



UNIVERSITI PUTRA MALAYSIA

**USE OF BACTERIAL CELLULOSE PRODUCED BY *Acetobacter xylinum*
AS BINDING AGENT IN FACIAL SCRUB FORMULATION**

NORHASLIZA BINTI HASAN

FK 2013 70



**USE OF BACTERIAL CELLULOSE PRODUCED BY *Acetobacter xylinum* AS
BINDING AGENT IN FACIAL SCRUB FORMULATION**

By

NORHASLIZA BINTI HASAN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirements for the Degree of Master of Science**

July 2013

COPYRIGHT

All material contained within the thesis, including without limitation text, logos, icons, photographs and all other artwork, is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia.

Copyright © Universiti Putra Malaysia



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirement for the degree of Master of Science

**USE OF BACTERIAL CELLULOSE PRODUCED BY *Acetobacter xylinum* AS
BINDING AGENT IN FACIAL SCRUB FORMULATION**

By

NORHASLIZA BINTI HASAN

July 2013

Chair: Dayang Radiah Binti Awang Biak, PhD

Faculty: Engineering

This study focuses on the production of bacterial cellulose (BC) and methylcellulose (MC) from *Acetobacter xylinum* and their applications as binding agent in facial scrubs formulation. The BC was prepared from the fermentation process using *A. xylinum*. MC was produced by chemically modified the BC. The facial scrubs formulation is consisted of BC or MC powder, glutinous rice powder, *Aloe vera* extract, ascorbic acid powder, olive oil, potato starch powder and deionized water. The characteristics of the binding agent, the rheology, shelf life and spreadability of the formulation were analysed. The BC powder has higher crystallinity index, larger pore size and smaller fibril size compared to MC powder. Meanwhile, MC powder has higher opacity value, but more brittle compared to BC powder. For this research, there were two types of formulated facial scrub prepared, namely water-based and oil-based facial scrub.

From the rheological characteristic, BC oil-based facial scrub was indicated to have less viscosity (18.54 Pa.s) at lower shear rate than BC water-based facial scrub (300.4 Pa.s) and MC oil-based facial scrub (38.84 Pa.s). All formulated and commercial facial scrubs shows flow behaviour index, $n < 1$, this means that the products exhibit shear thinning fluid as analysed using the Power law model. Furthermore, BC oil-based facial scrub gave higher value for work of shear (2.23 mJ), firmness (9448.7 g) and stickiness (-766.9 g), indicating that BC oil-based facial scrub is less spreadable than others but is more adhesive sample (2.30 mJ).

As a comparison with the commercial product, BC water-based facial scrub act as more spreadable product with *Simple* scrub, compared to BC oil-based that act as more adhesive product. MC oil-based facial scrub also showed the characteristic of adhesiveness but not as high as BC oil-based facial scrub. Eventhough BC water-based facial scrub showed very spreadable characteristic than others, it still has shorter shelf life and thus susceptible to microorganisms growth. Meanwhile, BC oil-based facial scrub has longer shelf life and is more adhesive indicating BC as a good potential for binding agent.

In conclusion, this study focused on facial scrub formulation using bacterial cellulose as binding agent. Comparison between BC and MC resulted in BC oil-based facial scrub formulation showed as a better binding agent due to the higher adhesiveness effect.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk Ijazah Master Sains

**PENGGUNAAN SELULOSA BAKTERIA YANG DIHASILKAN OLEH
Acetobacter xylinum SEBAGAI EJEN PENGIKAT DALAM FORMULASI
SKRUB MUKA**

