ISSN: 2278-7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 5, Issue 5, May 2016

Synthesis of Chitin from Crab Shells and its Utilization in Preparation of Nanostructured Film

S. L. Pandharipande[1] and Prakash H. Bhagat[2]
Associate Professor[1], B. Tech. 8th Semester[2]
Department of Chemical Engineering, Laxminarayan Institute of Technology,
Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur City, India

ABSTRACT- Chitin is the second most abundant polysaccharide and produced annually as much as cellulose. It is the main structural component of the exoskeletons of animals like insects and crustaceans. Crab, shrimp, squilla and fish scale waste is ideal raw material for chitin production. The extracted chitin can be used to produce chitin-derived products, such as chitosan also for bioplastic and nanostructured film production. The present work is aimed at extraction of chitin from crab shells. The methodology include acid hydrolysis, demineralization followed by deproteinization step. The chitin is synthesized and analysed by FTIR based on the interpretation of the spectrogram of the two sample of chitin synthesized in the present work, it can be said that all the functional groups expected are seen and the yield is obtained between 10.6-12.73%. The biocomposite of chitin along with chitosan has resulted in the formation ultrathin, labile, nanostructured film with good apparent texture. The advantages of such product could be its biodegradability, biocompatibility and effective use as biomedical interface.

Keywords: Biomaterial, Chitin, Crab shells, and Nanostructured film.

I. INTRODUCTION

Minimization of waste material and its reuse into valuable and biologically sustainable material is a challenge to researchers and scientist. Chitin is the second most abundant polysaccharide after cellulose. Chitin is a widespread polysaccharide in nature and produced annually as much as cellulose. It is the main structural component of the exoskeletons of animals like insects and crustaceans with an outer skeleton that include shrimp, crab, and lobster. More than 10^{11} tons per year of chitin is produced annually in aquatic biosphere. The use of this waste for renewable products such as chitin biopolymer and its derivatives is a dual purpose opportunity. Therefore, crab, shrimp, squilla and fish scale waste is idea raw material for synthesis of chitin. Extracted chitin from crab shells can be used to produce chitin-derived products, such as chitosan also for bioplastic and nanostructured film. The crab shells contains 25-30% chitin. 25% protein, 40-50% calcium carbonate. The disposal of this waste creates sever problem for human life so that the present work is aimed at investigating utilization of waste crab shells in synthesis of chitin.

II. LITERATURE REVIEW

The last decade has witnessed a lot of publications related to synthesis of chitin from crab shells. The present work is based on the literature review of research papers related to this topic and a brief summary of the papers referred is given below.

The paper titled “Conversion of crab shells to useful resources using sub-critical water treatment” highlights the use of temperature condition 533K-593K and reaction time 1-20 minute and synthesized high quality chitin [1]. The use of exoskeletons of shrimp and crab for extraction of chitosan and production of nanomembrane is also reported in the literature [2]. The paper titled “Extraction and characterization of chitin; a functional biopolymer obtained from scales of common carp fish” reports about proposed chitin synthesis process using fish scales as raw material [3]. A new approach for synthesis of chitin based on preparation, modification and application of chitin nanowhiskers has been reported in literature [4]. The paper titled “Isolation and FTIR spectroscopy characterization of chitin from local sources” and “Structural characteristics of chitin and chitosan isolated from the biomass of cultivated rotifer” give the FTIR analysis and its interpretation for chitin [5, 6]. Another paper; “Nanostructured

biocomposite film of high toughness based on native chitin nanofibres and chitosan" reports the synthesis of chitin and its utilization in nanostructured film [7].

III. PRESENT WORK

This work is preliminary study in synthesis of chitin biopolymer from waste crab shells. The objective of this work is to investigate the potential usage of crab shells that is being discarded as waste, for extraction of chitin to produce nanostructured film.

A. Materials and method

The raw materials used in present work include exoskeletons of crabs which were collected from the fish market Nagpur.

In chitin synthesis process acid hydrolysis method is used. In demineralization step hydrochloric acid is mixed with distilled water to prepare desired concentration of solution.

Sodium hydroxide is used in deproteinization step. Distilled water is used to wash sample after demineralization and deproteinization step. Hydrogen peroxide is used as a bleaching agent.

B. Methodology

Fig. 1 shows the details of process steps employed in extraction of chitin from crab shells and fig. 2 gives the photographic representation of process.

