.3 Different Bio-BandAIDS and commercial hydrocolloid in soil

1. Dry samples were weighed.

2. Samples were left in soil and water was added to keep the soil wet.

3. Wet samples were weighed two times every week

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2.6 Expression of a deacetylase from *Aspergillus nidulans* by *E. coli BL21*

2.6.1 Design of the fusion peptide

A fusion peptide (SUMO) (Butt TR, 2005) was added to increase the solubility of expressed deacetylase (**Figure 2.8.1.2**) from a fungus species called *Aspergillus nidulans* through the NCBI database (https://www.ncbi.nlm.nih.gov/nuccore/190576799). The whole sequence with the expression plasmid, pET-28a+ (**Figure 2.8.1.3**), was ordered through TWIST Bioscience.

	Sequence
SUMO	ATGTCGGACTCAGAAGTCAATCAAGAAGCTAAGCCAGAGGTCAAGCCAGAAGTCAAGCCTGAG ACTCACATCAATTTAAAGGTGTCCGATGGATCTTCAGAGATCTTCTTCAAGATCAAAAAGACCA CTCCTTTAAGAAGGCTGATGGAAGCGTTCGCTAAAAGACAGGGTAAGGAAATGGACTCCTTAAG ATTCTTGTACGACGGTATTAGAATTCAAGCTGATCAGACCCCTGAAGATTTGGACATGGAGGAT AACGATATTATTGAGGCTCACAGAGAACAGATTGGTGGT
Deacetylase	ATGCTGTTTCCTAATGTGCCGGGTGTGGCATCTCTTCTGTCACTGTTCGCCGCAACCCTCATCCTG AACACTCAAGCCTTGGCCATCAACACGATTGCGAACCTGACGGACCGACAACCGCGTGTTTCCT ACGGTCTGTATATTCACCATTGCTATGTTCCGGGAGTGGTGGCGCTGACCTTCGATGACGGCCCC TACATTTACACGGAAGAATTGTTAGACATACTCGCGCAGTACGGCGCCAAAGCGACCTTCTTTG TGAATGGCCACAATCTGGCTGGCAACGAATGGTTAATCCAGCGTGTTGTAAATGAAGGGCACCA GCTGGCAAGCCACACATGGGGCCATACCGATCTTACTGTTTTAAGCTATGATCAAATTGTCGATC AAATGACCCGGCTGGAGAGCGCCTTTGTAGCGTCCGTCGGGGTAGTTCCAACCTACATGCGCCC ACCGTATCTCGCGGCGAATGACTATGTTCTGGGCGTCATGGCTGAATTAGGTTATCATGTAATTG GTGCTAGTGTCGATACCAAAGACTATGAGAACGATCATCCTGATCTGATTGGCCGTAGTGTGGC CAAGTTTAACCAGGAGCTAGATCAGGGAGGCACGATCGTGTTGTCGCATGACATTCACGAGCAG ACCGTGCGCACGCTGACACATATCATGCTGGAAGAAGTGTATGAACGCGGGTTGCAGCCGACAA CTGTCGGTGGTTGTCTTGGTGATGATGCATGGTACAGATAA

Table 2.6.1.1 Sequence of SUMO and deacetylase used in fusion protein



Figure 2.6.1.2 Design of fusion deacetylase with SUMO

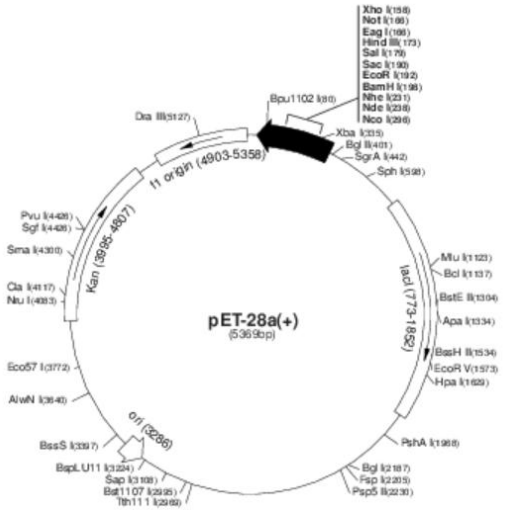


Figure 2.6.1.3 pET-28a+

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2.6.2 Cloning and Protein expression

The plasmid was transformed into *E. coli BL21* for expression. A single colony was picked up and incubated in 20ml LB broth containing kanamycin(1X) at 37°C with 150 rpm shaking overnight. A total of 6 ml incubated cell culture was then incubated into 240 ml LB broth containing kanamycin (1X) at 37°C with 150rpm shaking until the OD600 reached 0.6. Then, 0.4mM IPTG was used to induce the protein expression for 24 hours at 20°C. Then, the cells were harvested by centrifugation at 6000 × g for 20 minutes. The supernatant was collected. After that, 1 ml lysis buffer with 1 mM PMSF and 6 M urea per 10 ml culture was used to resuspend the pellet. Suspension was sonicated on ice (amplitude: 95%; time: 5 min; pulse: 2 s on, 2 s off). It was cleared by centrifugation at 15000 rpm, 4°C for 15 minutes.

After that, SDS-PAGE will be conducted to confirm whether the expression was induced successfully.

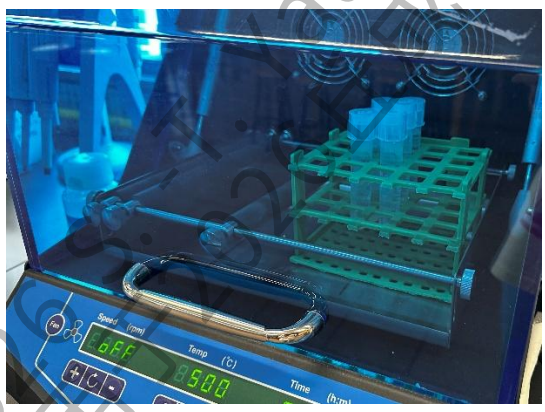
2.6.3 Fermentation of chitin BSF and crab chitin using a chitin deacetylase expressed from *E. Coli BL21*

1. About 0.03 g of chitin BSF was added to 200 µL of chitin deacetylase expressed from *E. Coli BL21* and 10.00cm^3 6 M urea.

2. The mixture was placed in an incubator at 50°C overnight to allow fermentation to take place.

3. Mass of chitosan obtained was weighed.

4. The above was repeated for crab chitin and pure chitin.



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Figure 2.6.3 Fermentation of pure chitin using a chitin deacetylase expressed from *E. coli BL21* in an incubator at 50°C

2.6.4 Designing a chitin deacetylase using AI

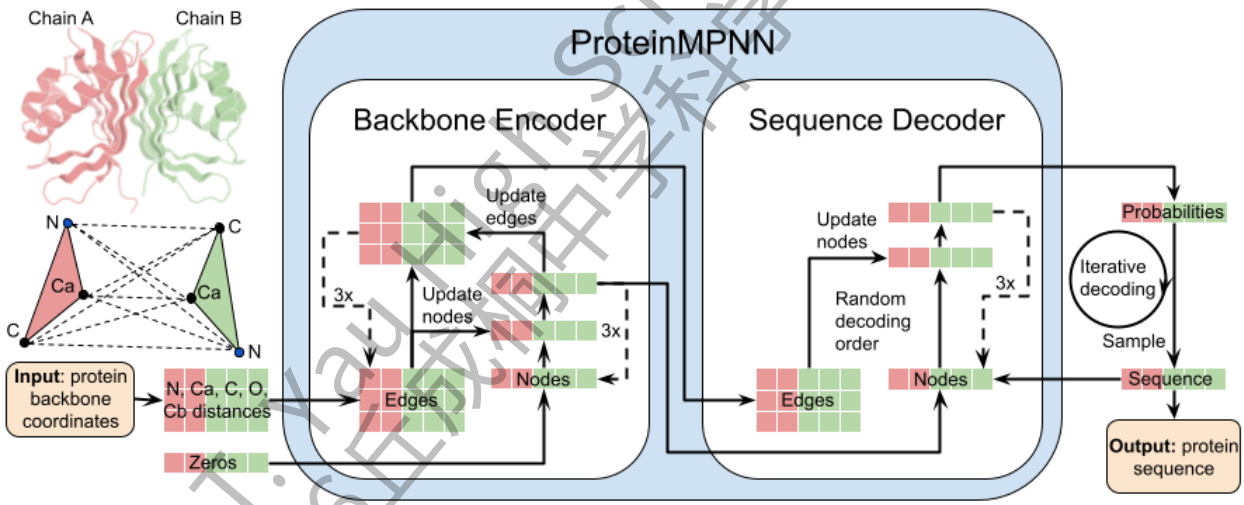
1. Translate is a tool which allows the translation of a nucleotide (DNA/RNA) sequence to a protein sequence.

https://web.expasy.org/translate/

2. AlphaFold 3 Server allows you to model a structure consisting of many biological molecules

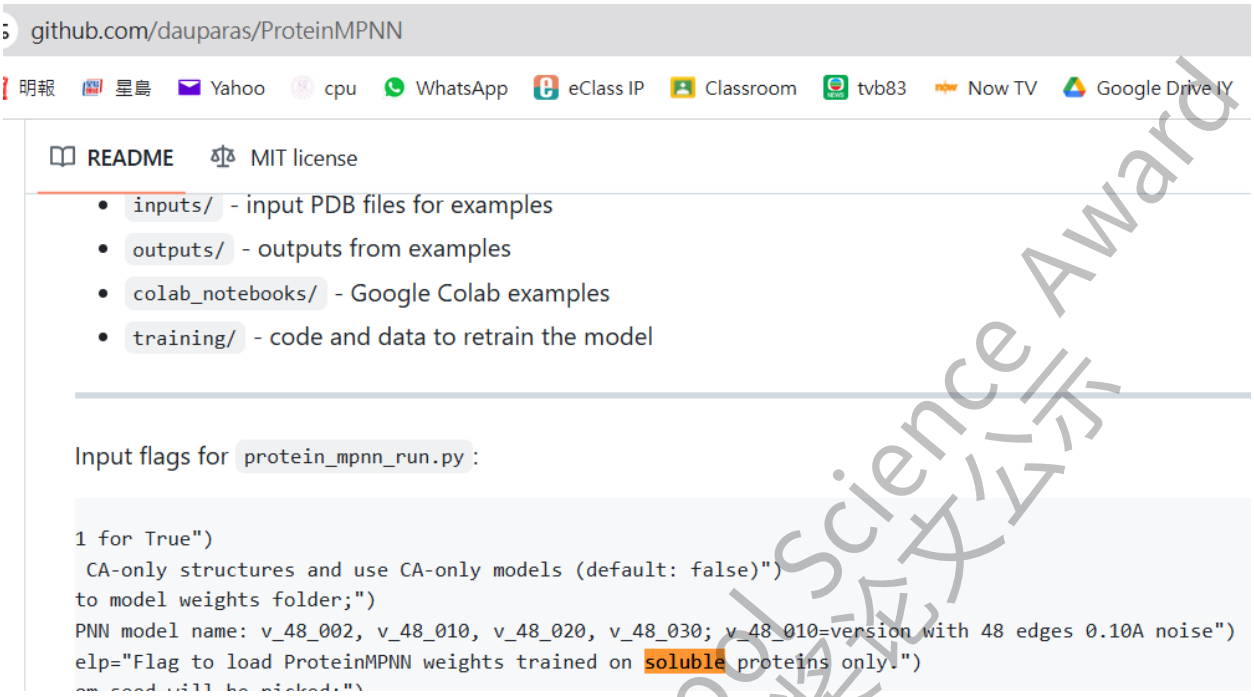
https://alphafoldserver.com/

3. ProteinMPNN (Protein Message Passing Neural Network) is a cutting-edge, deep learning-based, graph neural network designed to predict amino acid sequences for given protein backbones. The model provides the following endpoints. The input and output parameters correspond to properties such as solubilities in water.



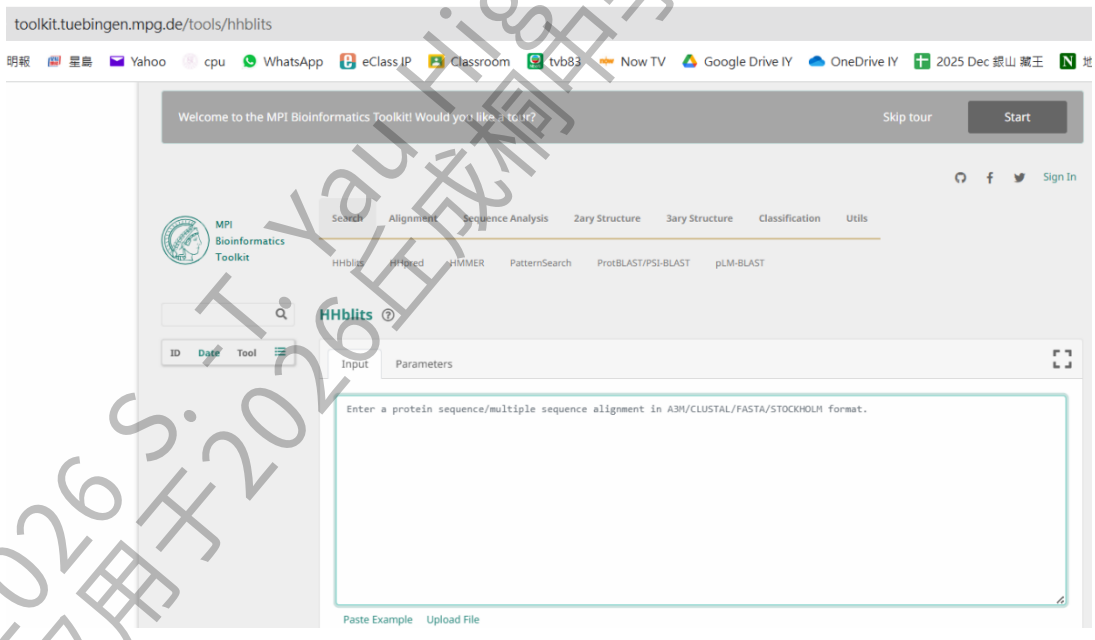
https://github.com/dauparas/ProteinMPNN

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4. Highly conserved sequences could be determined with a multiple sequence alignment MSA using HHblits. These highly conserved sequences had to be fixed during the sequence redesign.

https://toolkit.tuebingen.mpg.de/tools/hhblits



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3. Results

In the following section, "N/A" stands for "not applicable" unless otherwise stated.

3.1 Percentage yield of chitosan from chitin BSF and crab chitin using fermentation with a chitin deacetylase obtained from *Mucor rouxii*

3.1.1 Investigation of the percentage yield of chitin and chitosan (using 16.7M NaOH & chitin deacetylase from *Mucor rouxii)* of *Hermetia illucens* (black soldier fly BSF) & *Eriocheir sinensis* (Chinese mitten crab)

percentage yield by mass (%)	black soldier fly **BSF** (%)	crab (%)	black soldier fly **BSF** (%) (Elouali, 2025) (121°C, 2.17 atm)	crab (%) (Andrade, 2012)
chitin	69.2	33.5	34.7	56.0
chitosan (16.7 M NaOH, 80°C, 1 atm)	22.1	48.3	83.3	40.0
rouxii chitosan (50°C, 1atm)	59.0	57.1	N/A	N/A

Table 3.1.1 Percentage yield of chitin and chitosan (using 16.7M NaOH & chitin deacetylase from *Mucor rouxii* of *Hermetia illucens* (black soldier fly BSF) & *Eriocheir sinensis* (Chinese mitten crab)

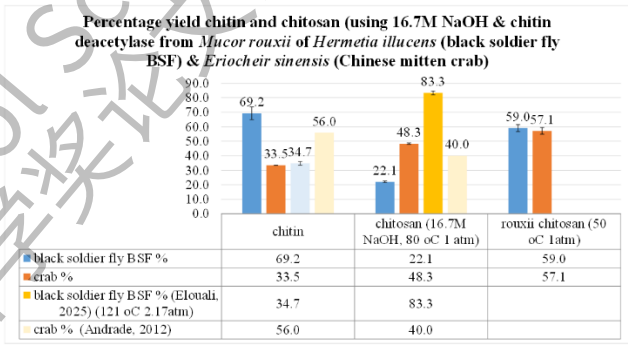


Figure 3.1.2 Percentage yield of chitin and chitosan (using 16.7M NaOH & chitin deacetylase from *Mucor rouxii* of *Hermetia illucens* (black soldier fly BSF) & *Eriocheir sinensis* (Chinese mitten crab)

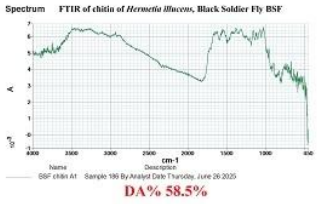
Conclusion:

Percentage yield of chitin of *Hermetia illusens* **BSF** (69.2%) and *Eriocheir sinensis* crab (33.5%) were consistent with Literature of 34.7% (Elouali, 2025) and 56.0% (Andrade, 2012).

