Development and Strength Characterization of Honey Coated Alchite Fibers for Bio Medical Applications

Muzammil Mehmood, Dr. Shahid Raza Malik, Dr. Rashid Masood

Abstract— Current research work aims at producing composite alchite fibers(core material made of alginate polymer + outer surface made of hydrolyzed chitosan) by wet spinning technique incorporating Pakistanis origin honey and then characterizing the strength of fibers in order to access their suitability to be used for the production of non-woven burn wound dressings. Nine control fibers were produced by varying the concentration of sodium alginate solution in the dope tank from 3.5 w/v % to 4.5 w/v % and that of hydrolysed chitosan solution from 1 w/v % to 2 w/v % in the coagulation bath. The developed fibers were then coated with small bee honey and 50% aloevera gel + 50% small bee honey by volume mixture to enhance antimicrobial and liquid absorption properties.The strength of uncoated fibers was found in the range 0f 40~50 cN.The strength of fibers showed slight decline after coating with small bee honey and 50% honey-aloevera mixture. Even after coating the fibers with honey and honey-aloevera mixture, the strength was found in the range of fourties which suggests its suitability to be used for the manufacturing of non woven dressings. The wound dressings made from these fibers would permit a trauma less replacement as they would keep the wound surface moist attributed to excellent gelling properties of the core material and would not leave debris upon removal attributed to high strength of fibers.

Index Terms— Alginate, Alchite, Biomedical, Burn wound dressings, Chitosan, Infection control

1 INTRODUCTION

In Pakistan, more than one million people annually suffer from burn injuries. According to WHO (World Health Organization), 35 % of burnt patients especially children in Pakistan get temporary or permanent disabilities. The major cause of this is the spreading of primary and secondary infection. Therefore, it is highly important to develop novel wound dressings to prevent microbial infections and to promote faster wound healing [1].

Traditional wound dressings are commonly made of cotton fibers in the form of gauze or woven cloth. Traditional wound dressings have a number of disadvantages like they are unable to prevent the microbial infection and lead to discomfort upon removal. They also render the wound dry as they have high water vapor transmission rate and leave debris onto the wound surface when removed which paves the way for infection [1].

Textile based novel wound dressings not only cover the wound but also protect the wound from microbial infections along with keeping the wound environment moist. These novel wound dressings are hemostatic, biocompatible, non-toxic and antimicrobial. These novel wound dressings include alginate dressings, chitosan dressings, hydrogels and capillary action dressings [2].

Alchite fibers developed in this research work are composite fibers with calcium alginate as core material and hydrolyzed chitosan as outer surface. The developed fiber is likely to show excellent strength alongwith high absorption properties due to the presence of alginate and honey [3].

In this perspective the developed Alchite fiber will be coated with honey to enhance its absorbency and its efficacy for the treatment of burn wounds [7]. After the accomplishment /approval of clinical trials, this study is likely to serve as a launching pad for the commercial production of "Burn Wound Dressings" in Pakistan.

2 MATERIALS AND METHODS

2.1 Materials

Sodium Alginate was imported from "Anhui Elite Industrial Co. Ltd China" with zero bacterial count and moisture content<15%. Chitosan was imported from "Fujain Huankang Biochemical Co. Ltd China" with a degree of deacetylation >60. Pakistanis origin natural honey was obtained from local market. Aloevera gel was extracted from freshly cut aloevera plant. Calcium chloride was obtained from "Mazhar International Pakistan"

2.2 Preparation of sodium alginate solution

3.5grams of Na-Alginate was dissolved in 96 grams of water to prepare 4 %(w/v) solution. The solution was stirred at 800 RPM for 4 hours using and electrically driven stirrer. The solu-