Oleh

NORHASLIZA BINTI HASAN

Julai 2013

Pengerusi: Dayang Radiah Binti Awang Biak, PhD

Fakulti: Kejuruteraan

Kajian ini memberikan tumpuan kepada pengeluaran selulosa bakteria (BC) dan metilselulosa (MC) daripada *Acetobacter xylinum* dan aplikasinya sebagai ejen pengikat di dalam formulasi skrub muka. BC telah disediakan daripada proses penapaian menggunakan *A. xylinum*. MC telah dihasilkan daripada BC secara ubahsuai kimia. Formulasi skrub muka ini terdiri daripada serbuk BC dan MC, tepung beras pulut, ekstrak *Aloe vera*, serbuk asid askorbik, minyak zaitun, tepung kanji ubi kentang dan air ternyahion. Ciri-ciri ejen pengikat, reologi, jangka hayat dan kebolehsapuan telah dianalisis. Serbuk BC mempunyai indeks penghabluran yang lebih tinggi, saiz liang yang lebih besar dan saiz fibril yang lebih kecil berbanding serbuk MC. Sementara itu, serbuk MC mempunyai kelegapan yang tinggi, tetapi lebih rapuh berbanding serbuk BC. Bagi penyelidikan ini, terdapat dua

jenis scrub muka yang diformulasikan telah disediakan, iaitu scrub muka berasaskan air dan berasaskan minyak.

Dari ciri reologi, scrub muka BC berasaskan minyak telah menunjukkan untuk mempunyai kelikatan yang kurang (18.54 Pa.s) pada kadar ricih yang rendah daripada scrub muka BC berasaskan air (300.4 Pa.s) dan scrub muka MC berasaskan minyak (38.84 Pa.s). Kesemua scrub muka yang diformulasi dan yang dikomersilkan menunjukkan indeks tingkah laku aliran, $n < 1$, ini bermaksud produk-produk tersebut mempamerkan cecair penipisan ricih seperti yang dianalisis menggunakan model undang-undang kuasa. Tambahan pula, scrub muka BC memberikan nilai yang lebih tinggi untuk kerja-kerja ricih (2.23 mJ), ketegasan (9448.7 g) dan kelekitan (-766.9 g), menunjukkan bahawa scrub muka BC berasaskan minyak adalah kurang merebak daripada yang lain tetapi adalah sampel yang lebih melekat (2.30 mJ).

Sebagai perbandingan dengan produk komersil, scrub muka BC berasaskan air bertindak sebagai produk yang lebih merebak dengan scrub *Simple*, berbanding dengan BC berasaskan minyak yang lebih bertindak sebagai produk yang lebih melekat. Scrub muka MC berasaskan minyak juga menunjukkan ciri-ciri perlekatan tetapi tidak setinggi scrub muka BC berasaskan minyak. Walaupun scrub muka BC berasaskan air menunjukkan ciri-ciri yang sangat merebak daripada yang lain, ia masih mempunyai jangka hayat yang lebih pendek dan oleh itu mudah terdedah kepada pertumbuhan mikroorganisma. Sementara itu, scrub muka BC berasaskan

minyak mempunyai jangka hayat yang lebih panjang dan lebih melekat menunjukkan BC mempunyai potensi sebagai ejen pengikatan yang lebih baik.

Kesimpulannya, kajian ini memberikan tumpuan kepada formulasi scrub muka menggunakan selulosa bakteria sebagai ejen pengikat. Perbandingan di antara BC dan MC memberikan keputusan bahawa formulasi BC berasaskan minyak menunjukkan ejen pengikat yang lebih baik disebabkan oleh kesan perlekatan yang lebih tinggi.



ACKNOWLEDGEMENTS

“In the name of Allah S.W.T., the most Benevolent and Merciful”

First of all, I would like to express my sincere appreciation to the chairperson of my supervisory committee, Dr. Dayang Radiah Binti Awang Biak for all the guidance and support for helping me to complete this thesis. Her friendly, kindness, encouragement and patience gave me the confidence to overcome all the problems during finishing this work.