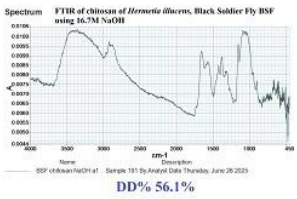
Percentage yield of chitosan (using 16.7 M NaOH; chitin deacetylase from *Mucor rouxii*) of *Hermetia illusens* **BSF** (22.1%; 59.0%) and *Eriocheir sinensis* crab (48.3%; 57.1%) were consistent with Literature of 83.3% (Elouali, 2025) and 40.0% (Andrade, 2012)

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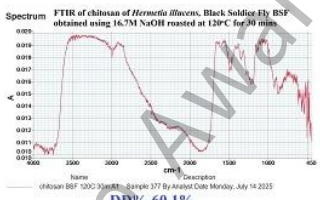
3.1.2 Investigation of the Degree of acetylation (DA%) of chitin and Degree of deacetylation (DD%) of chitosan (using 16.7 M NaOH) of *Hermetia illucens* (black soldier fly BSF) and *Eriocheir sinensis* (Chinese mitten crab)



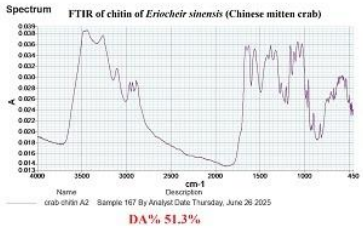
FTIR of chitin of *Hermetia illucens*, Black Soldier Fly BSF



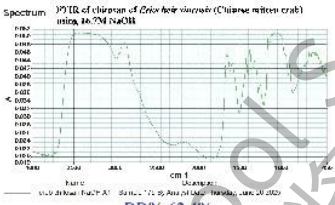
FTIR of chitosan of *Hermetia illuce* Black Soldier Fly BSF using 16.7M NaOH



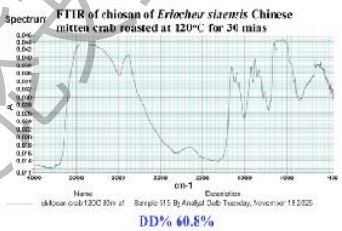
FTIR of chitosan of *Hermetia illucens*, Black Soldier Fly BSF obtained using 16.7M NaOH roasted at 120°C for 30 mins



FTIR of chitin of *Eriocheir sinensis* (Chinese mitten crab)



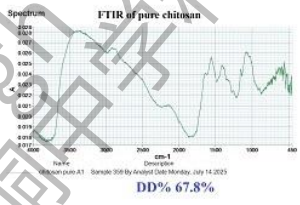
FTIR of chitosan of *Eriocheir sinensis* (Chinese mitten crab) using 16.7M NaOH



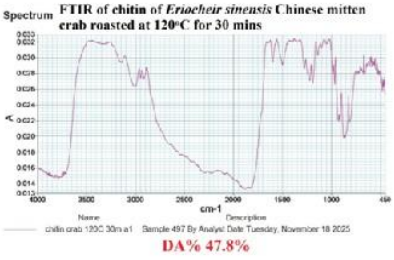
FTIR of chitosan of *Eriocheir sinensis* (Chinese mitten crab) roasted at 120°C for 30 mins



FTIR of pure chitin



FTIR of pure chitosan



FTIR of chitin of *Eriocheir sinensis* (Chinese mitten crab) roasted at 120°C for 30 mins

Figure 3.1.2.1 Degree of acetylation (DA%) of chitin and Degree of deacetylation (DD%) of chitosan (using 16.7 M NaOH) of *Hermetia illucens* (black soldier fly BSF) and *Eriocheir sinensis* (Chinese mitten crab)

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Table 3.1.2.2 Degree of acetylation (DA%) of chitin and Degree of deacetylation (DD%) of chitosan (using 16.7 M NaOH) of *Hermetia illucens* (black soldier fly BSF) and *Eriocheir sinensis* (Chinese mitten crab)

	degree of acetylation of chitin (DA%)	degree of deacetylation of chitosan (DD%)
black solder fly (**BSF**)	51.5	79.8
crab	50.7	76.9
pure chitin/chitosan	64.2	57.4
roasted crab chitin	58.7	N/A
black soldier fly (Mirwandhono, 2024)	88.0	N/A
black solder fly (Yong, 2022)	N/A	85.7
crab (Kumari, 2017)	N/A	70.0

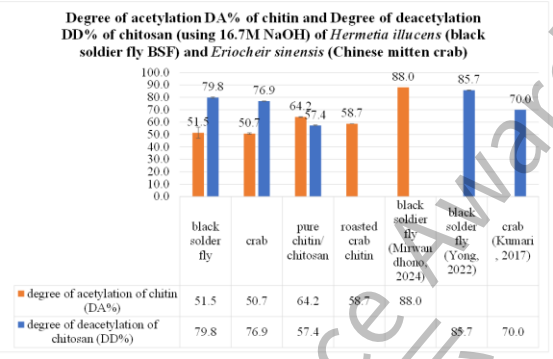


Figure 3.1.2.3 Degree of acetylation (DA%) of chitin and Degree of deacetylation (DD%) of chitosan (using 16.7 M NaOH) of *Hermetia illucens* (black soldier fly BSF) and *Eriocheir sinensis* (Chinese mitten crab)

Conclusion:

The DA% of chitin of **BSF** (51.5%) and DA% of crab (50.7%) were consistent with the DA% of pure chitin (64.2%) though all DA% values were lower than the literature DA% of 88.0% (Mirwandhono, 2024).

The DD% of chitosan of **BSF** (79.8%) and DD% of crab (76.9%) were consistent with the DD% of pure chitosan (57.4%) and literature DD% of **BSF** (85.7%) (Yong, 2022) and literature DD% of crab (70.0%) (Kumari, 2017).

3.1.3 Investigation of the percentage yield of chitosan of black soldier fly BSF chitin using fermentation using a chitin deacetylase from *Mucor rouxii*

Table 3.1.3.1 Percentage yield of chitosan of black soldier fly BSF chitin using fermentation using a chitin deacetylase from *Mucor rouxii*

Black soldier fly **BSF**	yield of chitosan (%)
chitin in DI water at 50°C	0.0
chitin with *Mucor rouxii* in DI water at 50°C	7.7
chitosan (chitin + NaOH) at 80°C	22.1
chitosan (chitin + vinegar) at 50°C	36.9
rouxii chitosan (chitin+ vinegar +*Mucor rouxii*) at 30°C	37.6
rouxii chitosan (chitin+ vinegar +*Mucor rouxii*) at 40°C	35.1
rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 50°C	59.0

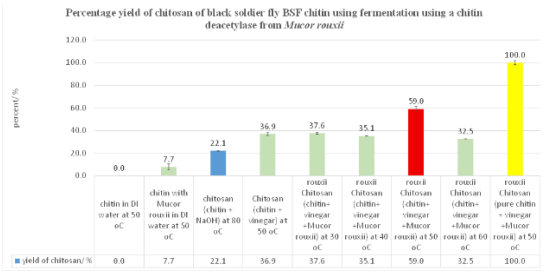


Figure 3.1.3.2 Percentage yield of chitosan of black soldier fly BSF chitin using fermentation using a chitin deacetylase from *Mucor rouxii*

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rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 60°C	32.5
rouxii Chitosan (pure chitin + vinegar +*Mucor rouxii*) at 50°C	100.0

Conclusion:

Percentage yield of **BSF** *rouxii* chitosan obtained from fermentation using a chitin deacetylase from *Mucor rouxii* was the highest at 50°C (59.0%) (cf. using 16.7 M NaOH at 80°C: 22.1%).

3.1.4 Investigation of the percentage yield of chitosan of crab chitin using fermentation using a chitin deacetylase from *Mucor rouxii*

Table 3.1.4.1 Percentage yield of chitosan of crab chitin using fermentation using a chitin deacetylase from *Mucor rouxii*

crab	yield of chitosan (%)
chitin in DI water at 50°C	0.0
chitin with *Mucor rouxii* in DI water at 50°C	0.0
chitosan (chitin + NaOH) at 80°C	48.3
chitosan (chitin + vinegar) at 50°C	38.4
rouxii chitosan (chitin + vinegar + *Mucor rouxii*) at 30°C	40.1
rouxii Chitosan (chitin + vinegar + *Mucor rouxii*) at 40°C	41.1
rouxii Chitosan (chitin+ vinegar + *Mucor rouxii*) at 50°C	57.1
rouxii Chitosan (chitin+ vinegar + *Mucor rouxii*) at 60°C	41.8
rouxii Chitosan (pure chitin + vinegar +*Mucor rouxii*) at 50°C	100.0

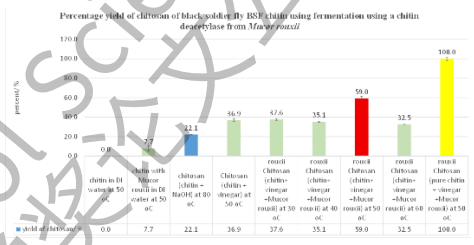


Figure 3.1.4.2 Percentage yield of chitosan of crab chitin using fermentation using a chitin deacetylase from *Mucor rouxii*

Conclusion:

Percentage yield of crab *rouxii* chitosan obtained from fermentation using a chitin deacetylase from *Mucor rouxii* was the highest at 50°C (57.0%) (cf. using 16.7 M NaOH at 80°C: 48.3%).

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3.1.5 Investigation of the DD% of chitosan obtained from chitin of black soldier fly BSF using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

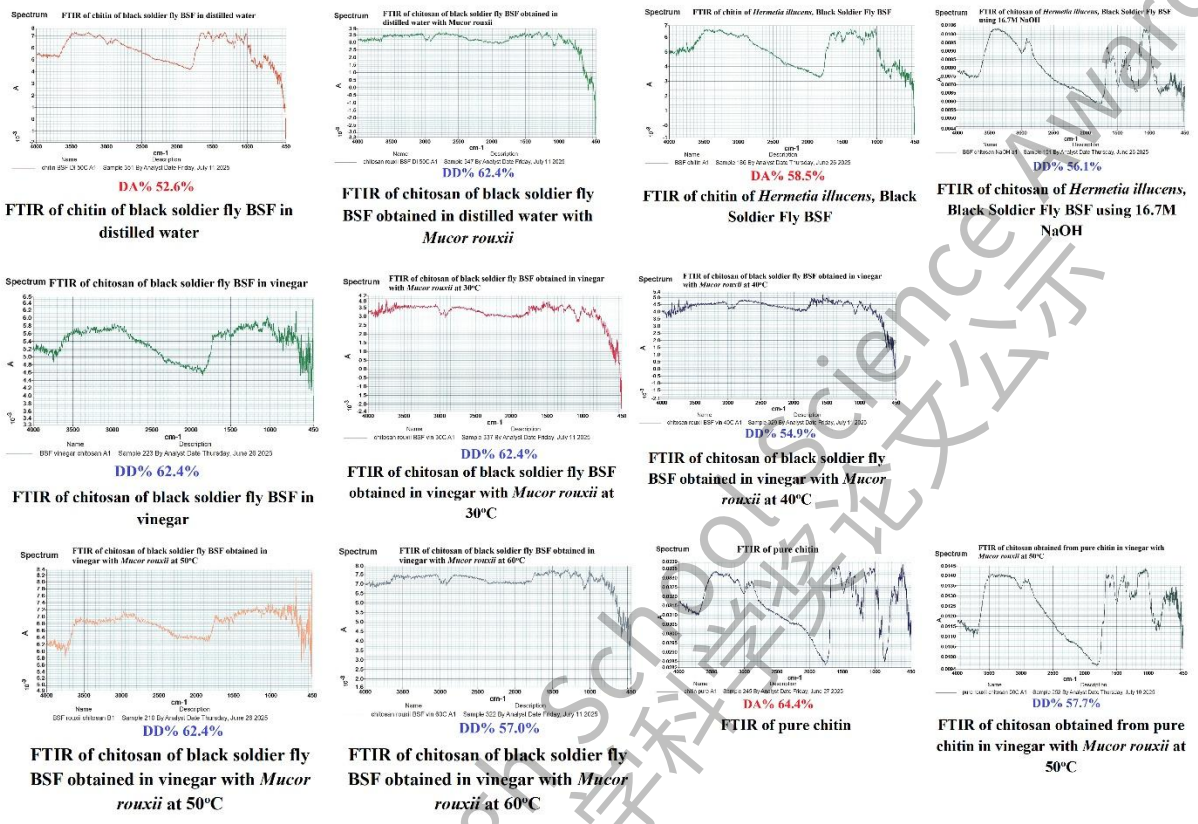


Figure 3.1.5.1 FTIR of chitosan obtained from chitin of black soldier fly BSF using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

Table 3.1.5.2 DD% of chitosan obtained from chitin of black soldier fly BSF using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

Black soldier fly **BSF**	DA% of chitin	DD% of chitosan
pure chitin	64.2	N.A.
chitin in DI water at 50 ºC	54.5	N.A.
chitin with *Mucor rouxii* in DI water at 50 oC	N.A.	62.4
chitosan (chitin + NaOH) at 80 ºC	N.A.	54.7
Chitosan (chitin + vinegar) at 50 ºC	N.A.	64.3
rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 30 ºC	N.A.	62.4

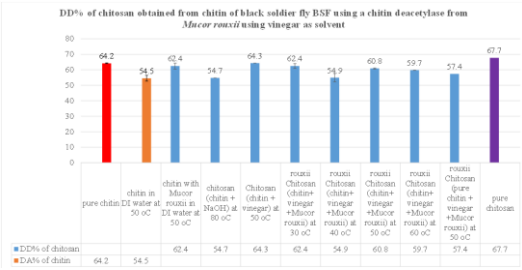


Figure 3.1.5.3 DD% of chitosan obtained from chitin of black soldier fly BSF using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

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rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 40 ºC	N.A.	54.9
rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 50 ºC	N.A.	60.8
rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 60 ºC	N.A.	59.7
rouxii Chitosan (chitin+ vinegar +*Mucor rouxii*) at 50 ºC	N.A.	57.4
pure chitosan	N.A.	67.7

Conclusion:

DD% of *rouxii* chitosan of black soldier fly **BSF** obtained using a chitin deacetylase from *Mucor rouxii* (about 54% to 65%) were consistent with the DD% of pure chitosan (67.7%).

3.1.6 Investigation of the DD% of chitosan obtained from chitin of crab using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

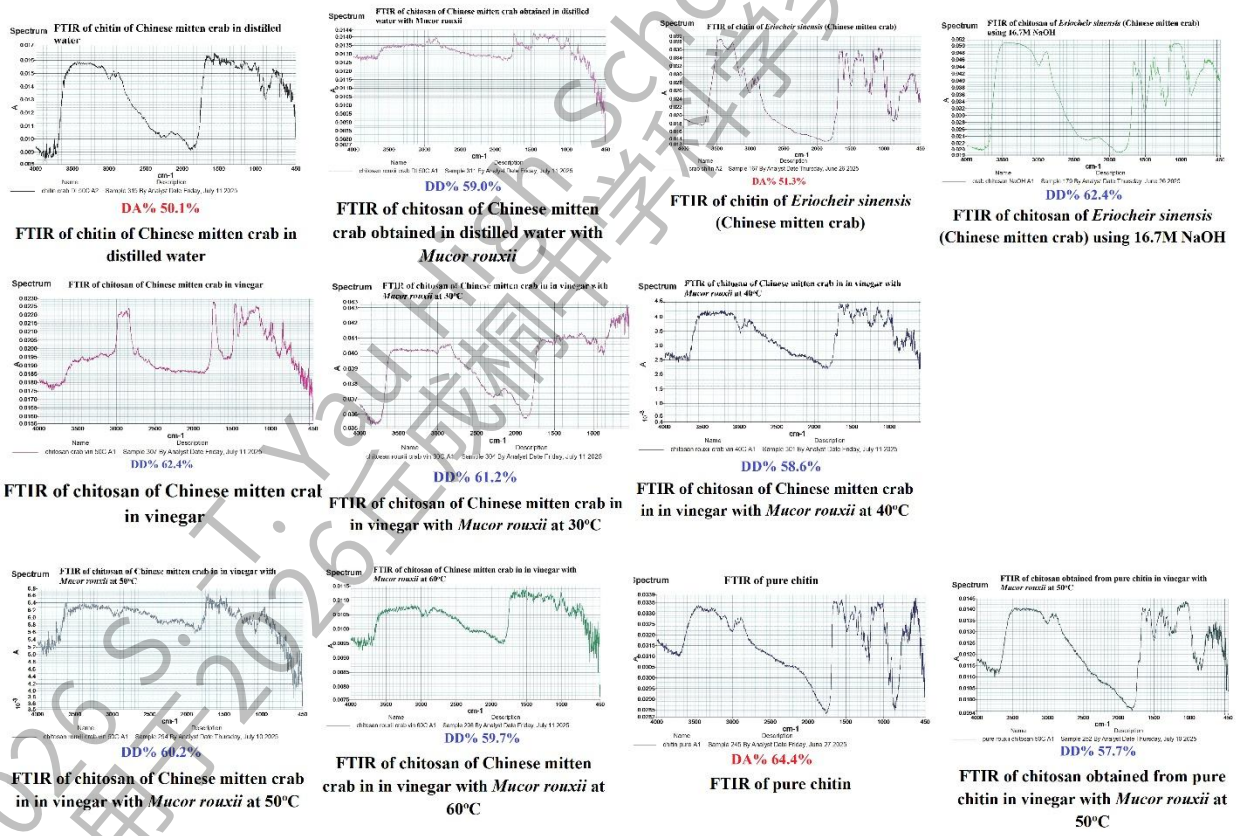


Figure 3.1.6.1 FTIR of chitosan obtained from chitin of crab using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

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Table 3.1.6.2 DD% of chitosan obtained from chitin of crab using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

crab	DA% of chitin	DD% of chitosan
pure chitin	64.2	N/A
chitin in DI water at 50°C	50.5	N/A
chitin with *Mucor rouxii* in DI water at 50°C	N/A	58.6
chitosan (chitin + NaOH) at 80°C	N/A	62.8
chitosan (chitin + vinegar) at 50°C	N/A	62.4
rouxii chitosan (chitin+ vinegar + *Mucor rouxii*) at 30°C	N/A	61.8
rouxii chitosan (chitin+ vinegar + *Mucor rouxii*) at 40°C	N/A	58.6
rouxii chitosan (chitin+ vinegar + *Mucor rouxii*) at 50°C	N/A	59.2
rouxii chitosan (chitin+ vinegar + *Mucor rouxii*) at 60°C	N/A	59.4
rouxii chitosan (pure chitin + vinegar + *Mucor rouxii*) at 50°C	N/A	57.4
pure chitosan	N/A	67.7

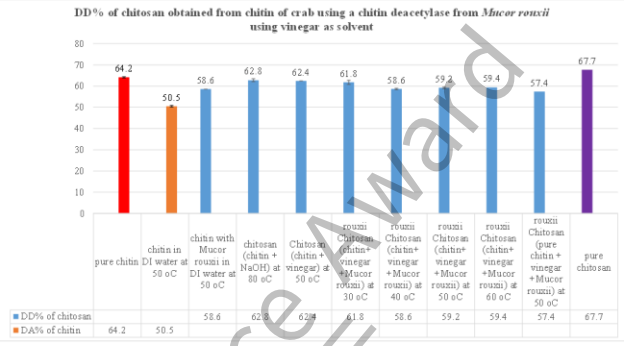


Figure 3.1.6.3 DD% of chitosan obtained from chitin of crab using a chitin deacetylase from *Mucor rouxii* using vinegar as solvent

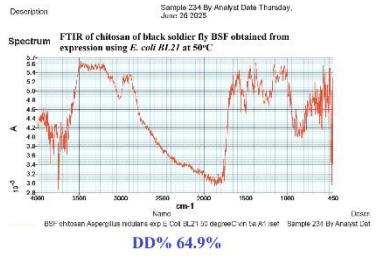
Conclusion:

DD% of *rouxii* chitosan of chinese mitten crab obtained using a chitin deacetylase from *Mucor rouxii* (about 57% to 63%) were consistent with the DD% of pure chitosan (67.7%).