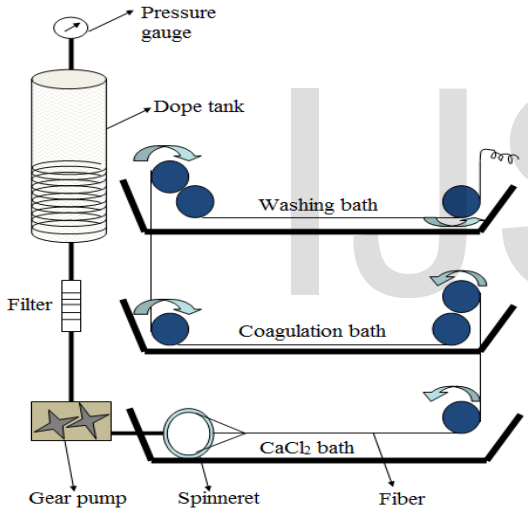
tion is left overnight in the dope tank for de-gasifying the solution. If the solution is not allowed to degasify, it causes extensive breakage during spinning. The same procedure was adopted for 4 %(w/v) solution & 4.5 %(w/v) solution. These solution concentrations were selected owing to their spinning suitability for the purpose [4].

2.3 Preparation of hydrolyzed chitosan solution

1gram of chitosan was dissolved in 1% acetic acid solution. The solution was stirred for 2 hours until a clear solution was formed. 3.5% HCl was added in the solution. Again the solution was stirred for 2 hours. The solution was heated for 4 hours in the reflux bottle. The solution was allowed to cool down overnight. Finally the solution was filtered before using in the coagulation bath to remove any undissolved chitosan. The same procedure was repeated for 1.5% and 2% solution. Current concentration limits were selected due to their wet spinning suitability [4].

2.4 Spinning the solution into fibers

The fibers were produced using wet spinning technique elaborated in the accompanying figure 1.



The sodium alginate solution was fed to the dope tank. This sodium alginate solution was spun into fibers of diameter 0.04 mm through the spinneret having 40 circular holes in it. Sodium alginate solution passed through the fabric filter and then through the spinneret due to the applied nitrogen gas pressure of 5 Psi. The fibers passed through the CaCl2 bath where the sodium ions were exchanged with Ca ions present in the calcium chloride bath [5]. This forms the fibers containing calcium alginate. These calcium alginate fibers then passed through the coagulation bath which contained hydrolyzed chitosan solution. Due to the interaction between the calcium alginate and hydrolyzed chitosan, a composite fiber was formed which was called alchite fiber [6].

The fibers then passed through the washing bath containing water in order to remove any unattached material to the fibers.

The fibers were then taken up onto the cone.

The same procedure was repeated with different concentrations of sodium alginate solution and different concentrations of hydrolyzed chitosan solution.

2.5 Drying and coating the spun fibers

The prepared fibers are dried in the acetone solution first and then for five minutes in the air at aluminum foil [9]. The fibers are completely dried out because excess moisture left over will result in the degradation of the fibers upon storage [10]. The fibers were then surface coated with small bee honey and with 50 volume % honey-alovera mixture.

2.6 Breaking strength of the spun fibers

The breaking force of fibers was calculated using single fiber tester. A 10 cm cut length is clamped between the load cell and the jaw. Tensile force applied to the fiber causes it to break. The results are shown on the monitor attached to the equipment.

2.7 Fiber samples prepared and their nomenclature

Sr #	Fiber code	Alginate solution (%w/v)	Hydrolyzed chitosan solution (%w/v)
1	F1	3.5	1.0
2	F2	4.0	1.0
3	F3	4.5	1.0
4	F4	3.5	1.5
5	F5	4.0	1.5
6	F6	4.5	1.5
7	F7	3.5	2.0
8	F8	4.0	2.0
9	F9	4.5	2.0

3 Results

3.1 Variation of breaking force with increase in coagulation bath concentration at 3.5 w/v% concentration in dope tank

As is evident from fig 2, breaking force of fibers increases from 41.3 cN to 47.7 cN as the concentration of hydrolyzed chitosan in the coagulation bath is increased from 1w/v% to 1.5w/v%. As the concentration of hydrolyzed chitosan in the coagulation bath is increased to 2w/v%, fiber strength is decreased to 45.5 cN.