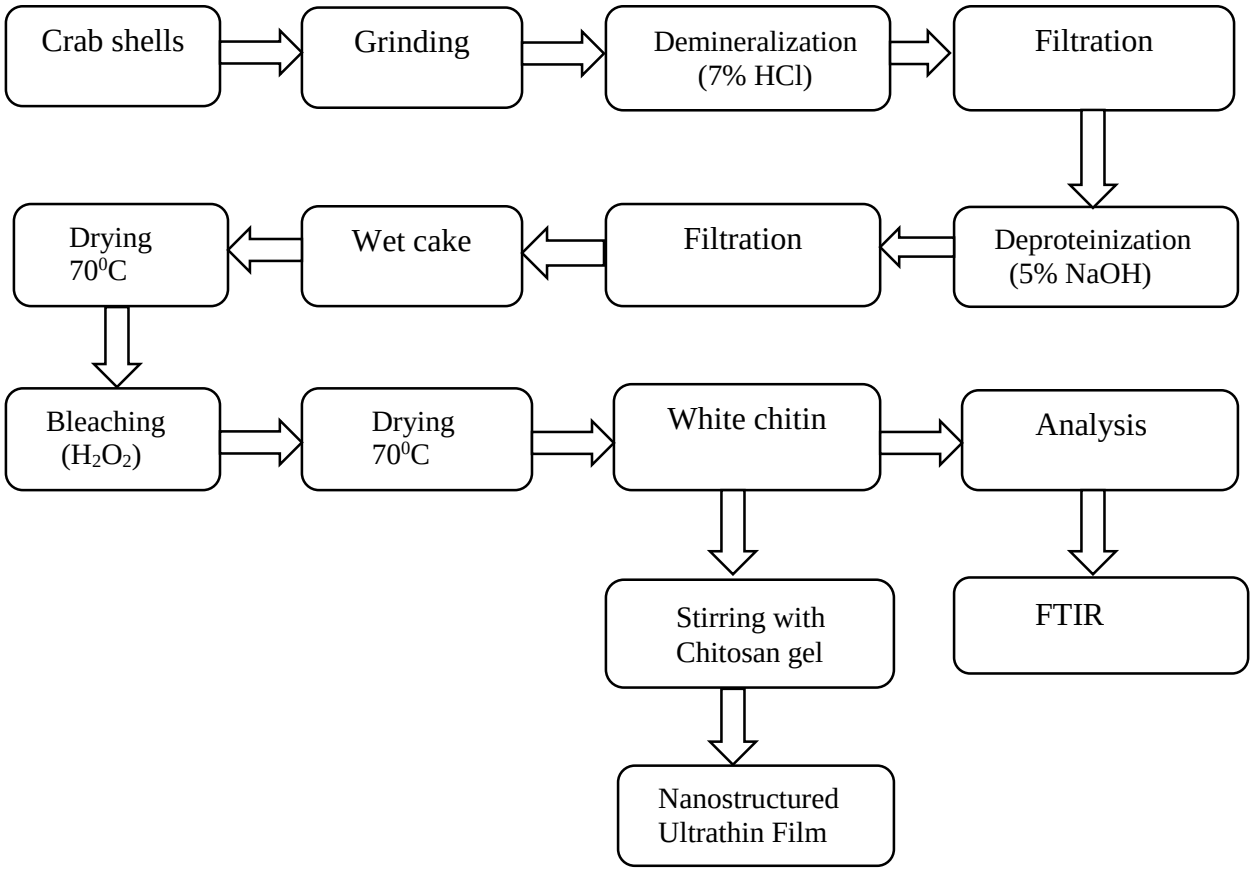

Fig. 1: Flow chart for extraction of chitin from crab shells.