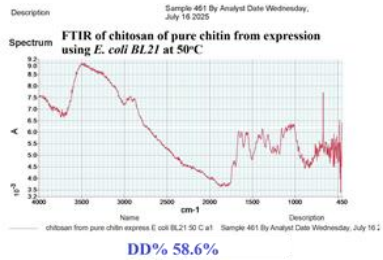
3.1.7 Investigation of the DD% of chitosan obtained from chitin of black soldier fly BSF using a chitin deacetylase from expression using *E. coli* BL21

3.1.7.1 Investigation of the DD% of chitosan obtained from chitin of black soldier fly BSF using a chitin deacetylase from expression using E. coli BL21

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FTIR of chitosan from BSF chitin obtained from a deacetylase (from *Aspergillus nidulans*) expressed using *E. coli BL21* in urea at 50°C



FTIR of chitosan of pure chitin from expression using *E. coli BL21* at 50°C

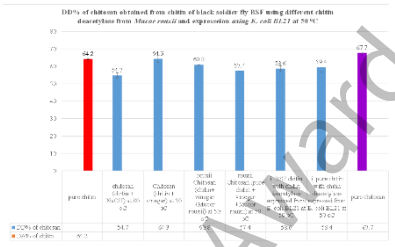
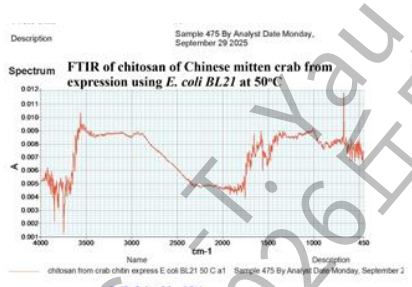


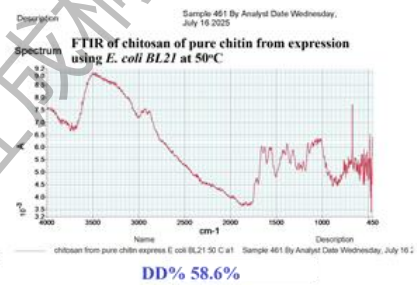
Figure 3.1.7.1 DD% of chitosan obtained from chitin of black soldier fly BSF using different chitin deacetylase from *Mucor rouxii* and expresseion *using E. coli BL21* at 50 °C

conclusion: DD% of chitosan from **BSF** obtained from a chitin deacetylase expressed using *E. coli BL21* at 50 °C was 58.6% which was consistent with the chitosan obtained from pure chitosan using expression (59.4%) and pure chitosan (67.7%).

3.1.7.2 Investigation of the DD% of chitosan obtained from crab chitin using a chitin deacetylase from expression using E. coli BL21



FTIR of chitosan of Chinese mitten crab from expression using *E. coli BL21* at 50°C



FTIR of chitosan of pure chitin from expression using *E. coli BL21* at 50°C

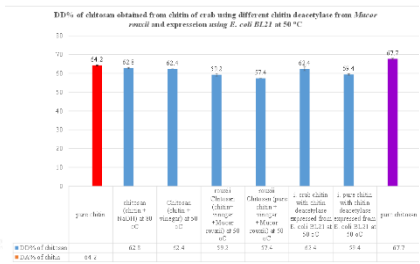


Figure 3.1.7.2 DD% of chitosan obtained from chitin of crab using different chitin deacetylase from *Mucor rouxii* and expression *using E. coli BL21* at 50 °C

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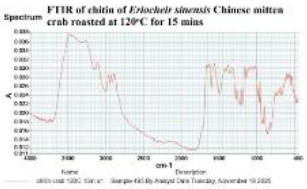
conclusion: DD% of chitosan from crab obtained from a chitin deacetylase expressed using *E. coli BL21* at 50 ºC was 62.4% which was consistent with the chitosan obtained from pure chitosan using expression (59.4%) and pure chitosan (67.7%).

3.1.8 Investigation of the DD% of chitosan obtained from chitin of black soldier fly BSF using an AI-designed chitin deacetylase from expression

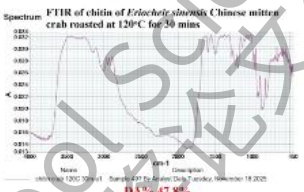
3.1.8.1 Investigation of the DA% of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for different time



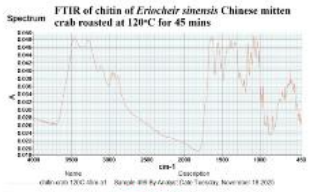
FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab at room temperature



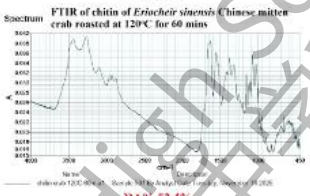
FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for 15 mins



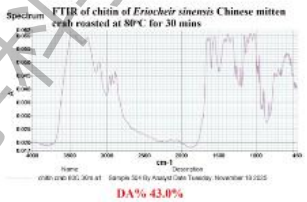
FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for 30 mins



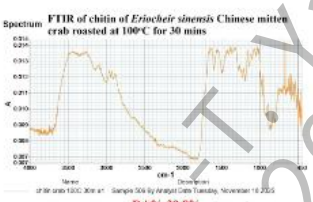
FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for 45 mins



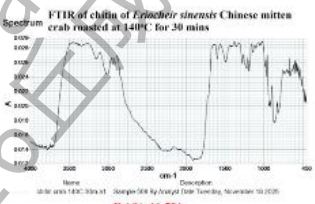
FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for 60 mins



FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 80ºC for 30 mins



FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 100ºC for 30 mins



FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 140ºC for 30 mins



FTIR of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 160ºC for 30 mins

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Table 3.1.8.1.1 DA% of crab chitin roasting at 120°C for different time

Time of roasting of crab chitin at 120°C /min	DA%
0	41.1
15	39.7
30	47.5
45	50.1
60	52.9

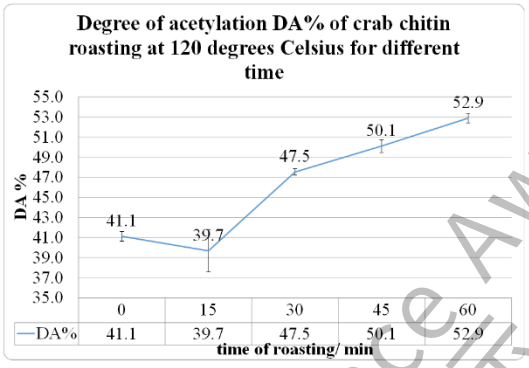


Figure 3.1.8.1.2 DA% of crab chitin roasting at 120 degrees Celsius for different time

Conclusion: Degree of acetylation DA% increased drastically from 39.7% to 47.5% when crab chitin was roasted at 120 °C for 15 to 30 mins, so structural changes took place (due to the reduction in number of -OH hydroxy groups)

3.1.8.2 Investigation of the DA% of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at different temperatures for 30 mins

Table 3.1.8.2.1 DA% of crab chitin roasting at different temperatures for 30 mins

Temperature of roasting of crab chitin at different temperature for 30 mins/ °C	DA%
25	41.1
80	41.8
100	40.0
120	47.5
140	46.9
160	44.9

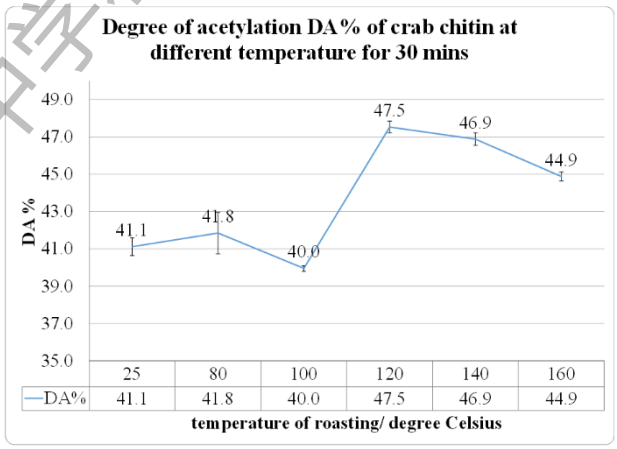


Figure 3.1.8.2.2 DA% of crab chitin roasting at different temperatures for 30 mins

conclusion: Degree of acetylation increased drastically from 40.0% to 47.5% when crab chitin was roasted between 100°C to 120 °C for 30 mins, so structural changes took place (due to the reduction in number of -OH hydroxy groups)

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3.1.8.3 Investigation of the toughness of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for different time

Table 3.1.8.3.1 Toughness of crab chitin roasting at 120ºC for different time

Time of roasting of crab chitin as coating at 120ºC /min	average force to punch 1mm/ N per mm
0	15.3
15	15.5
30	34.8
45	5.1
60	6.6
chitosan	21.4
roasted chitosan 120ºC 30min	32.1
Nexcare hydrocolloid	66.3

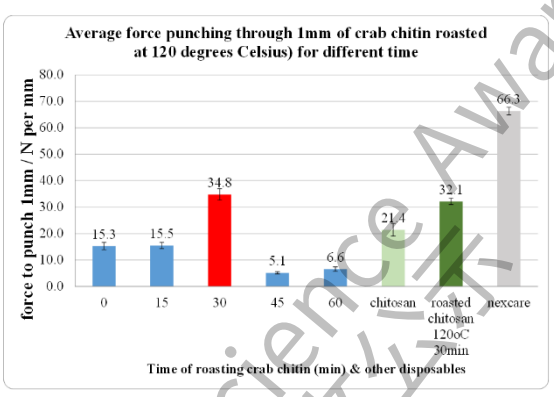


Figure 3.1.8.3.2 Toughness of crab chitin roasting at 120ºC for different time

Conclusion: The toughness of crab chitin was the highest when roasted at 120 ºC for 15 to 30mins (34.8N/mm) which was comparable with the toughness of Nexcare hydrocolloid (66.3N/mm).

3.1.8.4 Investigation of the toughness of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at different temperatures for 30 mins

Table 3.1.8.4.1 Toughness of crab chitin roasting at different temperatures for 30 mins

Temperature of roasting of crab chitin at different temperature for 30mins/ ºC	average force to punch 1mm/ N per mm
25	18.1
80	18.0
100	16.5
120	34.8
140	3.9
160	10.9
chitosan	21.4
roasted chitosan 120ºC 30min	32.1
nexcare	66.3

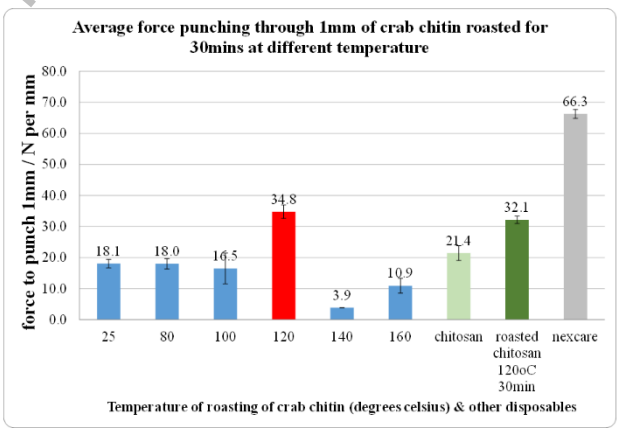


Figure 3.1.8.4.2 Toughness of crab chitin roasting at different temperatures for 30 mins

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Conclusion: The toughness of crab chitin was the highest when roasted at 100 to 120ºC for 30mins (34.8N/mm) which was comparable with the toughness of Nexcare hydrocolloid (66.3N/mm).

3.1.8.5 Investigation of the water resistance of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at 120ºC for different time

Table 3.1.8. 5.1 Water resistance of crab chitin roasting at 120ºC for different time

Time of roasting of crab chitin at 120ºC /min	water absorbance (%)
0	899
15	810
30	586
45	557
60	444
chitosan	978
roasted chitosan 120ºC 30min	512
Nexcare hydrocolloid	300

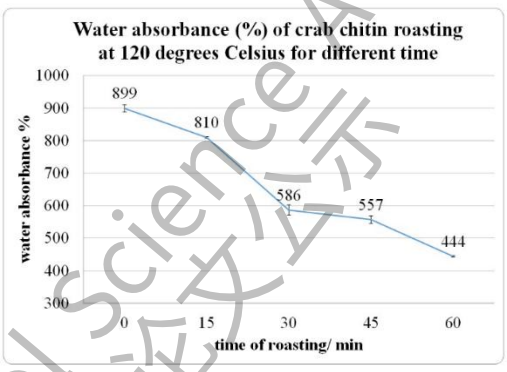


Figure 3.1.8.5.2 Water resistance of crab chitin roasting at 120ºC for different time

Conclusion: The water absorbance of crab chitin decreased drastically from 8.1 times to 5.9 times when roasted at 120 ºC for 15 to 30mins. Thus the water resistance was increased when roasted 120 ºC for 15 to 30mins. The water resistance of roasted crab chitin was comparable with that of Nexcare (3 times).

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3.1.8.6 Investigation of the water resistance of chitin of *Eriocheir sinensis* Chinese mitten crab roasted at different temperatures for 30 mins

Table 3.1.8.6.1 Water resistance of crab chitin roasting at different temperatures for 30 mins

Temperature of roasting of crab chitin at different temperature for 30mins/ ºC	water absorbance (%)
25	899
80	748
100	792
120	586
140	515
160	778
chitosan	978
roasted chitosan 120ºC 30min	512
nexcare hydrocolloid	300

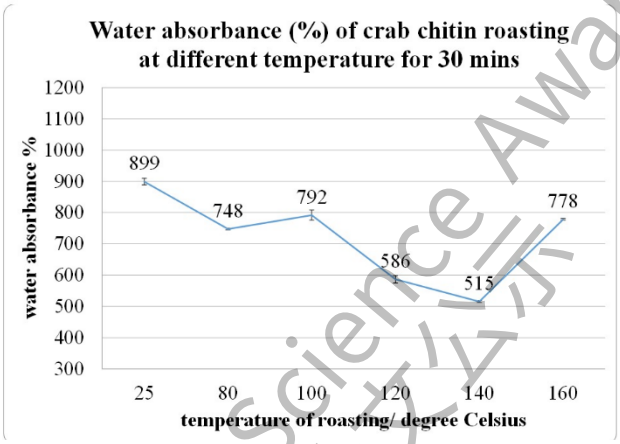


Figure 3.1.8.6.2 on Water resistance of crab chitin roasting at different temperatures for 30 mins

Conclusion: The water absorbance of crab chitin decreased drastically from 8.0 times to 5.9 times when roasted at 100 to 120 ºC for 30mins. Thus the water resistance was increased when roasted 100 to 120 ºC for 30mins. The water resistance of roasted crab chitin was comparable with that of Nexcare (3 times).

3.2 Testing and certification of anti-bacterial bio-BandAIDS based on IS997and SIST EN 13726-1-2002 and comparing water-resistance of different bio-BandAIDS

3.2.1 Testing and certification of anti-bacterial bio-BandAIDS based on IS997

Serial no.	Bandage Characteristics	Israeli Standard IS 977 [standard error in ( )]	Nexcare hydrocolloid	crab chitin only	crab rouxii dressing	crab rouxii BSF dressing	Roasted crab chitin only	crab chitosan (NaOH) only	Roasted crab chitosan (NaOH) only
3	Load per unit of area (gr/m^2) min.	*24*	493 (1.9)	243 (0.8)	253 (2.5)	199 (8.3)	293 (5.4)	159 (10.7)	211 (10.4)
4	Tension strength in the wrap direction (Newton) min.	50-67	4.3 (0.25)	9.5 (0.50)	23.0 (2.00)	28.3 (2.00)	16.0 (1.00)	more than 40	21.0 (1.00)
5	pH	4.5-8	7.2 (0.10)	6.2 (0.17)	6.4 (0.05)	6.9 (0.10)	6.3 (0.25)	6.8 (0.20)	6.9 (0.05)
204	Overall count of micro-bacteria (# bandages in oral bacteria from drinking water bottle overnight)	*The bandage is tested as described in European Pharmacopoeia	#numerous	#few (6)	#nil	#few(1)	#few(6)	#few(1)	#few(7)

*The number of micro-organisms as described in European Pharmacopoeia, updated edition,for products destined for application to skin.