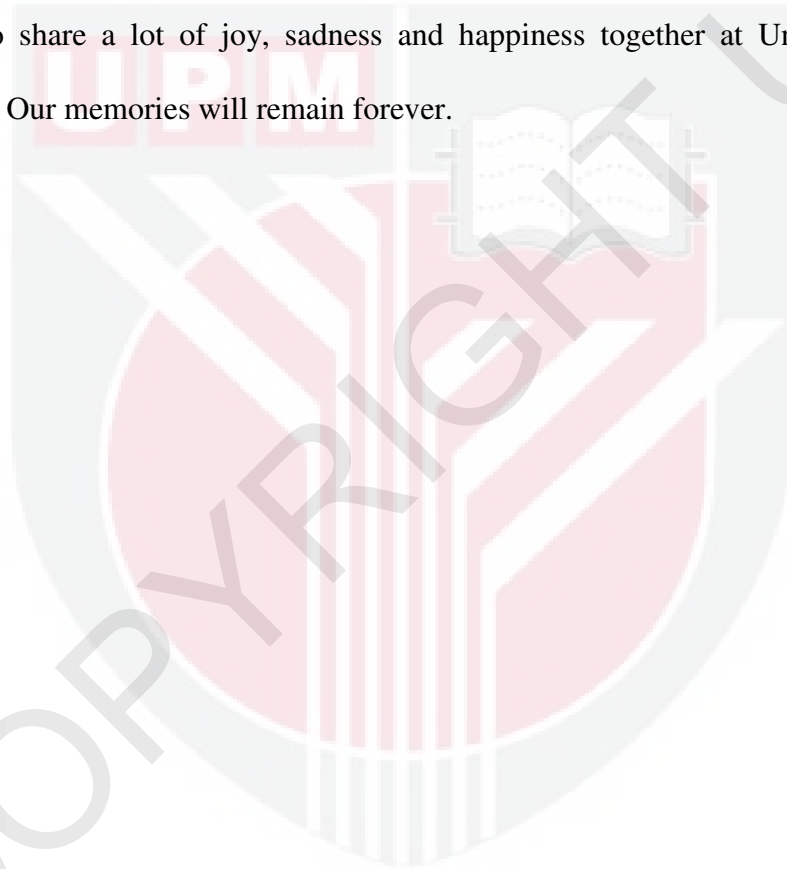
I also would like to thank the member of my supervisory committee, Assoc. Prof. Dr. Yus Aniza Binti Yusof. A lot of her ideas led me to finish my research together with her support and guidance. I am also would like to express my appreciation to Dr. Suryani Binti Kamarudin, the first person whom introduces me to “bacterial cellulose” area.

I am also very grateful to Universiti Putra Malaysia for giving me the opportunity to further my study here and providing me with a scholarship. I would like to thanks to all the staff especially from Chemical and Environmental Engineering Department, Faculty of Engineering for their help and contributions.

Million thanks to my beloved husband, Abu Bakr Mohd Hanim for his endless supports, his accompany and selfless love in these years. For my daughters, Aneesa Basheera, Adeena Bareera and Ateera Baheera, thank you for your love and the happiness that three of you bring to our family. I love all of you so much.

To my beloved mother, Che Moh Binti Deraman, thanks to you for giving birth to me and your endless support. Not forget to my late father, who is always in my memory even he could not see me graduate for this time. Special thanks to my mother in law, Noraidah Binti Abdul Rahman for helping me with my thesis and all my family members for their love, prayers and moral supports.

Last but not least, my deepest gratitude to all my friends, especially my labmates that willing to share a lot of joy, sadness and happiness together at Universiti Putra Malaysia. Our memories will remain forever.



I certify that a Thesis Examination Committee has met on July 2013 to conduct the final examination of Norhasliza Binti Hasan on her thesis entitled " Use of Bacterial Cellulose Produced by *Acetobacter xylinum* as Binding Agent in Facial Scrub Formulation" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Suraya Binti Abdul Rashid, PhD

Associate Professor Dr.
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Zurina Binti Zainal Abidin, PhD

Associate Professor Dr.
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Arbakariya Bin Ariff, PhD

Professor Dr.
Faculty of Biotechnology & Biomolecular Sciences
Universiti Putra Malaysia
(Internal Examiner)