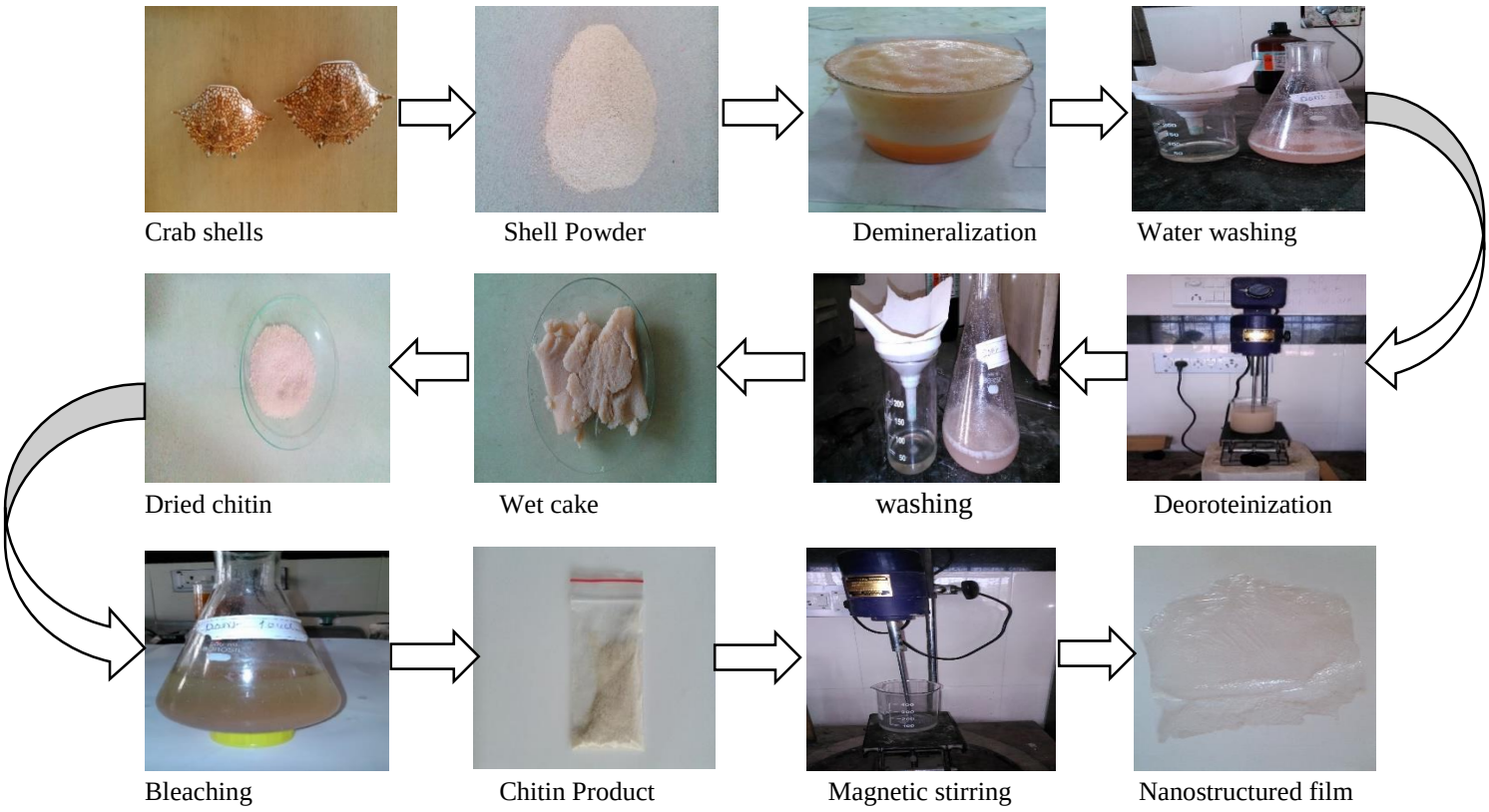

Fig. 2: Photographic representation of process.

C. Experimental procedure

The overview of experimental procedure followed is as given below,

- Crab shells were cleaned and washed thoroughly to remove any foreign materials, followed by grinding to get particle size 0.30-0.35 mm.
- In demineralization process, crab shell powder was added slowly to 7% Hydrochloric acid with continuous stirring to avoid effervescence and heated at 60^0C for 2-3 hours to remove carbonate and phosphate content from the crab shell powder.
- In deproteinization step, the acid hydrolyzed sample was treated with 5% w/v sodium hydroxide to reduce nitrogen content of protein, followed by washing to remove any traces of sodium hydroxide.
- The sample was filtered, washed repeatedly with distilled water to remove any traces of chemicals and soluble impurities.
- The filtered sample was then dried in an oven at 70^0C for 3 hours.
- The dried demineralized, deproteinized and deodorized white sample of chitin was obtained.
- In bleaching step, the dried sample washed with hydrogen peroxide to reduce pigment of chitin, followed by drying and storing under airtight condition.

D. Observations

Two trial runs have been conducted and details of the process parameters are given in table 1.

Table 1: Details of process parameters.

Sr. No	Parameter	Run-1	Run-2
1	Weight of shell powder	20 g	15 g
2	Particle size	0.3 mm	0.35 mm
3	Temperature	60^0C	60^0C
4	Concentration of demineralizer	7% HCl	7% HCl
5	Shell powder to acid ratio	1:20	3:70
6	Concentration of deproteinizer	5% NaOH	5% NaOH
7	H_2O_2 to water ratio (Bleaching)	---------	1:10
8	Product appearance	Slightly brown	White
9	Solubility in water	Insoluble	Insoluble

Table 2: Details of the chitin yield obtained.