Figure 3.2.1.1 Testing and certification of anti-bacterial bio-BandAIDS based on IS997

Conclusion:

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ALL Bio-**BandAIDS** of crab *rouxii* dressing, crab *rouxii* **BSF** dressing, crab chitosan (16.7 M NaOH) only and Roasted crab chitosan (16.7 M NaOH) only outperformed commercial hydrocolloid of Nexcare in the testing and certification based on IS 997. Tensile strength of Bio-**BandAIDS** of crab chitosan (16.7 M NaOH) only (>40 N), roasted chitosan (16.7 M NaOH) only (21.0 N), crab *rouxii* **BSF** dressing (28.3 N) and crab *rouxii* dressing (23.0 N) performed the best as their tension strength were the highest. (cf. commercial hydrocolloid of Nexcare: 4.3 N only)

3.2.2 Testing and certification of anti-bacterial bio-BandAIDS based on SIST EN 13726-1-2002

	Free Swell Absorptive capacity FSA (Mass of synthetic blood absorbed per bio-BandAIDS of crab with different dressings for 30 min at 37°C)
Nexcare hydrocolloid	0.97
crab chitin only	4.84
crab *rouxii* dressing	**14.68**
crab *rouxii* BSF dressing	**7.53**
***rouxii* BSF dressing**	**10.88**
Roasted crab chitin only	6.17
crab chitosan (NaOH) only	**7.99**
Roasted crab chitosan (NaOH) only	6.33

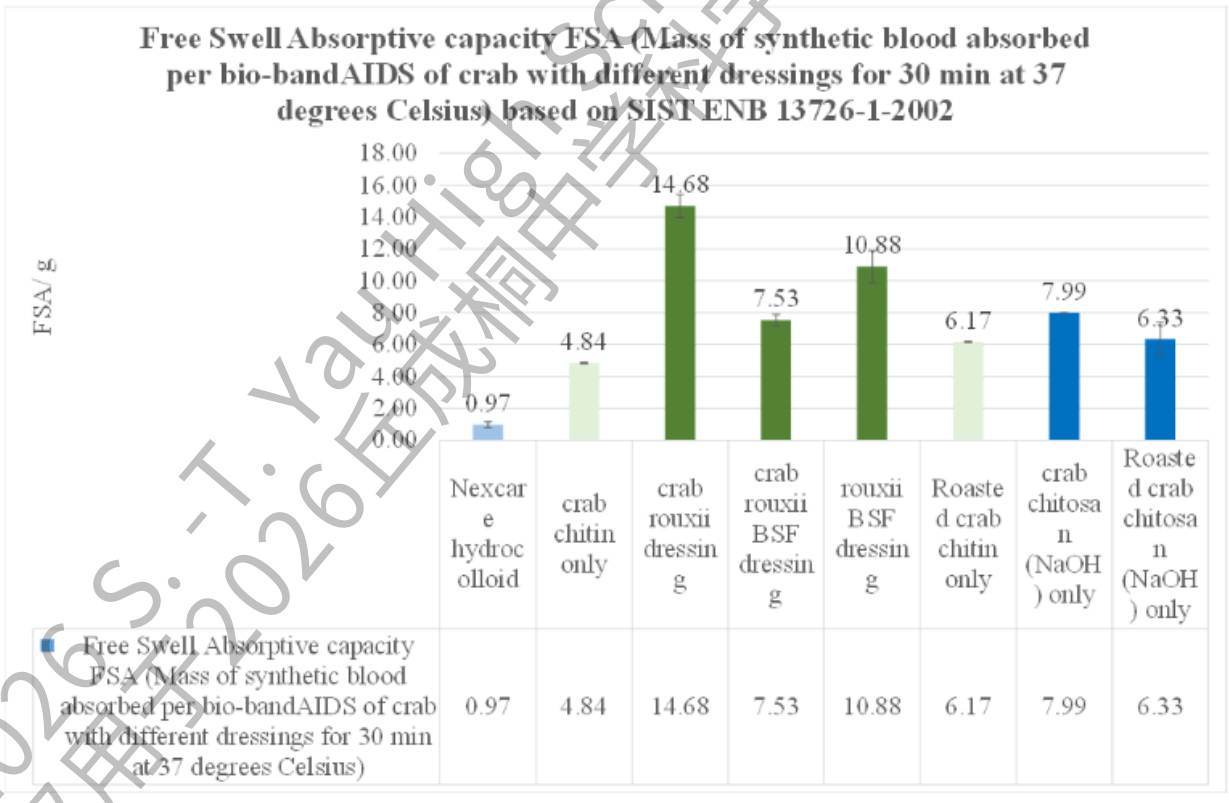


Figure 3.2.2.1 Testing and certification of anti-bacterial bio-BandAIDS based on SIST EN 13726-1-2002

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Conclusion:

Free Swell Absorptive Capacity FSA of bio-**BandAIDS** of crab *rouxii* dressing (11.68), crab *rouxii* **BSF** dressing (7.53) and *rouxii* **BSF** dressing only (10.88) were the highest. FSA of crab chitosan (16.7 M NaOH) only (7.99) was also high. (cf. commercial hydrocolloid of Nexcare: 0.97)

3.2.3 Investigation of the water absorbance of different bandages

Table 3.2.3.1 Water absorbance of different bandages

Water proofness	Water absorbance (%)
Nexcare hydrocolloid	276
crab chitin only	**61**
crab *rouxii* dressing	**78**
crab *rouxii* BSF dressing	**74**
Roasted crab chitin only	**102**
Roasted crab chitosan (NaOH) only	370
crab chitosan (NaOH) only	468

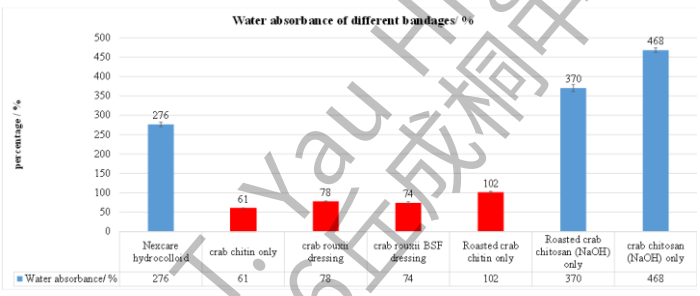


Figure 3.2.3.2 Water absorbance of different bandages

Conclusion:

Water resistance of bio-**BandAIDS** of crab chitin only (61%), crab *rouxii* dressing (78%), crab *rouxii* **BSF** dressing (74%) and roasted crab chitin (102%) were the best (cf. Commercial hydrocolloid of Nexcare: 276%).
Obviously crab *rouxii* dressing and crab *rouxii* **BSF** dressing were the best raw materials for the production of bio-

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BandAIDS based on the testing and certification of bio-**BandAIDS** based on IS997, SIST EN 13726-1-2002 and water resistance.

Serial no.	Bandage Characteristics	Israeli Standard IS 977 [standard error in ( )]	Nexcare hydrocolloid	crab chitin only	crab rouxii dressing	crab rouxii BSF dressing	Roasted crab chitin only	crab chitosan (NaOH) only	Roasted crab chitosan (NaOH) only
3	Load per unit of area (gr/m^2) min.	*24*	493 (1.9)	243 (0.8)	253 (2.5)	199 (8.3)	293 (5.4)	159 (10.7)	211 (10.4)
4	Tension strength in the wrap direction (Newton) min.	50-67	4.3 (0.25)	9.5 (0.50)	23.0 (2.00)	28.3 (2.00)	16.0 (1.00)	more than 40	21.0 (1.00)
5	pH	4.5-8	7.2 (0.10)	6.2 (0.17)	6.4 (0.05)	6.9 (0.10)	6.3 (0.25)	6.8 (0.20)	6.9 (0.05)
204	Overall count of micro-bacteria (# bandages in oral bacteria from drinking water bottle overnight)	*The bandage is tested as described in European Pharmacopoeia	#numerous	#few (6)	#nil	#few(1)	#few(6)	#few(1)	#few(7)
*The number of micro-organisms as described in European Pharmacopoeia, updated edition,for products destined for application to skin.									
	Free Swell Absoptive capacity (FSA)	SIST EN 13726-1-2002 / mass per 100 cm^2 [standard	Nexcare hydrocolloid	crab chitin only	crab rouxii dressing	crab rouxii BSF dressing	Roasted crab chitin only	crab chitosan (NaOH) only	Roasted crab chitosan (NaOH) only
	Free Swell Mass of synthetic blood	(not specified)	0.97 (0.16)	4.84 (0.03)	14.68 (0.72)	7.53 (0.35)	6.17 (0.02)	7.99 (0.02)	3.89 (0.25)
	waterproofness (% of water absorbed)	(not specified)	278% (satisfactory)	61% (good)	78% (good)	74% (good)	102% (good)	370% (satisfactory	468% (satisfactory

Figure 3.2.3.2 Summary of the testing and certification of bio-BandAIDS based on IS997, SIST EN 13726-1-2002 and water resistance

3.3 Investigation of the anti-bacterial effect of different kinds of bio-BandAIDS

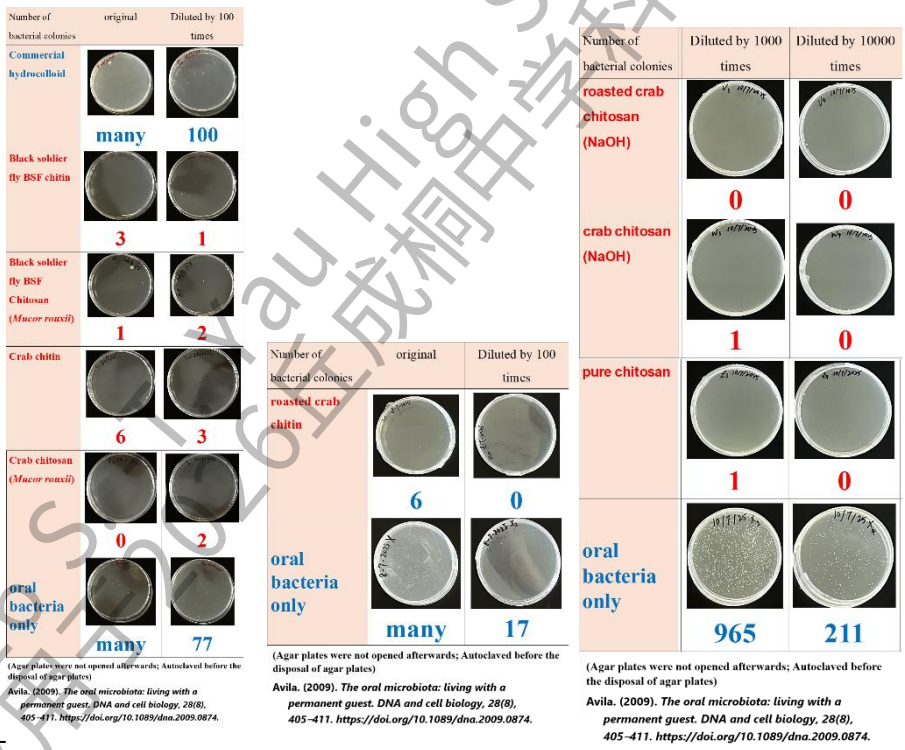


Figure 3.3.1 The anti-bacterial effect of different kinds of bio-BandAIDS

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Conclusion:

Number of oral bacterial colonies for the original sample and dilution factor 10^{-2} of black soldier fly **BSF** chitin (3,1), **BSF** *rouxii* chitosan (1,2), crab chitin (6,3) and crab *rouxii* chitosan (0,2) were fewer than that of the control of oral bacteria only (many, 77).

Number of oral bacterial colonies for the original sample and dilution factor 10^{-2} of roasted crab chitin (6,0) was fewer than that of the control of oral bacteria only (many, 17).

Number of oral bacterial colonies for the dilution factor 10^{-3} and dilution factor 10^{-4} of roasted crab chitosan (16.7M NaOH) (0,0), crab chitosan (16.7M NaOH) (1,0), and pure chitosan (1,0) were fewer than that of the control of oral bacteria only (965, 211).

Thus, black soldier fly **BSF** chitin, **BSF** *rouxii* chitosan, crab chitin, crab *rouxii* chitosan, roasted crab chitin, roasted crab chitosan (16.7M NaOH), crab chitosan (16.7M NaOH) and pure chitosan were anti-bacterial, so they were suitable raw materials for making anti-bacterial bio-**BandAIDS**.

Number of oral bacterial colonies for the original sample and dilution factor 10^{-2} of a commercial hydrocolloid of Nexcare (many,100) were similar to that of the control of oral bacteria only (many, 77). Thus, the commercial hydrocolloid of Nexcare was NOT anti-bacterial.

3.4 Investigation of the presence of protein allergens of different kinds of bio-BandAIDS



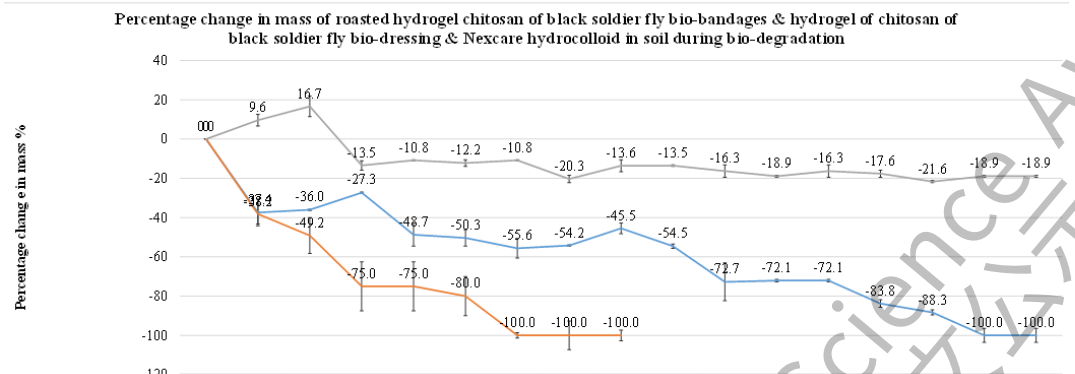
Figure 3.4.1 Presence of protein allergens of different kinds of bio-BandAIDS

Conclusion:

As surface protein allergens were found to be absent in crab *rouxii* dressing, crab *rouxii* **BSF** dressing, roasted chitin only and crab chitin only when tested using 3M ALLTEC C60, anti-bacterial bio-**BandAIDS** should be non-allergic.

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3.5 Investigation of the biodegradability of different bio-BandAIDS



	Day 1	Day 7	Day 10	Day14	Day17	Day21	Day24	Day28	Day31	Day35	Day38	Day42	Day45	Day 49	Day 52	Day 56	Day 59
crab rouxii dressing	0	-37.4	-36.0	-27.3	-48.7	-50.3	-55.6	-54.2	-45.5	-54.5	-72.7	-72.1	-72.1	-83.8	-88.3	-100.0	-100.0
crab rouxii BSF dressing	0	-38.2	-49.2	-75.0	-75.0	-80.0	-100.0	-100.0	-100.0								
commercial hydrocolloid	0.0	9.6	16.7	-13.5	-10.8	-12.2	-10.8	-20.3	-13.6	-13.5	-16.3	-18.9	-16.3	-17.6	-21.6	-18.9	-18.9

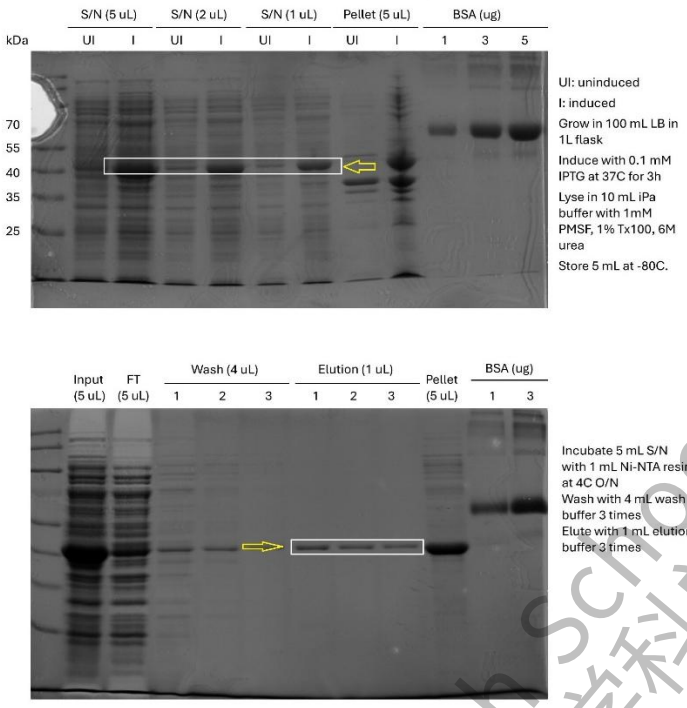
Table 3.5 Percentage change in mass of roasted hydrogel chitosan of black soldier fly bio-bandages & hydrogel of chitosan of black soldier fly bio-dressing & Nexcare hydrocolloid in soil during bio-degradation

Conclusion: It took 24 days for Bio-**BandAIDS** of crab rouxii BSF dressing and 56 days for Bio-**BandAIDS** of crab rouxii dressing to be fully biodegraded in soil. Commercial hydrocolloid was NOT biodegradable.