Mohd Cairul Iqbal Bin Mohd Amin, PhD

Associate Professor Dr.
Faculty of Pharmacy
Universiti Kebangsaan Malaysia
(External Examiner)

NORITAH OMAR, PhD

Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 October 2013

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Dayang Radiah Binti Awang Biak, PhD

Senior Lecturer
Faculty of Engineering
University Putra Malaysia
(Chairman)

Yus Aniza Binti Yusof, PhD

Associate Professor
Faculty of Engineering
University Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD

Professor and Dean
School of Graduates Studies
Universiti Putra Malaysia

Date:

DECLARATION

I hereby conform that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of the thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____

Date: 9 July 2013

Name and Matric No: Norhasliza Binti Hasan (GS24357)

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____

Name of

Chairman of

Supervisory

Committee: Dr. Dayang Radiah Awang

Biak

Signature: _____

Name of

Member of

Supervisory

Committee: Assoc. Prof. Dr. Yus Aniza

Yusof

TABLE OF CONTENTS

	Page
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	viii
APPROVAL	x
DECLARATION	xii
LIST OF TABLES	xvii
LIST OF FIGURES	xviii
LIST OF ABBREVIATIONS	xxi
CHAPTER	
1 INTRODUCTION	1
2 LITERATURE REVIEW	8
2.0 Introduction	8
2.1 Market analysis	8
2.2 Natural cosmetics	11
2.3 Facial scrub	12
2.4 <i>Acetobacter xylinum</i>	14
2.5 Bacterial cellulose	15
2.5.1 Methylcellulose	17
2.6 Application of bacterial cellulose in cosmetic	19
2.7 Facial scrub formulation	21
2.7.1 Preservative	21
2.7.2 Moisturizer	22
2.7.3 Binding agent	24
2.7.4 Exfoliating agent	25
2.7.5 Emollient	26
2.7.6 Thickener	27
2.8 Characterization method	28

	2.8.1	Functional group analysis	28
	2.8.2	Morphology analysis	30
	2.8.3	Opacity analysis	31
	2.8.4	Crystallinity analysis	33
	2.8.5	Rheological studies	35
	2.8.6	Spreadability analysis	38
	2.9	Product benchmarking	39
	2.10	Summary	42
3		METHODOLOGY	43
	3.0	Introduction	43
	3.1	Materials	46
	3.2	Preparation for seed culture of <i>Acetobacter xylinum</i>	46
	3.3	Preparation of bacterial cellulose powder	48
	3.3.1	Preparation of pure bacterial cellulose (BC) powder	48
	3.3.2	Preparation of methylcellulose (MC) powder	48
	3.4	Characterization of BC and MC powder	49
	3.4.1	Functional group analysis	49
	3.4.2	Morphology analysis	50
	3.4.3	Opacity analysis	50
	3.4.4	Crystallinity analysis	51
	3.5	Facial scrub formulation	52
	3.5.1	Preparation and characterization of facial scrub	52
	3.5.2	Shelf life assessment of facial scrub	55
	3.5.3	Rheological studies	57
	3.5.4	Spreadability test	58
4		RESULTS AND DISCUSSION	60
	4.0	Introduction	60
	4.1	Characterization of BC and MC powder	60
	4.1.1	Functional group analysis	62
	4.1.2	Morphology analysis	65

4.1.3	Opacity analysis	68
4.1.4	Crystallinity analysis	70
4.2	Facial scrub formulation	74
4.2.1	Preparation and characterization of facial scrub	74
4.2.2	Shelf life assessment of facial scrub	76
4.2.3	Rheological characteristic of water-based and oil-based facial scrub	82
4.3	Rheological comparison of various facial scrub products	87
4.4	Spreadability test	92
4.5	Summary	98
5	CONCLUSION AND RECOMMENDATIONS	99
5.0	Conclusions	99
5.1	Recommendations for future research	100
	REFERENCES	102
	APPENDICES	145
	BIODATA OF STUDENT	136
	PUBLICATIONS	137