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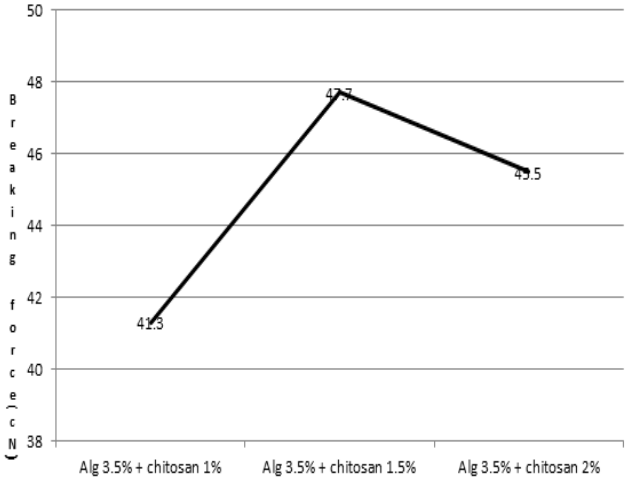
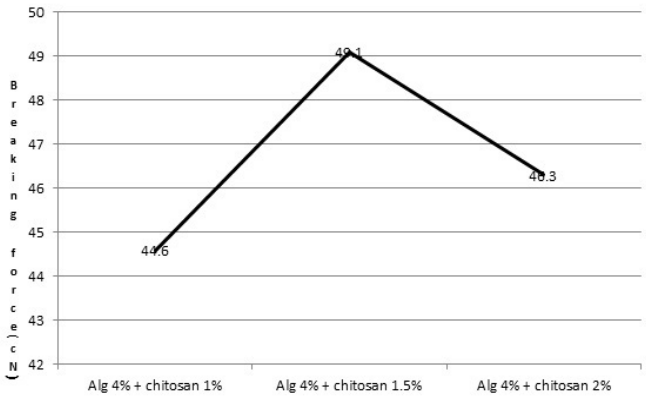


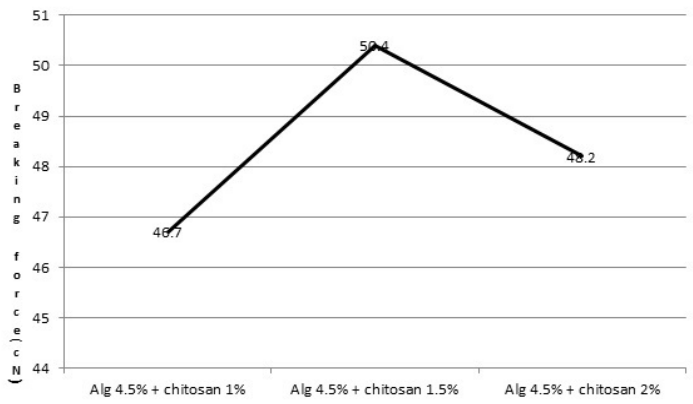
3.2 Variation of breaking force with increase in coagulation bath concentration at 4 w/v% concentration in dope tank

As is indicated from fig.3, the breaking force of fibers increases from 44.6 cN to 49.1 cN as the concentration of hydrolyzed chitosan in the coagulation bath is increased from 1w/v% to 1.5w/v%. As the concentration of hydrolyzed chitosan in the coagulation bath is increased to 2w/v%, the breaking force is reduced to 46.3 cN.

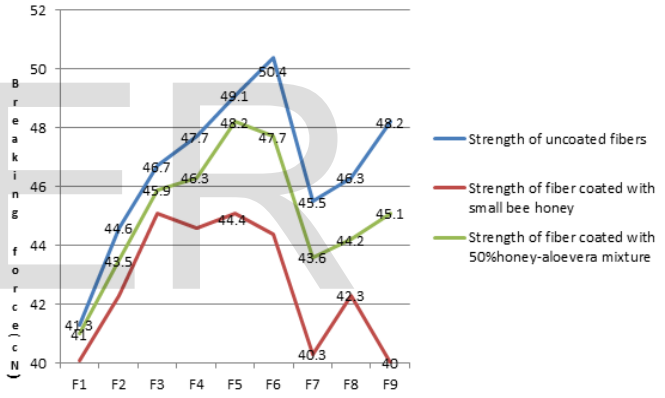


3.3 Variation of breaking force with increase in coagulation bath concentration at 4.5 w/v% concentration in dope tank

As is indicated from fig.4, the breaking force of fibers increases from 46.7 cN to 50.4 cN as the concentration of hydrolyzed chitosan in the coagulation bath is increased from 1w/v% to 1.5w/v%. As the concentration of hydrolyzed chitosan in the coagulation bath is increased to 2w/v%, the breaking force is reduced to 48.2 cN.