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3.6 Expression of a deacetylase from *Aspergillus nidulans* by *E. coli BL21*

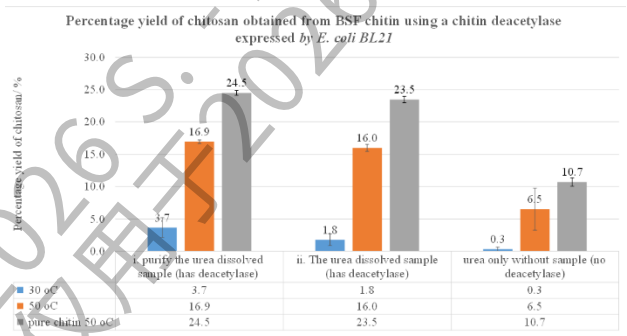
3.6.1 With 6M urea, most of the deacetylase with dissolved in the supernatant (S/N) as shown in lane 6-8 in SDS-Page shown in Figure. 3.6.1.1

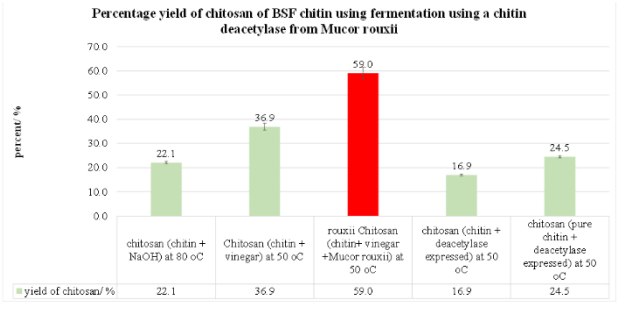


SDS-Page for SUMO-deacetylase with 6M urea as solvent (arrow shown the target size of protein band)

Figure 3.6.1 SDS-Page for SUMO-deacetylase with 6M urea as solvent (arrow shown the target size of protein band)

3.6.2 Percentage yield of chitosan obtained from BSF chitin





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Table 3.6.2.1 Percentage yield of chitosan from BSF chitin at different temperature

Table 3.6.2.2 Percentage yield of chitosan from BSF chitin using deacetylase from expression, *Mucor rouxii,* 16.7M NaOH and vinegar at 50ºC

Conclusion: Percentage yield of chitosan from **BSF** chitin using deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* was increased from 3.7% to 16.9% when the temperature was increased from 30 ºC to 50 ºC in 6M urea showing that the optimum temperature for such deacetylase was 50ºC. (cf. pure chitin 24.5% at 50 ºC with chitin deacetylase expressed by *E. coli*) (cf. Using vinegar only at 50ºC 36.9%; *Mucor rouxii* in vinegar 59.0% at 50ºC; 16.7M NaOH 22.1% at 80ºC)

3.6.3 Percentage yield of chitosan obtained from crab chitin

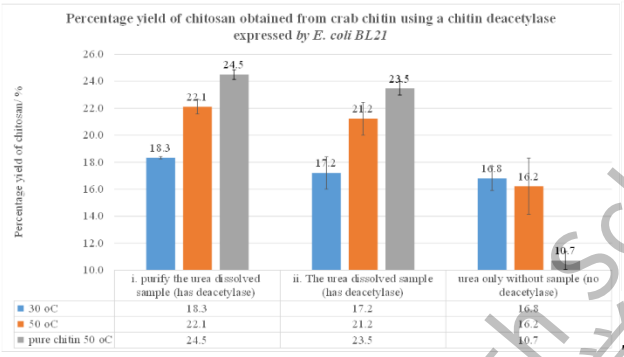


Table 3.6.3.1 Percentage yield of chitosan from crab chitin at different temperature

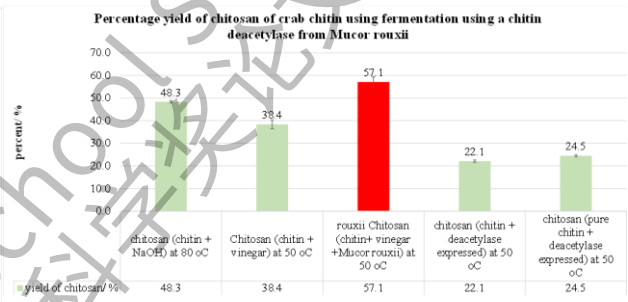


Table 3.6.3.2 Percentage yield of chitosan from crab chitin using deacetylase from expression, *Mucor rouxii,* 16.7M NaOH and vinegar at 50ºC

Conclusion: Percentage yield of chitosan from crab chitin using deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* was increased from 18.3% to 22.1% when the temperature was increased from 30ºC to 50ºC showing that the optimum temperature for such deacetylase was 50ºC. (cf. pure chitin using chitin deacetylase expressed by *E. coli*: 24.5%) (Using vinegar only at 50ºC 38.4%; *Mucor rouxii* in vinegar 57.1% at 50ºC; 16.7M NaOH 48.3% at 80ºC)

3.6.4 Design of a chitin deacetylase that is more water-soluble using AI such as AlphaFold 3, ProteinMPNN

3.6.4.1 The Multiple sequence alignment MSA precomputed and the fixed residues list

fixed_positions="1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 42 43 45 48 51 55 57 58 59 60 61 62 63 64 65 66 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 92 93 94 95 97 98 99 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116

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117 120 121 122 123 124 126 127 131 132 134 136 137 138 139 142 144 150 151 152 153 155 156 163 167 177 178 179 180 181 182 184 188 190 193 206 208 209 210 223 224 226 227 229 233 234 238 240 242 247"

3.6.4.2 Sequences of some chitin deacetylase designed by ProteinMPNN (AI deacetylase)

	Amino sequence
	Deactylase_Mg, score=1.6106, global_score=1.6556, fixed_chains=[], designed_chains=['A'], model_name=v_48_020, git_hash=8907e6671bfbfc92303b5f79c4b5e6ce47cdef57, seed=662 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPRVSYGLYIHHCYVPGVVALTFDDGPYIYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVDQMTRLE SAFVASVGVVPTYMRPPYLAANDYVLGVMAELGYHVIGASVDTKDYENDHPDLIGRSVAKFNQELD QGGTIVLSHDIHEQTVRTLTHIMLEEVYERGLQPTTVGGCLGDDAWYR T=0.1, sample=1, score=0.7557, global_score=1.3185, seq_recovery=0.4742 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGEWITDCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLD SAFVEAVGVRPRYTRPPYLAADERVLAVMKELGYRVIGASIDTKDYEYDSPELVGKSVERFREQLAA GGTIVLSHEDYKYSVTILTPIMLEEIYRRGLQPTTVAGALGDENWYA T=0.1, sample=2, score=0.7595, global_score=1.3291, seq_recovery=0.4536 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGELITDCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLW SAFVEAVGVRPRYTRPPYLAADERTLAVAKELGLVVIGASIDTKDYEYDSPELVGKSVERFREQLAAG GTIVLSHEDYKNSVLTLTPIMLEEIYARGLQATTVGGALGDENWYA T=0.1, sample=3, score=0.7860, global_score=1.3241, seq_recovery=0.4433 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSTGELITQCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLW SAFVEAVGVRPRFTRPPYLAADERVLAVAKELGLRVIGASIDTKDYEYDSEELIGKSVERFREQLAAG GTIVLSHEDYRYSVTTLTPIMLEEIYRRGLQATTVAGALGDDKWYA T=0.1, sample=4, score=0.7852, global_score=1.3403, seq_recovery=0.5052 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGELITDCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVDEMTRLW SAFVEAVGVKPRYMRPPYLAADERVLEVAKELGLRVIGASIDTKDYEYDSPELIGKSVERFREQLAAG GTIVLSHENYKESVLTLTPIMLEEIYKRGLQATTVGGALGDDKWYA T=0.1, sample=5, score=0.7956, global_score=1.3382, seq_recovery=0.4845 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSTGEWITDCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVQEMTRLD

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SAFVKAVGVRPRYTRPPYLAADERTLAVAKELGLVVVGASIDTKDYEYDSEELVGKSVERFRAQLAA

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SAFVEAVGVEPRFTRPPYLAADERVLAVAKELGLRVIGASIDTKDYEYDSEELIGKSVERFREQLAAG
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global_score=1.3302, seq_recovery=0.4845
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSTGELITQCRVPGTVALTFDDGPYEYT
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score=0.8043, global_score=1.3427, seq_recovery=0.5052
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SAFVKAVGVEPRYTRPPYLAADERVLEVMKELGYRVIGASIDTKDYEYDSEELVGKSVERFRAQLDA
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GGTIVLSHENFKSSVFKLTPIMLEEIYARGLQPTTVGGALGDTKWAA T=0.2, sample=3, score=0.8291,
global_score=1.3584, seq_recovery=0.4433

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MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPPVSNGEWITDCRVPGKVALTFDDGPYKY
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SAFVEAVGVEPTYVRPPYLAADDRVLAVMKELGYVVVGYSIDTKDYEYDSEELIGKSVERFREQLAQ
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GGTIVLSHEDYKYSVTTLTPIMLEEIYARGLQATTVGGALGDSDWYA T=0.2, sample=11,
score=0.8320, global_score=1.3614, seq_recovery=0.4845
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGELITHCRVPGVVALTFDDGPYEYT
EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLH
SAFVEAVGVEPRFMRPPYLAADERVLEVAKELGYRVIGASIDTKDYEYDSEELIGKSVERFREQLAAG
GTIVLSHEDYKYSVKKLTPIMLEEIYARGLQATTVAGALGDKEWYR T=0.2, sample=12, score=0.8018,
global_score=1.3478, seq_recovery=0.4639
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSFGEWIRNCRVPGTVALTFDDGPYEYT
EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLD
SAFVKAVGVKPRYMRPPYLAADERTLAVAKELGYRVIGASIDTKDYEYDSPELVGKSVERFREQLAA
GGTIVLSHENYKYSVTVLTPIMLEEIYARGLQATTVGGALGDDKWYA T=0.2, sample=13,
score=0.8311, global_score=1.3634, seq_recovery=0.4330
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WSAFVEAVGVRPRYLRPPYLAADERTLAVAKELGLRVIGYSIDTKDYEYDSPELVGKSVERFREQLA
QGGTIVLSHEDYKYSVTTLLPIMLEEIYKRGLQATTVGGALGDSDWYE T=0.2, sample=14,
score=0.8068, global_score=1.3435, seq_recovery=0.4639
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EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVEEMTRLW
SAFVEAVGVRPKYMRPPYLAADERVLAVAKELGLVVIGASIDTKDYEYDSPELVGKSVERFRKQLAE
GGTIVLSHENYKESVTTLTPIMLEEIYKRGLQATTVGGALGDSDWYS T=0.2, sample=15, score=0.8166,
global_score=1.3564, seq_recovery=0.4742
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPQVSTGEWITQCRVPGTVALTFDDGPYEYT
EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVEEMTRLD
SAFVEAVGVRPRYTRPPYLAADEKVLKVMKELGYVVIGASIDTKDYEYDSPELIGKSVERFKKQLAE
GGTIVLSHEDKKYSVTELTPIMLEEIYKRGLQATTVGGALGDSNWYD T=0.2, sample=16,
score=0.8162, global_score=1.3531, seq_recovery=0.4948
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SAFVDAVGVRTRYMRPPYLAADDRVLAVAAELGYRVIGASIDTKDYEYDSPELVGKSVDRFLKQLD
AGGTIVLSHEDYYYSVKILTPIMLEEIYRRGLQATTVGGALGDTNWYA T=0.2, sample=17,
score=0.8626, global_score=1.3734, seq_recovery=0.4742
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EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLES

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AFVEAVGVKTRFTRPPYLAADEKVLQVMKELGYVVIGASIDTKDYEYDSPELIGKSVELFKKQLAEG GTIVLSHEDYKYSVLILTPIMLEEIYKRGLQATTVGGALGDTNWYR T=0.2, sample=18, score=0.8058, global_score=1.3509, seq_recovery=0.4330

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EGGTIVLSHENYKYSVTILTPIMLEEIYKRGLQATTVGGALGDDKWYA T=0.3, sample=1, score=0.8840, global_score=1.3653, seq_recovery=0.4845
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TEELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVNEMTQL
DSAFVKAVGVRSTYTRPPYLAADERVLEVFKELGYVVIGYSIDTKDYEYDSPELIGKAVERFKKQLAE
GGTIVLSHEDKKYSVFELTPIMLEEIYKRGLQATTVAGALGDSKWYK T=0.3, sample=3, score=0.8249, global_score=1.3530, seq_recovery=0.4742
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SAFVEAVGVEPRFTRPPYGAADEKVLEVMKELGYVVIGWSIDTKDYEYDSEELVGKSVERFRKQLAE
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EELLDILAQYGAKATFFVNGHHLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIKDEMTRLW
SAFVDAVGVEPRYMRPPYLAADDKVLEVAAELGLVVIGYSIDTKDYEYDSPELIGKSVDLFREQLAA
GGTIVLSHENYKYSVTELLPIMLEEIYARGLQPTTVGGALGDDKWYA T=0.3, sample=5, score=0.8588, global_score=1.3654, seq_recovery=0.4433
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EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVEEMTRLD
SAFVEAVGVVPRLMRPPYLAADERVLAVAKELGYRVVGYSIDTKDYENDSPELVGKSVDRFKEQLD
AGGTIVLSHEDYKYSVTILTPIMLEEIYARGLQATTVGGALGDKNWFK T=0.3, sample=7, score=0.8409, global_score=1.3430, seq_recovery=0.4124
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GGTIVLSHEDYKYSVTILTPIMLEEIYKRGLQATTVAGALGDSKWYK T=0.3, sample=8, score=0.8398,

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global_score=1.3445, seq_recovery=0.4536
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGEWITDCKVPGTVALTFDDGPYEYT
EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVDEMTQLW
SAFVEAVGVRPRLTRPPYLAADENVLAVARELGLRVIGASIDTKDYEYDSEELVGKSVERFLKQLDA
GGTIVLSHENYKYSVLTLTPIMLEEIYARGLQATTVGGALGDSRWYA T=0.3, sample=9, score=0.8683,
global_score=1.3784, seq_recovery=0.4330
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPAVSAGELITDCRVEGTVALTFDDGPYKYT
EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVAEMTRLH
SAFVEAVGVRPRYTRPPYLAADEKVLAVAKELGYVVIGASIDTKDYEYDSEELIGKSVDRFLEQLDAG
GTIVLSHEDKKYSVTTLLPIMLEEIYARGLQPTTVAGALGDERWFA T=0.3, sample=10, score=0.8753,
global_score=1.3670, seq_recovery=0.4639
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EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLH
SAFVKAVGVEPRYTRPPYLAADEKVLDVMKELGYVVIGASIDTKDYEYDSEELIGKSVDRFLEQLKK
GGTIVLSHEDLKYSVTKLLPIMLEEIYRRGLQATTVGGALGDKDWYK T=0.3, sample=11,
score=0.8636, global_score=1.3643, seq_recovery=0.4330
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SAFVKAVGVEPRFTRPPYLAANDKVLAVYKELGYVVIGYSIDTKDYEYDSEELVGKSVERFLKQLAE
GGTIVLSHENYKYSVTKLTPIMLEEIYRRGLQATTVGGALGDEDWYK T=0.3, sample=12,
score=0.8418, global_score=1.3483, seq_recovery=0.4742
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EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVEEMTRLD
SAFVKAVGVKPRYTRPPYLAADDKVLAVMKELGYVVIGASIDTKDYETDSEELVGKSVERFREQLAA
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global_score=1.3723, seq_recovery=0.4433
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global_score=1.3909, seq_recovery=0.4639
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SAFVKAVGVRPKYTRPPYLAADEKTLAVAKELGYVVIGASIDTKDYEHDSPELIGKSVDRFLEQLDNG
GTIVLSHENFFYSVKVLTPIMLEEIYSRGLQATTVGGGLGDSNWYA T=0.3, sample=15, score=0.8454,
global_score=1.3585, seq_recovery=0.4639

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MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGEWITHCRVPGKVALTFDDGPYKY
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HSAFVEAVGVEPRFMRPPYLAADERVLEVARELGLRVIGASIDTKDYEYDSEELVGKSVERFREQLDK
GGTIVLSHEDYKYSVLILTPIMLEEIYKRGLQATTVGGALGDDRWFA T=0.3, sample=16, score=0.8321,
global_score=1.3534, seq_recovery=0.4536
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AFVEAVGVEPTYTRPPYMAADEKVLAVAKELGLRVIGFSIDTKDYEYDSEELVGKSVERFREQLDAG
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global_score=1.3541, seq_recovery=0.4433
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SAFVQAVGVRPRYTRPPYLAADAKVLAVAKELGLRVIGASIDTKDYEYDSPELVGKAVERFREQLAA
GGTIVLSHEDKKYSVTHLTPIMLEEIYARGLQPTTVAGALGDDNWYA T=0.3, sample=18,
score=0.8562, global_score=1.3649, seq_recovery=0.4639
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EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVSEMTTLES
AFVKAVGVKPTYTRPPYLAADEKVLEVAKELGKVVIGASIDTKDYEHDSPELVGKSVDRFRKQLDEG
GTIVLSHEDYKYSVTILTPIMLEEIYKRGLQATTVGGALGDDNWFK T=0.3, sample=19, score=0.8460,
global_score=1.3716, seq_recovery=0.4742
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SAFVEAVGVKPRYMRPPYLAADEKTLAVAKELGYVVIGASIDTKDYEHDSEELVGESVERFKKQLDA
GGTIVLSHEDYKMSVTILTPIMLEEIYKRGLQPTTVGGALGDEKWYA T=0.3, sample=20, score=0.8288,
global_score=1.3434, seq_recovery=0.4948
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGEWITQCRVPGTVALTFDDGPYEYT
EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLH
SAFVEAVGVKPRYMRPPYLAADKRVLEVAKELGYVVIGASIDTKDYEYDSPELVGKSVELFKEQLAK
GGTIVLSHEDYRYSVLELTPIMLEEIYARGLQPTTVGGALGDDNWYA T=0.3, sample=21, score=0.8695,
global_score=1.3752, seq_recovery=0.4433
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AFVEAVGVRPRYTRPPYMAADERVLAVAKELGYVVVGASIDTKDYEYDSPDLVGKSVARFREQLAA
GGTIVLSHEDYKESVLRLTPIMLEEIYARGLQPTTVAGALGDSNWYF T=0.3, sample=22, score=0.8570,
global_score=1.3652, seq_recovery=0.4433
MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSTGELITNCRVPGTVALTFDDGPYEYT

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	EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVQEMTRLW SAFVEAVGVEPRYTRPPYLAADARVLEVAKELGLRVIGASIDTKDYEHDSEELVGLSVKRFLEQLDNG GTIVLSHEDYKYSVHILTPIMLEEIYKRGLQATTVGGALGDSKWYR T=0.3, sample=23, score=0.8950, global_score=1.3670, seq_recovery=0.4639 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGKMITHCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYDQIVAEMTNLH SAFVDAVGVEPKFVRPPYLAADDKVLAVAKELGYVVIGASIDTKDYEYDSPELIGKSVERFREQLAA GGTIVLSHEDKYYSVKELLPIMLEEIYRRGLQATTVGGALGDTDWYA T=0.3, sample=24, score=0.8421, global_score=1.3719, seq_recovery=0.4330 MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPQVSYGELITDCRVPGTVALTFDDGPYEYT EELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHTDLTVLSYEQIVAEMTQLD SAFVEAVGVKPRYIRPPYMAADDRTLAVAKELGYRVIGASIDTKDYEYDSEELVGKSVERFLEQLAA GGTIVLSHEDYKYSVTVLTPIMLEEIYRRGLQATTVGGALGDDNWYT

3.6.4.3 Design of an AI deacetylase that should be more water-soluble

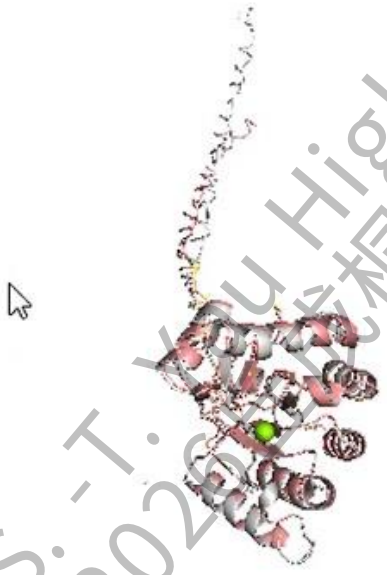
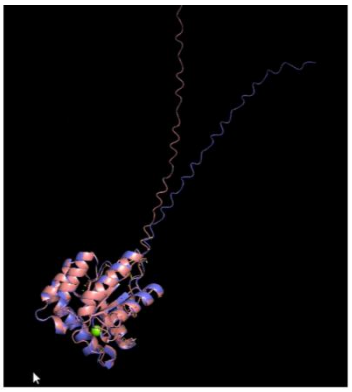


Figure 3.6.4.3.1 A more water-soluble chitin deacetylase designed by AlphaFold 3, ProteinMPNN (AI deacetylase) with the best score



The pink one is the original chitin deacetylase
the blue one is the AI deacetylase with the best score

Figure 3.6.4.3.2 The pink one is the original chitin deacetylase.