Sample	S1	S2
Weight of shell powder	20 g	15 g
Shell powder to acid ratio	1:20	3:70
Product appearance	Slightly brown	White
Yield	2.12	1.91
%Yield	10.60	12.73

The present work has successfully extracted chitin from crab shells. The details of %yield obtained for two experimental runs is given in table 2.

E. Preparation of nanostructured film

Gel of 0.2 g of chitosan in 4% acetic acid is prepared. A colloidal suspension of approximately 0.07wt% solid content of chitin is dispersed in chitosan gel formed and whole mixture stirred for 7 hours.
Casting was done on a polyethylene film surface.
The resulting film of chitin and chitosan was dried at 40^0C temperature.

F. Analysis of chitin using FTIR

The samples were analysed by FTIR and the graph depicting wave number versus % transmittance is shown in fig. 3 and fig. 4.

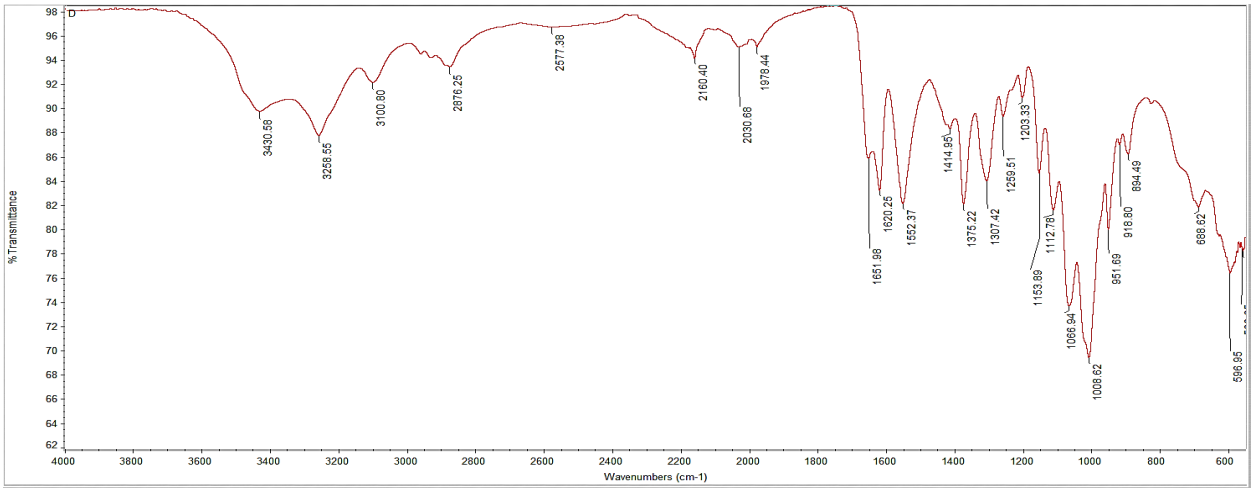

Fig. 3: FTIR spectrogram of the chitin sample 1.