3.4 Effect of coating on breaking force of fibers



4 DISCUSSIONS

The increase in the strength of fibers with increase in the coagulation bath concentration upto 1.5 w/v% is attributed to the fact that the more chitosan interacts with the alginate polymer at this concentration [12]. Beyond this limit, the fiber strength shows a decline because of the poor interaction between the alginate and chitosan polymer [13].

Small bee honey when used as coating material showed greater decline in strength due to its osmolarity effect while the same effect was somewhat half in case of 50%honey-aloevera mixture due to reduced osmolarity effect and reduced brittleness effect [14].

5 CONCLUSIONS

Highest strength (50.4 cN) fibers are produced at 4.5% alginate + 1.5% hydrolyzed chitosan concentration designated as F6 which are highly suitable for the production of non woven dressings.

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The hydrolyzed chitosan concentration of 1.5 w/v% was found to be most suitable for thr production of high strength composite alchite fibers.

The 50% honey-aloevera mixture is found to be more suitable for coating for as it causes almost half decline in strength than pure small bee honey.

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REFERENCES

[1] Nikolay Vassilev, Maria Vassileva, IanaNikolaeva "Simultaneous P-solubilizing and biocontrol activity of microorganisms: potentials and future trends", Applied Microbiology and Biotechnology, Vol. 71, pp. 137-144, 2006.

[2] Tijana Ristić, Monika Novak1,Lidija Fras Zemljič. "Antimicrobial efficiency of functionalized cellulose fibres as potential." Formatex: 36-51, 2011.

[3] Majeti. N. V, Ravi Kumar. "A review of chitin and chitosan applications." Reactive and functional polymers 46: 1-27, 2010.

[4] R.Masood, "Production and comparative study of calcium Alginate and silver nano particle containing calcium alginate fibers and their active use as antimicrobials," M.Sc dissertation, University of Bolton, Bolton, June2005.

[5] S., Baranoski. "Wound dressing, a myriad of challenging decisions." Home Healthcare Nurse: 307-317, 2005.

[6] Brown, M.A.Daya, M.R.Worley, J.A. "Experience with chitosan dressing in a civilian EMS system." J.Emesg, Med: 30-37, 2009.

[7] B.Gupta, Roopali Agarwal. "Textile based smart wound dressings." Indian journal of fiber and textile research 35: 174-187, 2010.

[8] Chawla, A. K. Singla and M. "Chitosan: some pharmaceutical and biological aspects. Journal of pharmacy and pharmacology: 1047-1067, 2010.

[9] Clare, K. "industrial Gums: Polysaccharides and their derivatives.": 105-143, 1993.

[10] Englehart, M. S. Tieu, B.H et al. "A novel highly porous silica and chitosan based hemostatic dressing is superior than gauze." Polym Int: 884-890, 2008.

[11] Francesko, A, Tzana, T. "Chitin, chitosan and its derivatives for wound healing and tissue engineering." Adv Biochem Engg: 125-127, 2008.

[12] L.G, Ovington. "Wound dressing their evolution and use." cutaneous wound healing: 221-226, 2001.

[13] LIU, Wanshun. Achitosanbasedfiber material, preparing method and application thereof. European patent application: Patent WO 2008/138202, 24 February 2010.

[14] Minami, Saburo. , Jpn J Vet .Res Volume 44: 218-219, 1997.

[15] P.K. Dutaa, M.N.V. Ravi Kumar. "Waste utilization: chitosan fibres by direct dissolution." Indian Chemist Convention. New Delhi, 1997. 17-20.

[16] Wnek G.E., Bowling G.L. "Informal Health Care." Encylopedia of Biomaterials and Biomedical Engineering: 136-143, 2008.

[17] Y., Qin. "Advanced wound dressing." The Journal of Textile Institute volume 92: 136, 2001.

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