The blue one is the AI deacetylase with the best score

Table 3.6.4.3.3 The amino sequence of the AI designed chitin deacetylase with the best score of water solubility

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	Amino sequence
AI deacetylase with the best score of water solubility	MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGELITDCR VPGTVALTFDDGPYEYTEELLDILAQYGAKATFFVNGHNLAGNEWLIQR VVNEGHQLASHTWGHTDLTVLSYEQIVDEMTRLDSAFVEAVGVVPRYM RPPYLAADERVLAVAKELGYVVIGASIDTKDYEYDSPELVGKSVERFREQ LAAGGTIVLSHEDYKYSVTILTPIMLEEIYARGLQATTVGGALGDSNWYK

Conclusion: The more water-soluble AI deacetylase designed by AlphaFold 3, ProteinMPNN and the original deacetylase had similar shape.

3.6.4.4 Investigation of the SDS-page, percentage yield and DD% of chitosan obtained using the AI designed deacetylase

3.6.4.4.1 Investigation of the SDS-page of chitosan obtained using the AI designed deacetylase

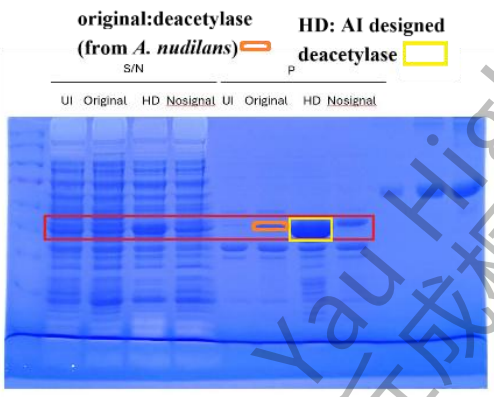


Figure 3.6.4.4.1.1 SDS-Page for SUMO- deacetylase with 6M urea as solvent (red box shown the target size of protein band)

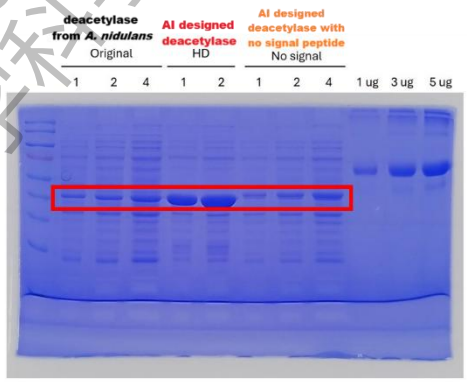
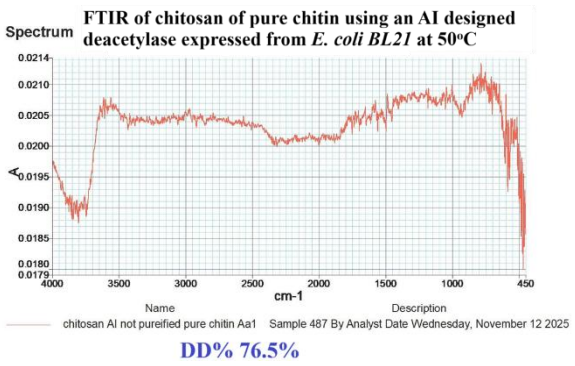


Figure 3.6.4.4.1.2 SDS-Page for SUMO-deacetylase with 6M urea as solvent (red box shown the target size of protein band)

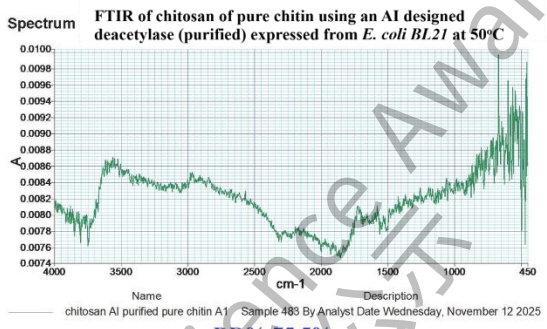
Conclusion: The amount of AI designed deacetylase expressed from *E. coli BL21* was much higher than that of the original deacetylase from *A. nidulans*.

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3.6.4.4.2 Investigation of the DD% and percentage yield of chitosan obtained from chitin of black soldier fly BSF using an AI-designed chitin deacetylase from expression



FTIR of chitosan of pure chitin using an AI designed deacetylase (original: *A. nidulans*) expressed from *E. coli BL21* at 50°C



FTIR of chitosan of pure chitin using an AI designed deacetylase (original: *A. nidulans* (purified) expressed from *E. coli BL21* at 50°C

Table 3.6.4.4.2.1 Percentage yield of chitosan (from pure chitin) obtained using AI designed deacetylase

Pure chitin	Percentage yield of chitosan %
original of deacetylase from *A. nidulans*	3.86
AI designed deacetylase	5.08
AI designed deacetylase (purified)	6.18
AI designed deacetylase with no peptide signal	4.91
control (6M urea only)	0.00

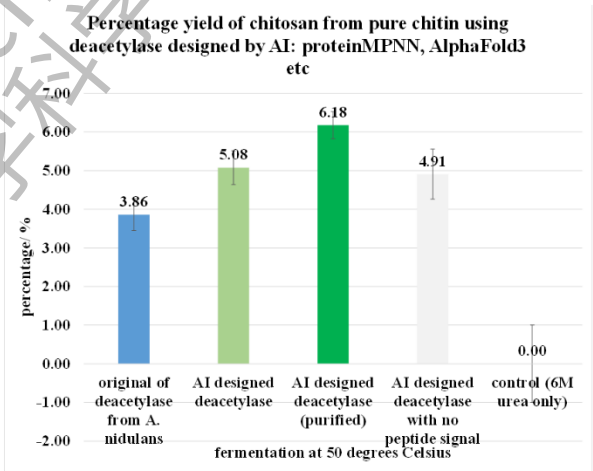


Figure 3.6.4.4.2.2 Percentage yield of chitosan (from pure chitin) obtained using AI designed deacetylase

Conclusion:

The degree of deacetylation DD% of chitosan (from pure chitin) obtained using the AI designed deacetylase was about 75% which was consistent with the DD% of pure chitosan of 67.7%.

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The percentage yield of chitosan (from pure chitin) were 5.08% using AI designed deacetylase and 6.18 % using AI designed purified deacetylase (c.f. Original of deacetylase from *A. Nidulans* of 3.86%). Thus the use of AI designed deacetylase using ProteinMPNN, AlphaFold 3 etc could increase the percentage yield of chitosan from fermentation of chitin by 31.6% with AI deacetylase and 60.1% with the purified AI deacetylase.

4. Findings

4.1 Percentage yield of chitosan BSF from chitin BSF using different methods

Percentage yield of **BSF** *rouxii* chitosan obtained from fermentation using a chitin deacetylase from *Mucor rouxii* was the highest at 50 ºC (59.0%). (cf. using 16.7M NaOH at 80 ºC: 22.1%)

Percentage yield of crab *rouxii* chitosan obtained from fermentation using a chitin deacetylase from *Mucor rouxii* was the highest at 50 ºC (57.0%). (cf. using 16.7M NaOH at 80 ºC: 48.3%)

4.2 Investigation of the anti-bacterial effect of different anti-bacterial Bio-BandAIDS of crab *rouxii* dressing and crab *rouxii* BSF dressing, roasted chitin only and crab chitin only

Number of oral bacterial colonies for the original sample and dilution factor 10^{-2} of black soldier fly **BSF** chitin (3,1), **BSF** *rouxii* chitosan (1,2), crab chitin (6,3) and crab *rouxii* chitosan (0,2) were fewer than that of the control of oral bacteria only (many, 77).

Number of oral bacterial colonies for the original sample and dilution factor 10^{-2} of roasted crab chitin (6,0) was fewer than that of the control of oral bacteria only (many, 17).

Number of oral bacterial colonies for the dilution factor 10^{-3} and dilution factor 10^{-4} of roasted crab chitosan (16.7M NaOH) (0,0), crab chitosan (16.7M NaOH) (1,0), and pure chitosan (1,0) were fewer than that of the control of oral bacteria only (965, 211).
Thus, black soldier fly **BSF** chitin, **BSF** *rouxii* chitosan, crab chitin, crab *rouxii* chitosan, roasted crab chitin, roasted crab chitosan (16.7M NaOH), crab chitosan (16.7M NaOH) and pure chitosan were anti-bacterial, so they were suitable raw materials for making anti-bacterial bio-**BandAIDS**.

Number of oral bacterial colonies for the original sample and dilution factor 10^{-2} of a commercial hydrocolloid of Nexcare (many,100) were similar to that of the control of oral bacteria only (many, 77). Thus, the commercial hydrocolloid of Nexcare was NOT anti-bacterial. (Avila, 2009)

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4.3 Effect of roasting on the toughness and water resistance of crab chitin as bandages

Degree of acetylation DA% increased drastically from 39.7% to 47.5% when crab chitin was roasted at 120 ºC for 15 to 30 mins, so structural changes took place (due to the reduction in number of -OH hydroxy groups)

Degree of acetylation increased drastically from 40.0% to 47.5% when crab chitin was roasted between 100ºC to 120 ºC for 30 mins, so structural changes took place (due to the reduction in number of -OH hydroxy groups)

The toughness of crab chitin was the highest when roasted at 120 ºC for 15 to 30mins (34.8N/mm) which was comparable with the toughness of Nexcare hydrocolloid (66.3N/mm).

The toughness of crab chitin was the highest when roasted at 100 to 120ºC for 30mins (34.8N/mm) which was comparable with the toughness of Nexcare hydrocolloid (66.3N/mm).

The water absorbance of crab chitin decreased drastically from 8.1 times to 5.9 times when roasted at 120 ºC for 15 to 30mins. Thus the water resistance was increased when roasted 120 ºC for 15 to 30mins. The water resistance of roasted crab chitin was comparable with that of Nexcare (3 times).

The water absorbance of crab chitin decreased drastically from 8.0 times to 5.9 times when roasted at 100 to 120 ºC for 30mins. Thus the water resistance was increased when roasted 100 to 120 ºC for 30mins. The water resistance of roasted crab chitin was comparable with that of Nexcare (3 times).

Thus, roasted crab chitin should be suitable for making the water-resistant coating of Bio-**BandAIDS**.

4.4 Investigation of the presence of surface protein on different anti-bacterial Bio-BandAIDS of crab *rouxii* dressing and crab *rouxii* BSF dressing, roasted chitin only and crab chitin only and commercial hydrocolloid that might cause allergic effects.

The results revealed an incredible absence of surface proteins on different anti-bacterial Bio-**BandAIDS** of crab *rouxii* dressing and crab *rouxii* **BSF** dressing, roasted chitin only and crab chitin only and commercial hydrocolloid, indicating that these materials were non-allergic. This remarkable characteristic highlights the potential of different anti-bacterial Bio-**BandAIDS** of crab *rouxii* dressing and crab *rouxii* **BSF** dressing as a safe option for consumers, free from the risk of allergic reactions.

4.5 Investigation of the biodegradability of crab *rouxii* dressing, crab *rouxii* BSF dressing and commercial hydrocolloid

It took 24 days for Bio-**BandAIDS** of crab rouxii BSF dressing and 56 days for Bio-**BandAIDS** of crab rouxii dressing to be fully biodegraded in soil. Commercial hydrocolloid was NOT biodegradable.

4.6 Testing and certification of Bio-BandAIDS based on IS997 (2004) and SIST EN 13726-1

ALL Bio-**BandAIDS** of crab *rouxii* dressing, crab *rouxii* **BSF** dressing, crab chitosan (16.7M NaOH) only and Roasted crab chitosan (16.7M NaOH) only outperformed commercial hydrocolloid of Nexcare in the testing and certification based on IS 997. (IS997, 2004) Tensile strength of Bio-**BandAIDS** of crab chitosan (16.7M NaOH) only (>40N), roasted chitosan (16.7M NaOH) only (21.0N), crab *rouxii* **BSF** dressing (28.3N) and crab *rouxii*

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dressing (23.0N) performed the best as their tension strength were the highest. (cf. commercial hydrocolloid of Nexcare: 4.3N only)

FSA Free Swell Absorptive Capacity based on SIST EN 13726-1 (SIST(EN)13726-1-2002) of bio-**BandAIDS** of crab *rouxii* dressing (11.68), crab *rouxii* **BSF** dressing (7.53) and *rouxii* **BSF** dressing only (10.88) were the highest. FSA of crab chitosan (16.7M NaOH) only (7.99) was also high. (cf. commercial hydrocolloid of Nexcare:: 0.97)

4.7 Expression of a deacetylase from *Aspergillus nidulans* by *E. coli BL21*

Percentage yield of chitosan from **BSF** chitin using deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* was increased from 3.7% to 16.9% when the temperature was increased from 30 ºC to 50 ºC in 6M urea showing that the optimum temperature for such deacetylase was 50ºC. (cf. pure chitin 24.5% at 50 ºC with chitin deacetylase expressed by *E. coli*) (cf. Using vinegar only at 50ºC 36.9%; *Mucor rouxii* in vinegar 59.0% at 50ºC; 16.7M NaOH 22.1% at 80ºC)

Percentage yield of chitosan from crab chitin using deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* was increased from 18.3% to 22.1% when the temperature was increased from 30ºC to 50ºC showing that the optimum temperature for such deacetylase was 50ºC. (cf. pure chitin using chitin deacetylase expressed by *E. coli*: 24.5%) (Using vinegar only at 50ºC 38.4%; *Mucor rouxii* in vinegar 57.1% at 50ºC; 16.7M NaOH 48.3% at 80ºC)

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4.8 AI deacetylase designed with the best score in water solubility



Figure 4.8.1 A more water-soluble chitin deacetylase designed by AlphaFold 3, ProteinMPNN (AI deacetylase) with the best score

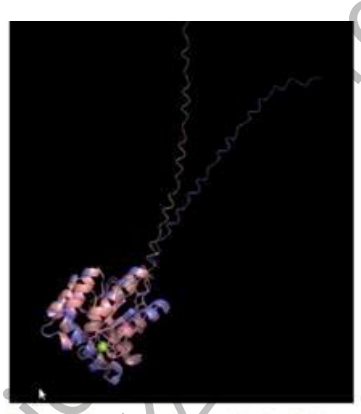


Figure 4.8.2 The pink one is the original chitin deacetylase.

The blue one is the AI deacetylase with the best score

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5. Discussion

5.1 Versatility of chitosan dressing

From **3.3**, it was obvious that crab *rouxii* dressing, crab *rouxii* **BSF** dressing, roasted chitin only and crab chitin only were potent anti-bacterial agents. Commercial bandages are neither bio-degradable nor anti-bacterial. crab *rouxii* dressing and crab *rouxii* **BSF** dressing could be alternatives of dressings for the manufacture of better commercial bandages making them anti-bacterial and hence accelerate wound healing. (Park, 2018).

5.2 Comparison of Bio-BandAIDS with other inventions of bandages or dressings

	 Anti-bacterial Bio-BandAIDS	A kind of medical dressing and preparation method thereof	Wound dressing	A functional multilayer hemostatic antibacterial dressing	Surgical medical dressing and preparation method thereof
Description	Anti-bacterial bio-bandAIDS are anti-bacterial bandages made of chitin with dressings that are anti-bacterial by using crab chitosan and black soldier fly BSF chitosan. Crab chitosan and BSF chitosan are produced using fermentation by chitin deacetylase obtained in 3 ways: a. Using *Mucor rouxii* b. Expression by *E. coli BL21* c. Expression using a chitin deacetylase designed by AI	A kind of medical dressing, is made up of the biological raw material such as chitosan derivatives and sodium alginate fiber, and wherein chitosan derivatives are carboxymethyl chitosan quaternary ammonium salt. Preparation method include will sodium alginate fiber be acidified after be made powder, mix with olivine or allochite, then hybrid particles are carried out swelling, required medical dressing is made by the way of microwave, freeze-drying. The medical dressing being made has good penetrability, water imbibition and water-retaining property and biodegradable.	Wound dressings comprising one or more benefit agents that, in use, are released into the wound to aid in wound healing or provide other therapeutic benefit, absorbent components for use as or in a wound dressing, and non-adherent wound dressings comprising a perforated non-adherent skin contact layer.	The utility model discloses a functional multi-layer hemostatic and antibacterial dressing, which is a four-layer structure, which sequentially includes a wound contact layer, a liquid absorption layer, a barrier layer and a bandaging and fixing layer according to the contact with the wound surface from the inside to the outside. The wound contact layer is based on degradable natural polymer nanofibers with a diameter of 200-400 nm, and the drug-loaded inorganic materials are distributed in the nanofibers; the liquid absorption layer is made of water-absorbing fibers and The non-woven material layer is composed of superabsorbent resin; the barrier layer is a non-woven material layer composed of hydrophobic fibers; the wrapping and fixing layer is a low-sensitivity elastic medical adhesive tape layer in strip shape. Since the wound surface contact layer is a nanofibrous structure containing inorganic materials, the loaded drug can quickly reach the skin wound surface after being released, so as to realize the effects of hemostasis, antibacterial, and wound healing promotion. The utility model also has the characteristics of good biocompatibility, excellent physical and mechanical properties, simple preparation process and favorable industrial production.	The invention provides a surgical medical dressing. The surgical medical dressing is prepared from biological raw materials such as a chitosan derivative and sodium alginate fibers, wherein the chitosan derivative is carboxymethyl chitosan quaternary ammonium salt. The preparation method comprises acidizing sodium alginate fibers, processing the acidized sodium alginate fibers to obtain powder, mixing the powder and olivine or epidote, then swelling the mixture particles, and carrying out microwave radiation and freeze-drying to obtain the surgical medical dressing. The prepared surgical medical dressing has good moisture permeability, water absorptivity, water retentivity and biodegradability.

	 Anti-bacterial Bio-BandAIDS	A kind of medical dressing and preparation method thereof	Wound dressing	A functional multilayer hemostatic antibacterial dressing	Surgical medical dressing and preparation method thereof
Reference	Anti-bacterial Bio-BandAIDS	CN106729942A (张天奇, 2017)	WO2015173547A1 (Cotton, 2015)	CN209678849U (赵蓉蓉 & 任翔翔, 2018)	CN105999367A (耿雪花, 2016)
Strengths	Anti-bacterial Haemostatic	Chitosan derivatives used as anti-bacterial and haemostatic agents	Manuka honey, produced from the nectar of the plant species Leptospermum scopahum, is in the dressing which as antibacterial	Antibacterial Good biocompatibility	Antibacterial Have moisture retention, wound surface is made to moisten, will not adhere wound surface, producing mechanical injuries of property again
	Bio-degradable	Bio-degradable	Biodegradable pol yester serving as haemostatic agent such as polylactic acid and polyglycolic acid are used	Degradable	Bio-degradable
	Sustainable development				
	Non-allergic		Non-allergic	Non-allergic	

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 Anti-bacterial Bio-BandAIDS	A kind of medical dressing and preparation method thereof	Wound dressing	A functional multilayer hemostatic antibacterial dressing	Surgical medical dressing and preparation method thereof
Weaknesses	1.Chemical methods are employed in the production of the chitosan derivatives using olivine ($(Mg, Fe)_2SiO_4$), allochite (or Epidote. {Ca2}{Al2Fe^{3+}}(SiO4)(Si2O7)O(OH)) etc using microwave and freeze-drying.	1.Only part of the wound dressing is bio-degradable 2. Not sustainable as honey is a food source; Using honey to manufacture the wound dressing would cause a surge in food price	1.Only part of the material is degradable 2.May not be stable as the layers are combined by adhesive or acupuncture, movement may cause instability between layers leading to shedding	1. Absorption capacity is not very strong, so for highly exudative wounds, other auxiliary dressings are often needed to enhance absorption. 2. Product cost is relatively high. 3. Some patients may be allergic to the ingredients.

Anti-bacterial Bio-BandAIDS of crab chitin with *rouxii* chitosan of black soldier fly BSF as dressing

Nil

5.3 Sustainable Development Goals (SDGs)

5.3.1 6th SDG Taget 6.3: Fermentation and the improvement of water quality

As the incorporation of fermentation using *Mucor rouxii* and a deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* would eliminate the use of highly corrosive 16.7M NaOH, dumping and minimizing release of hazardous chemicals and materials and so improving water quality by reducing pollution and the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally fulfilling SDG Target 6.3.

5.3.2 Bio-BandAIDS of crab *rouxii* dressing and crab *rouxii* BSF dressing meet the 12th sustainable development goal (SDG) of the United Nations - Ensure sustainable consumption and production patterns, in 3 ways.

5.3.2.1 12th SDG: Upcycling of BSF shells and responsible consumption and production they put into words the value of recycling.

Chitosan extracted from the **BSF** shells are used as the dressing on the Bio-**BandAIDS** of crab *rouxii* **BSF** dressing. This is an innovative and up-cycling of use of **BSF** shells to obtain chitosan which was more well-known for being used in the pharmaceutical industry. It was also used in fat loss products since it has the ability to reduce the fat and cholesterol absorbed by the body. It was also used in the development of anti-bacterial films for food packaging. Considering all its benefits, edible, anti-bacterial, biodegradable, we came up with the idea to coat it on to these disposables to improve them, creating a new application of chitosan.

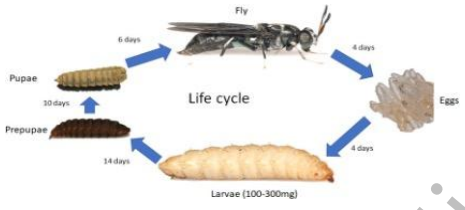
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5.3.2.2 12th SDG Target 12.5: Bio-BandAIDS of crab *rouxii* dressing and crab *rouxii* BSF dressing replacing hydrocolloid as bandages

Hence achieving the Target 12.5 by substantially reducing waste generation through plastic prevention. Together with its biodegradability, anti-bacterial Bio-**BandAIDS** of crab *rouxii* dressing and crab *rouxii* **BSF** dressing can ensure sustainable development with no doubt.

5.3.2.3 12th SDG Target 12.2: Obtaining chitosan from BSF and achieving the sustainable management and efficient use of natural resources

The source of chitosan used in anti-bacterial Bio-**BandAIDS** of crab *rouxii* **BSF** dressing can be extracted from Black Soldier Fly (**BSF**). In the life cycle of **BSF**, the **BSF** shells are disposed of after **BSF** has reached adulthood and become mature. To make our anti-bacterial dressing of crab chitosan and **BSF** chitosan, the shells of **BSF** will be converted into chitosan, hence reducing waste production. Crab shell, as another source of chitosan to make the dressing can also be well used. As a result, they won't be disposed of as waste. Target 12.2 can therefore be achieved.



https://www.facebook.com/photo.php?fbid=1751043650440 55&set=pb.100076334761771.-2207520000&type=3

Figure 5.5.2 Life cycle of Black Soldier Fly BSF

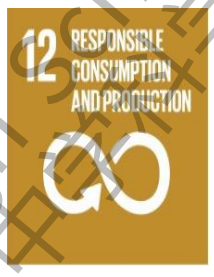


Figure 5.5.2 12th SDG



Figure 5.5.3 Target 12.5



Figure 5.5.4 Target 12.2

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5.3.2.4 11th SDG Target 11.9: Circular economy of BSF and implementing integrated policies and plans towards resource efficiency

Making use of **BSF** also supports the development of the circular economy and nothing will be wasted during the entire process. Nowadays, **BSF** larvae are used to consume food wastes. They will then undergo prepupae, pupae, and adult stage. When the **BSF** pupae mature to adults, they will undergo ecdysis and the shells will separate from the insects themselves without manual operation. The shells can then be used in many circumstances as it contains a high percentage of chitin and can be further converted into chitosan, in this case, the chitosan dressing on our Bio-**BandAIDS** of crab *rouxii* **BSF** dressing. The adults will then reproduce offspring and die soon. Since **BSF** is a high value animal protein, the dead or excess individuals can be used as fish feed or food for livestock. Apart from being used as a protein source, **BSF** can also be used as a fertiliser for soil amendments. These can potentially help promote other industries' growth. More plants bring more food waste for the **BSF** larvae to consume. Leading this whole process self-sustainable.

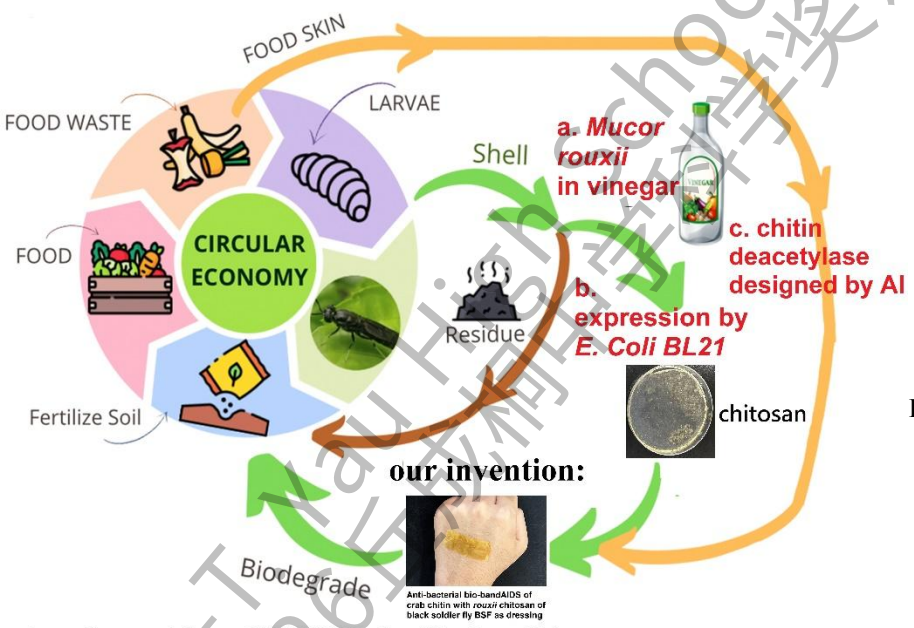


Figure 5.5.3.1 Circular economy operated by black soldier fly BSF



Figure 5.5.3.1 Target 11.9

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6. Limitations

6.1 Testing and certification of water resistance and breathability of chitin

6.1.1 Testing water resistance

Testing water resistance involves subjecting a product to simulated water exposure and observing its behavior, using methods like the hydrostatic pressure test for textiles etc. based on BS EN 20811:1992. (BS(EN)20811, 1992) Textiles. Determination of resistance to water penetration. Hydrostatic pressure test (British Standard)

A specimen is subjected to a steadily increasing pressure of water on one face, under standard conditions, until penetration occurs in three places. The water pressure may be applied from below or from above the test specimen. The hydrostatic head supported by a fabric is a measure of the resistance to the passage of water through the fabric.

However, it is unlikely that hydrostatic pressure test could be done in a secondary school laboratory.

6.1.2 Testing breathability of chitin

Breathability testing measures a material's ability to let water vapor pass through it, using metrics like Moisture Vapour Transmission Rate (MVTR) (grams per square meter per 24 hours) and Thermal Evaporative Resistance (RET) (resistance to evaporation). Common lab methods include the Upright Cup Test, ie. ASTM E96-00e1

Standard Test Methods for Water Vapor Transmission of Materials. (ASTM(E96), 2017)

However, ASTM E96-00e1 Standard Test Methods for Water Vapor Transmission of Materials, is unlikely to be done in a secondary school laboratory.

6.2 Investigation of the biocompatibility of Bio-BandAIDS

Biocompatibility testing of Bio-**BandAIDS** could be done based on ISO 10993. Some materials may induce adverse effects when in contact with human tissue. The manufacturer is thus obliged to evaluate each device for potential adverse effects prior to marketing. However, **ISO 10993-10:2021(en)**— Part 10: Tests for skin sensitization could not be performed in a secondary school laboratory.

6.3 Investigation of the toxicity of Bio-BandAIDS

The evaluation of the presence and extent of the cytotoxic effect of Bio-**BandAIDS**, if any, could be undertaken based on ISO 10993-5:2009(en) Biological evaluation of medical devices — Part 5: Tests for in vitro cytotoxicity to make assessment and measurements of cell damage. However, ISO 10993-5:2009(en) could not be done in a secondary school laboratory.

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7. Further Studies

7.1 Testing and certification of water resistance of Bio-BandAIDS

Testing water resistance involves subjecting a product to simulated water exposure and observing its behavior, using methods like the hydrostatic pressure test for textiles etc. based on BS EN 20811:1992. (BS(EN)20811, 1992) Textiles. Determination of resistance to water penetration. Hydrostatic pressure test (British Standard)

A specimen is subjected to a steadily increasing pressure of water on one face, under standard conditions, until penetration occurs in three places. The water pressure may be applied from below or from above the test specimen. The hydrostatic head supported by a fabric is a measure of the resistance to the passage of water through the fabric. Similarly, water resistance of Bio-**BandAIDS** could be done based on BS EN 20811:1992.

7.2 Testing and certification of breathability of Bio-BandAIDS

Breathability testing measures a material's ability to let water vapor pass through it, using metrics like Moisture Vapour Transmission Rate (MVTR) (grams per square meter per 24 hours) and Thermal Evaporative Resistance (RET) (resistance to evaporation). Common lab methods include the Upright Cup Test, ie. ASTM E96-00e1

Standard Test Methods for Water Vapor Transmission of Materials. (ASTM(E96), 2017) Similarly, breathability of Bio-**BandAIDS** could also be tested and certified based on ASTM E96-00e1 .

7.3 Adaptation of BSF chitosan dressing and crab chitosan dressing to Commercial Products for problematic wound management

This investigation had confirmed the anti-bacterial ability of different chitosan dressing such as crab and black soldier fly **BSF**. These chitosan dressing are not just biodegradable and environmentally-friendly but also as dressing material for problematic wound management as most dressings available on the market heal wounds by surface-based interactions between the dressing material and the wound, so dressings take a passive role in healing wounds. Further study could be performed to investigate the applicability of **BSF** chitosan dressing and crab chitosan dressing to commercial bandages to accelerate wound healing. (Park, 2018)

7.4 Fermentation of chitin of BSF and crab to chitosan using chitin deacetylase

Mucor rouxii and expression of a deacetylase from *Aspergillus nidulans* by *E. coli BL21* were found to be greener ways to obtain chitosan. (Tsigos, 1999) Further studies could be done on expression of chitin deacetylase from different sources. (Yin, 2023) (Wang, 2010)

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Fungi	Phylum	Optimal pH/Temp. (°C)	pI	Molecular Weight (kDa)	Carbohydrate contents (%)	Refs
Mucor rouxii	Mucoromycotina	4.5, 50	3.0	75–80	30	[7]
Absidia coerulea	Mucoromycotina	5.0, 50	NA	75	NA	[8]
Rhizpus circinans	Mucoromycotina	5.5–6.0, 37	NA	75	NA	[9]
Rhizopus nigricans	Mucoromycotina	NA	NA	100	53	[10]
Mortierella sp. DY-52[#]	Mucoromycotina	5.5, 60	NA	50, 59	NA	[11]
Colletotrichum lindemuthianum (ATCC 56676)[#]	Ascomycotina	12, 60	3.7	32–33	NA	[12]
Colletotrichum lindemuthianum (DSM 63144)[#]	Ascomycotina	8.5, 50	3.0	150	67	[13]
Colletotrichum lindemuthianum (UPS 9)[#,*]	Ascomycotina	8.0, 60	NA	25	0	[14]
Aspergillus nidulans[#]	Ascomycotina	7.0, 50	2.8	27	28	[15]
Metarhizium anisopliae[#]	Ascomycotina	8.5, NA	3.6	70, 37, 26	NA	[16]
Scopulariopsis brevicaulis	Ascomycotina	7.5, 55	NA	55	NA	[17]
Saccharomyces cerevisiae Cda2p	Ascomycotina	8.0, 50	NA	43	18	[18]
Schizosaccharomyces pombe	Ascomycotina	NA	NA	NA	NA	[19]
Flammulina velutipes	Basidiomycotina	7.0, 60	NA	31	0	[20]
Cryptococcus neoformans	Basidiomycotina	NA	NA	NA	NA	[21]

[#], extracellular chitin deacetylases;

[*], structure available;

NA, not available.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2817921/table/t1-marinedrugs-08-00024/?report=objectonly

Figure 7.3 Sources of different chitin deacetylase
(Zhao, 2010)

7.5 Investigation of the biocompatibility of Bio-BandAIDS

Biocompatibility testing of Bio-**BandAIDS** could be done based on ISO 10993. Some materials may induce adverse effects when in contact with human tissue. The manufacturer is thus obliged to evaluate each device for potential adverse effects prior to marketing, so testing based on **ISO 10993-10:2021(en)**— Part 10: Tests for skin sensitization could be performed to ensure the eligibility of marketing of Bio-**BandAIDS**. ` (ISO10993(10), 2021)

7.6 Investigation of the toxicity of Bio-BandAIDS

The evaluation of the presence and extent of the cytotoxic effect of Bio-**BandAIDS**, if any, could be undertaken based on ISO 10993-5:2009(en) Biological evaluation of medical devices — Part 5: Tests for in vitro cytotoxicity to make assessment and measurements of cell damage. (ISO10993(5), 2009)

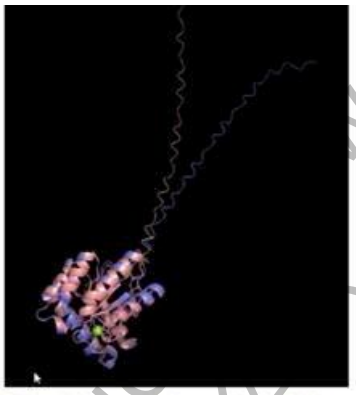
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7.7 Expression of the more water-soluble chitin deacetylase designed by AI



A more water-soluble chitin deacetylase designed by AlphaFold 3 (AI deacetylase) with the best score

Figure 3.10.3.3.1 A more water-soluble chitin deacetylase designed by AlphaFold 3 (AI deacetylase) with the best score



The pink one is the original chitin deacetylase
the blue one is the AI deacetylase with the best score

Figure 3.10.3.3.2 The pink one is the original chitin deacetylase.

The blue one is the AI deacetylase with the best score

As the amino sequence of the more water-soluble AI deacetylase was worked out, expression would be done to apply this AI deacetylase in the production of chitosan from **BSF** and crab so as to obtain a higher yield of chitosan for making anti-bacterial **BandAIDS**.

	Amino sequence
AI deacetylase with the best score of water solubility	MLFPNVPGVASLLSLFAATLILNTQALAINTIANLTDRQPEVSYGELITDCRVPGTVALT FDDGPYEYTEELLDILAQYGAKATFFVNGHNLAGNEWLIQRVVNEGHQLASHTWGHT DLTVLSYEQIVDEMTRLDSAFVEAVGVVPRYMRPPYLAADERVLAVAKELGYVVIGA SIDTKDYEYDSPELVGKSVERFREQLAAGGTIVLSHEDYKYSVTILTPIMLEEIYARGLQ ATTVGGALGDSNWYK

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8. Summary

BandAIDS were anti-bacterial as Black soldier fly **BSF** chitin, **BSF** *rouxii* chitosan, crab chitin, crab *rouxii* chitosan, #roasted crab chitin, #roasted crab chitosan (16.7M NaOH), crab chitosan (16.7M NaOH) and pure chitosan were anti-bacterial, so they were suitable raw materials for making anti-bacterial bio-**BandAIDS** as there were fewer oral bacterial colonies. The commercial hydrocolloid of Nexcare was NOT anti-bacterial.

It took 24days for Bio-**BandAIDS** of crab *rouxii* **BSF** dressing to be fully biodegraded in soil.

ALL Bio-**BandAIDS** of crab *rouxii* dressing, crab *rouxii* **BSF** dressing, crab chitosan (16.7M NaOH) only and #roasted crab chitosan (16.7M NaOH) only outperformed commercial hydrocolloid of Nexcare in the testing and certification based on IS 997. (IS997, 2004) Tensile strength of Bio-**BandAIDS** of crab chitosan (16.7M NaOH) only (>40N), #roasted chitosan (16.7M NaOH) only (21.0N), crab *rouxii* **BSF** dressing (28.3N) and crab *rouxii* dressing (23.0N) performed the best as their tension strength were the highest. (cf. commercial hydrocolloid of Nexcare: 4.3N only).

Besides, FSA Free Swell Absorptive Capacity based on SIST EN 13726-1 (SIST(EN)13726-1-2002) of bio-**BandAIDS** of crab *rouxii* dressing (11.68), crab *rouxii* **BSF** dressing (7.53) and *rouxii* **BSF** dressing only (10.88) were the highest. FSA of crab chitosan (16.7M NaOH) only (7.99) was also high. (cf. commercial hydrocolloid of Nexcare:: 0.97)

Water resistance of bio-**BandAIDS** of crab chitin only (61%) , crab *rouxii* dressing (78%) and crab *rouxii* **BSF** dressing (74%) were the best (cf. Commercial hydrocolloid of Nexcare: (276%).

Percentage yield of chitosan from **BSF** chitin and crab chitin using deacetylase (from *Aspergillus nidulans*) expressed by *E. coli BL21* was increased from 3.7% to 16.9% and 18.3% to 22.1% when the temperature was increased from 30 ºC to 50 ºC in 6M urea showing that the optimum temperature for such deacetylase was 50ºC. (cf. pure chitin 24.5% at 50 ºC with chitin deacetylase expressed by *E. coli*) (cf. Using vinegar only at 50ºC: 36.9% and 38.4%; *Mucor rouxii* in vinegar: 59.0% and 57.1% at 50ºC; 16.7M NaOH: 22.1% and 48.3% at 80ºC). Structural changes of BSF chitin and crab chitin to chitosan were confirmed using FTIR Spectrum II as DD% of *rouxii* chitosan of black soldier fly **BSF** obtained using a chitin deacetylase from *Mucor rouxii* (about 54% to 65%) were consistent with the DD% of pure chitosan (67.7%) and DD% of *rouxii* chitosan of Chinese mitten crab obtained using a chitin deacetylase from *Mucor rouxii* (about 57% to 63%) were consistent with the DD% of pure chitosan (67.7%)

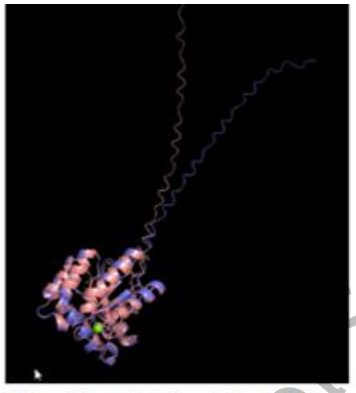
The more water-soluble AI deacetylase designed by AlphaFold 3, ProteinMPNN and the original deacetylase had similar shape. In doing so, the yield of chitosan would be drastically increased. The percentage yield of chitosan (from pure chitin) were 5.08% and 6.18 % using AI designed deacetylase at 50ºC (c.f. Original of deacetylase from *A. Nidulans* of 3.86%). Thus the use of AI designed deacetylase using ProteinMPNN, AlphaFold 3 etc could

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increase the percentage yield of chitosan from fermentation of chitin by 31.6% and 60.1% (purified AI deacetylase). DD% of chitosan of pure chitin obtained using an AI designed deacetylase (original: *A. nidulans*) expressed from *E. coli BL21* (about 76.5% to 75.5% from purified AI deacetylase) were consistent with the DD% of pure chitosan (67.7%)



A more water-soluble chitin deacetylase designed by AlphaFold 3 (AI deacetylase) with the best score



The pink one is the original chitin deacetylase
the blue one is the AI deacetylase with the best score

As surface protein allergens were found to be absent in crab *rouxii* dressing, crab *rouxii* **BSF** dressing, [#]roasted chitin only and crab chitin only when tested using 3M ALLTEC C60, anti-bacterial bio-**BandAIDS** should be non-allergic. (ALLTEC, C60)

Obviously crab *rouxii* dressing and crab *rouxii* **BSF** dressing were the best raw materials to produce anti-bacterial bio-**BandAIDS** based on the testing and certification of bio-**BandAIDS** based on IS997 and SIST EN 13726-1-2002 and good water resistance. Anti-bacterial bio-**BandAIDS** should be eligible for marketing.

[[#]roasting done at 120ºC for 30 mins (Ashenhurst, 2023)]

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9. References

Abdullah. (2020). Effect of chitin addition on water resistance properties of starch-based bioplastic properties, IOP Conference Series:, 483 (2020) 012002, p.1-10.

Abramson. (2024). *Accurate structure prediction of biomolecular interactions with AlphaFold 3, Nature, 630, pp 493-500 https://www.nature.com/articles/s41586-024-07487-w.*

Alabaraoye. (2018). Biopolymer (Chitin) from Various Marine Seashell Wastes: Isolation and Characterization, Journal of Polymers and the Environment , Volume 26, pages 2207–2218.

ALLTEC. (C60). https://www.neogen.com/categories/allergens/clean-trace-surface-allergen-protein-test-swab/.

Andrade. (2012). • The Use of Exoskeletons of Shrimp (Litopenaeus vanammei) and Crab (Ucides cordatus) for the Extraction of Chitosan and Production of Nanomembrane, Materials Sciences and Applications 03(07) 495-508.

Antonov A., I. G. (2019). *Production of chitin from dead Hermetia Illucens. IOPConference Series: Earth and Environmental Science, 315(4), 042003.*

Ashenhurst. (2023). Alcohols To Ethers via Acid Catalysis. *Master Organic Chemistry*. Retrieved from https://www.masterorganicchemistry.com/2014/11/14/ether-synthesis-via-alcohols-and-acid/

ASTM(E96). (2017). ASTM E96-00e1 Standard Test Methods for Water Vapor Transmission of Materials.

Avila. (2009). *The oral microbiota: living with a permanent guest. DNA and cell biology, 28(8), 405–411. https://doi.org/10.1089/dna.2009.0874.*

Baharlouei. (2022). Chitin and Chitosan: Prospective Biomedical Applications in Drug Delivery, Cancer Treatment, and Wound Healing, Mar. Drugs 2022, 20, 460. https://doi.org/10.3390/md20070460.

Benhabiles. (2012). Antibacterial activity of chitin, chitosan and its oligomers prepared from shrimp shell waste, Food Hydrocolloids, Volume 29, Issue 1, Pages 48-56.

Biskup. (2012). Determination of degree of deacetylation of chitosan - Comparision of Methods, Progress on Chemistry and application of Chitin and its Derivatives 2012:5-20.

Bonatesta. (2025). An R Package for Multiple Sequence Alignment, User Manual / Package Vignette, Version 1.41.3. Retrieved from https://bioconductor.org/packages/devel/bioc/vignettes/msa/inst/doc/msa.pdf

2026 S.T. Yau High School Science Award 仅用于2026丘成桐中学科学奖论文公示

BS(EN)20811. (1992). BS EN 20811:1992 Textiles. Determination of resistance to water penetration. Hydrostatic pressure test (British Standard), https://webstore.ansi.org/standards/bsi/bsen208111992?srsltid=AfmBOorL48lviD2sIgcnizT9dz4g1K4Zy2vCiAxNyVdB7hVLrCuDQHn4.

Butt TR, E. S. (2005). *SUMO fusion technology for difficult-to-express proteins. Protein Expr Purif. 2005 Sep;43(1):1-9.*

Cho. (2000). *Preparation and solubility in acid and water of partially deacetylated chitins. Biomacromolecules. 2000 Winter;1(4):609-14.*

Costa. (2021). *Chitosan as a Valuable Biomolecule from Seafood Industry Waste in the Design of Green Food Packaging, October 2021. Biomolecules 11(11):1599.*

Cotton. (2015). *Wood dressing. WO201517354 7A1.*

Croisier. (2013). Chitosan-based biomaterials for tissue engineering. *European Polymer Journal, 49(4),*, pp. 780-792.

Dauparas. (2022). *Robust deep learning based protein sequence design using ProteinMPNN, bioRxiv, Science doi: 10.1126/science.add2187, https://www.biorxiv.org/content/10.1101/2022.06.03.494563v1.*

Elouali. (2025). Extraction of chitin and chitosan from Hermetia illucens breeding waste: A greener approach for industrial application, International Journal of Biological Macromolecules, Volume 285, 138302.

G Reese, R. A. (1999). Tropomyosin: an invertebrate pan-allergen,G Reese 1, R Ayuso, S B Lehrer.

Goy. (2009). *A review of the antimicrobial activity of chitosan. Tecnologia, vol.19 no.3 São Carlos 2009, p.241-247.*

Graham. (1998). Modern Superabsorbent Polymer Technology. *Chemie Ingenieur Technik, 70(8)*, pp. 1036-1036.

Hahn. (2020). Current state of chitin purification and chitosan production from insects, J Chem Technol Biotechnol 2020; 95: 2775–2795.

Iber. (2021). A Review of Various Sources of Chitin and Chitosan in Nature, Journal of Renewable Materials, Volume 10, Issue 4, 29 October 2021, Pages 1097-1123.

IS997. (2004). https://www.sii.org.il/en/lobby/importers/laboratory-tests/enviorment-and-shielding/.

ISO10993(10). (2021). ISO 10993-10:2021(en), Biological evaluation of medical devices — Part 10: Tests for skin sensitization, https://www.iso.org/obp/ui/en/#iso:std:iso:10993:-10:ed-4:v1:en.

2026 S.T. Yau High School Science Award 仅用于2026丘成桐中学科学奖论文公示

ISO10993(5). (2009). ISO 10993-5:2009(en) Biological evaluation of medical devices — Part 5: Tests for in vitro cytotoxicity, https://www.iso.org/obp/ui/en/#iso:std:iso:10993:-5:ed-3:v1:en.

Jumper. (2021). Highly accurate protein structure prediction with AlphaFold, Nature volume 596, pages583–589.

Kucharska. (2019). Chitin and Chitosan: Properties and Applications, Chapter 7, Antimicrobial Properties of Chitin and Chitosan, https://doi.org/10.1002/9781119450467.ch7 .

Kumari. (2017). Physicochemical properties and characterization of chitosan synthesized from fish scales, crab and shrimp shells, International Journal of Biological Macromolecules Volume 104, Part B, Pages 1697-1705.

Lončarević. (2017). Lysozyme-Induced Degradation of Chitosan: The Characterisation of Degraded Chitosan Scaffolds. *Journal of Tissue Repair and Regeneration*, 12-22.

Lu. (2010). Studies on Mucor racemosus Fermentation to Manufacture Gamma-linolenic Acid Functional Food Douchi, Food Sci. Technol. Res., 16 (6), 543 – 548.

Lv. (2016). *7 - High-performance superplasticizer based on chitosan. Biopolymers and Biotech Admixtures for Eco-Efficient Construction Materials. Pages 131-150.*

Martinou. (1993). Isolation of chitin deacetylase from Mucor rouxii by immunoaffinity chromatography, Journal of Chromatography, 644 35-41.

Mirwandhono. (2024). Isolation and characterization of chitosan from black soldier fly exuviae, 10th International Conference on Sustainable Agriculture and Environment, IOP Conf. Series: Earth and Environmental Science 1362, 012013.

Mohammed. (2013). Extraction of chitin from prawn shells and conversion to low molecular mass chitosan, Food Hydrocolloids, Volume 31, Issue 2, Pages 166-171.

Okoya. (2016). Chitosan-Grafted Carbon for the Sequestration of Heavy Metals in Aqueous Solution. *American Chemical Science Journal 11(3)*, pp. 1-14.

Pandharipande. (2016). Synthesis of Chitin from Crab Shells and its Utilization in Preparation of Nanostructured Film, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 5, Issue 5, p.1378-1383.

Park. (2018). Chitosan-Based Dressing Materials for Problematic Wound Management, Adv Exp Med Biol, 2018:1077:527-537. doi: 10.1007/978-981-13-0947-2_28.

2026 S.T. Yau High School Science Award
仅用于2026丘成桐中学科学奖论文公示

Periayah. (2012). Chitosan-derivatives as hemostatic agents: their role in tissue regeneration, Regenerative Research 1(1) 2012 38-46 .

Pires. (2014). The Effect of Chitin Alkaline Deacetylation at Different Condition on Particle Properties. *Procedia Chemistry, Volume 9*, pp. pp 220-225, 2014.

Priyadarshi. (2020). Chitosan-based biodegradable functional films for food packaging, Innovative Food Science & Emerging Technologies, Volume 62, 102346, p.1-20.

Remmert. (2012). HHblits: lightning-fast iterative protein sequence searching by HMM-HMM alignment. *Nature Methods, 9*, 173-175.

SIST(EN)13726-1-2002. (n.d.). https://cdn.standards.iteh.ai/samples/9445/f3ea1058a29a440a99a50051409b979d/SIST-EN-13726-1-2002.pdf.

Soetemans. (2020). Characteristics of chitin extracted from black soldier fly in different life stages, International Journal of Biological Macromolecules 165 (2020) 3206–3214.

Srinivasan. (2023). Chapter 8 - Antibacterial efficacy of natural compounds chitin and chitosan: a mechanistic disclosure, Handbook of Natural Polymers, Volume 1: Sources, Synthesis, and Characterization, Pages 177-201.

Sumida. (2024). Improving Protein Expression, Stability, and Function with ProteinMPNN, J. Am. Chem. Soc. 2024, 146, 2054−2061.

Vo. (2021). Simple fabrication of a chitin wound healing membrane from Soft-Shell crab carapace, Materials Letters, Volume 297 129995.

Wang. (2010). *Cloning of a Heat-Stable Chitin Deacetylase Gene from Aspergillus nidulans and its Functional Expression in Escherichia coli.* Department of Life Science and Engineering, Harbin Institute of Technology, Harbin 150001, China: Appl Biochem Biotechnol 162:843–854.

Yamamoto. (2025). Hydrophobization of Chitin Nanofibers by Grafting of Partially 2-Deoxygenated Amyloses Through Enzymatic Approach, Molecules 2025, 30, 16, p.1-14.

Yanat. (2023). Advances in chitin-based nanoparticle use in biodegradable polymers: A review, Carbohydrate Polymers Volume 312 (120789) p.1-11.

Yin. (2023). *Expression and Molecular Modification of Chitin Deacetylase from Streptomyces bacillaris. Molecules, 28(1): 113, 1-16. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9822392/pdf/molecules-28-00113.pdf.*

2026 S.T. Yau High School Science Award 仅用于2026丘成桐中学科学奖公示

Yong. (2022). Chitosan isolated from black soldier flies Hermetia illucens: Structure and enzymatic hydrolysis, Process Biochemistry , Volume 118, July 2022, Pages 171-181.

Zhang. (2024). Recent advances of chitosan as a hemostatic material: Hemostatic mechanism, material design and prospective application, Carbohydrate Polymers, Volume 327, 121673.

Zhao. (2010). *Chitin Deacetylases: Properties and Applications. Mar Drugs. 2010 Jan; 8(1): 24–46.*

Zhu. (2019). Robust chitin films with good biocompatibility and breathable properties, Carbohydrate Polymers, Volume 212, 15 May 2019, Pages 361-367.

张天奇. (2017). *A kind of medical dressing and preparation method thereof. CN106729942A.*

赵荟菁, & 任翔翔. (2018). *A functional multilayer hemostatic antibacterial dressing. https://patentimages.storage.googleapis.com/c8/fd/f1/a2d06a2e6362a7/CN105999367B.pdf.*

耿雲花. (2016). *Surgical medical dressing and preparation method thereof. CN105999367A.*

GenAI

- **Appendix**

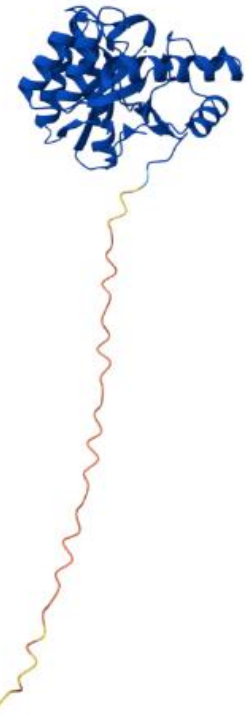
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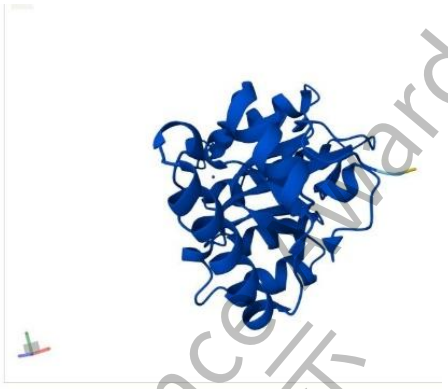
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python $proteinmpnn_path/helper_scripts/make_fixed_positions_dict.py --input_path=$path_for_parsed_chains --output_path=$path_for_fixed_positions --chain_list "$chains_to_design" --position_list "$fixed_positions"
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    --chain_id_jsonl $path_for_assigned_chains \
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    --fixed_positions_jsonl $path_for_fixed_positions \
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AI deacetylase designed



AI deacetylase designed without signal peptide

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