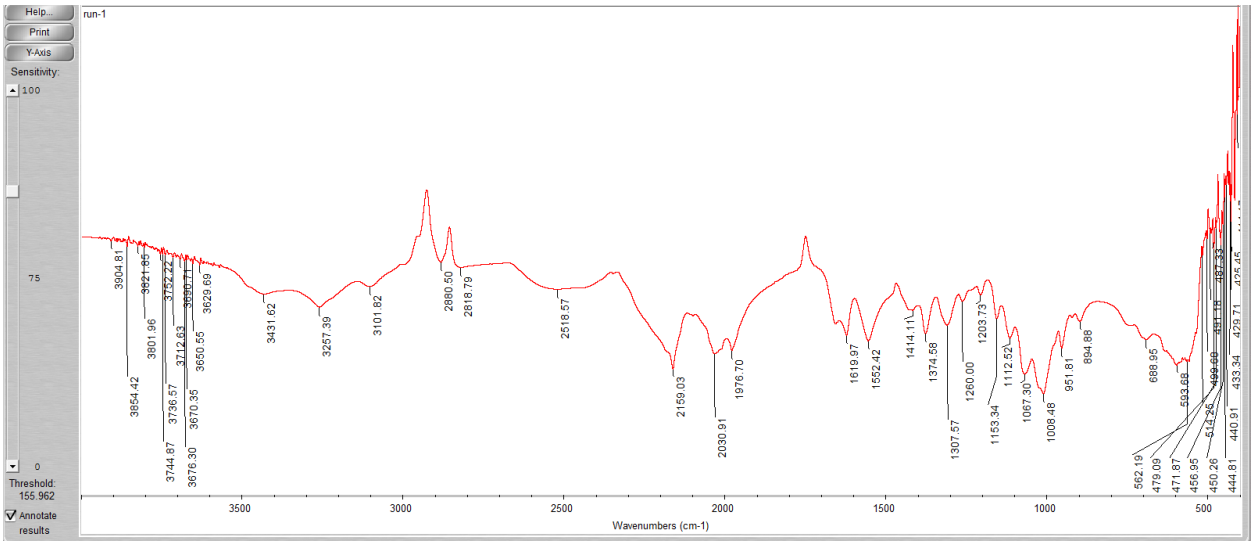

Fig. 4: FTIR spectrogram of the chitin sample 2.

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

IV. RESULT AND DISCUSSION

From interpretation of FTIR it can be said that all the functional groups which are added during synthesis have been identified in the form of peaks that include amide, carbonyl and hydroxyl groups. This indicates the successive formation of chitin biopolymer. During acid hydrolysis of chitin desired temperature is maintained to remove minerals such as calcium carbonate and proteins. It can also be interfered that as shell powder to acid ratio increases, yield and product appearance also increases. The yield of chitin extracted from crab shells is between 10.60-12.73% and is acceptable.

The nanostructured film formed using chitin is observed to be labile with good apparent texture and transparency.

V. CONCLUSION

The present work is aimed at the preliminary studies in extraction of chitin from crab shells using chemical method. Based on observation of the trial experimental runs, it can be concluded that the product obtained has

similar texture and colour as that of commercial grade chitin.

Based on visual observations and apparent physical properties, two samples have been selected for FTIR analysis, which indicated successful synthesis of chitin. Based on FTIR interpretation it can be concluded that present work has successfully synthesized chitin from waste raw material such as crab shells.

The visual observation of nanostructured film formed from chitin is also indicative of the possible utilization of chitin into the value added product. The advantages of this product are, it is biodegradable, bio compatible and can be effectively used as biomedical interface.

The extracted chitin from crab shells exhibits tremendous industrial, medical and pharmaceutical applications. However it is felt necessary to perform more number of experiments supported with appropriate analytical methods to substantiate the claim and optimize the process further.

ACKNOWLEDGEMENT

Authors are thankful to director of L.I.T. Nagpur for facilities & encouragement throughout work.

Authors are also thankful to VNIT, Nagpur for FTIR analysis support.

REFERENCES

[1] Hidemi Nakamura, Hiroki Oozono, Norihisa Nakai and Hiroyuki Yoshida
Proceeding on International Symposium 2015 on Ecotopia Science 11 may 27-29, 2015.

[2] Sania M. B. de Andrade Rasiah Ladchumananandasivam, Brismak G. da Rocha, Debora D. Belarmino, Alcione O. Galvao.
Material Science and Applications, 2012, 3, 495-508.

[3] S.G. Zaku, S.A. Emmanuel O. C. Aguzue and S. A. Thomas.
African Journal of Food Science Vol. 5(8), pp. 478-483 August 2011.

[4] M. Mincea, A. Negrulescu and V. Ostafe.
Rev. Adv. Mater. Sci. 30 (2012) 225-242.

[5] K. Prabhu and E. Natarajan.
Advance in Applied Science Research, 2012, 3 (2): 1870-1875.

[6] I. F. M. Rumengan, E. Suryanto, R. Modaso, S. Wullur, T. E. Tallei and D. Limbong.
International Journal of Fisheries and Aquatic Science 3(1): 12-18, 2014.

[7] Ngesa E. Mushi, Simon Utsel and Lars A. Berglund.
Frontiers in Chemistry, November 2014, Vol. 2, Article 99.

[8] Prakash H. Bhagat, B. Tech, LIT, Nagpur: "Synthesis of chitin from crab shells and its utilization in preparation of nanopaper membrane", project report 2015-2016.

AUTHORS

S. L. Pandharipande working as a associate professor in Chemical Engineering Department of Laxminarayan Institute of Technology, Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur. He did his masters in 1985 & joined LIT as a Lecturer. He has co-authored three books titled 'Process Calculations', 'Principles of Distillation' & 'Artificial Neural Network'. He has two copyrights 'elite-ANN' & 'elite-GA' to his credit as co-worker & has more than 60 papers published in journals of repute.

Prakash H. Bhagat currently pursuing the Bachelor of Technology in Chemical Engineering from Laxminarayan Institute of Technology, Nagpur, Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur.