

ผลของตัวแปรในสูตรตำรับฟิล์มไคโตแซนต่อยาเม็ดโพรพราโนลอล ไฮโดรคลอไรด์

นายรัชชัย แพชมัด



วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาเภสัชศาสตรมหาบัณฑิต

ภาควิชาเภสัชอุตสาหกรรม

บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

พ.ศ. 2538

ISBN 974 - 631 - 443 - 2

ลิขสิทธิ์ของบัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย

**Effect of Variables in Chitosan Film Formulations on Propranolol
Hydrochloride Tablets**

Mr. Thawatchai Phaechamud

**A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of Master of Science in Pharmacy
Department of Manufacturing Pharmacy
Graduate School
Chulalongkorn University
1995
ISBN 974 - 631 - 443 - 2**

Thesis title Effect of Variables in Chitosan Film
 Formulations on Propranolol Hydrochloride
 Tablets
By Mr.Thawatchai Phaechamud
Department Manufacturing Pharmacy
Thesis Advisor Assoc. Prof. Garnpimol C.Ritthidej, Ph.D

.....

Accepted by the Graduate School, Chulalongkorn
University in Partial Fulfilment of the Requirements for the
Master's Degree.

Santi Thoongsuwan Dean of Graduate School
(Assoc. Prof. Santi Thoongsuwan, Ph.D.)

Thesis Committee

P. Kulvanich Chairman
(Assist. Prof. Poj Kulvanich, Ph.D.)

Garnpimol C. Ritthidej Thesis Advisor
(Assoc. Prof. Garnpimol C. Ritthidej, Ph.D.)

W. Thanindrarn Member
(Assist. Prof. Wichein Thanindrarn)

Parkpoom Tengaminuay Member
(Parkpoom Tengaminuay, Ph.D.)

พิมพ์ต้นฉบับบทคัดย่อวิทยานิพนธ์ภายในกรอบสี่เหลี่ยมนี้เพียงแผ่นเดียว

อรัชชัย แพชมัด : ผลของตัวแปรในสูตรตำรับฟิล์มไคโตแซนต่อยาเม็ดโพรพราโนลอลไฮโดรคลอไรด์ (EFFECT OF VARIABLES IN CHITOSAN FILM FORMULATIONS ON PROPRANOLOL HYDROCHLORIDE TABLETS) อ.ที่ปรึกษา : รศ.ดร.กาญจน์พิมล ฤทธิเดช, 265 หน้า. ISBN 974-631-443-2

ไคโตแซนน้ำหนักโมเลกุลแตกต่างกัน 3 ชนิด (L<M<H) นำมาละลายในสารละลายกรดอะซิติกความเข้มข้น 1% โดยน้ำหนักเพื่อเตรียมเป็นสารละลายสำหรับเคลือบที่ให้ความหนืดประมาณ 125 มิลลิ-ปาสคาลรีนาทิจ ซึ่งได้ความเข้มข้น 2.025% โดยน้ำหนักจากไคโตแซน L, 1.75% โดยน้ำหนักจากไคโตแซน M และ 0.825% โดยน้ำหนักจากไคโตแซน H พลาสติไซเซอร์ 3 ชนิดคือ โพรไพลีน ไกลคอล, โพลีเอทรีลีน ไกลคอล 400 และไตรอะซิทีน ในความเข้มข้น 10, 20 และ 30% โดยน้ำหนักของไคโตแซน ถูกเติมลงในสารละลายสำหรับเคลือบเหล่านี้ สามารถเคลือบยาเม็ดโพรพราโนลอลไฮโดร-คลอไรด์ด้วยวิธีพ่นเคลือบในหม้อเคลือบ ซึ่งยาเม็ดเคลือบที่ได้มีลักษณะผิวมันเงา สีค่อนข้างเหลือง การปลดปล่อยตัวยาจากยาเม็ดที่เคลือบด้วยสารละลายไคโตแซน H ที่ใส่พลาสติไซเซอร์ จะช้ากว่าที่เคลือบด้วยสารละลายสำหรับเคลือบไคโตแซน M และ ไคโตแซน L สำหรับยา เม็ดเคลือบที่ใช้โพรไพลีน ไกลคอลเป็นพลาสติไซเซอร์ ยาเม็ดที่ได้จากสารละลายผสมระหว่างสารละลายไคโตแซน L และ H ให้การปลดปล่อยตัวยาดำสุด ยกเว้นเมื่อใช้โพรไพลีน ไกลคอล 10% สำหรับยา เม็ดเคลือบจากสารละลายไคโตแซน L, M และ H การเพิ่มปริมาณโพรไพลีน ไกลคอล มีแนวโน้มการเพิ่มการปลดปล่อยตัวยา ในขณะที่การเพิ่มปริมาณโพลีเอทรีลีน ไกลคอล 400 และ ไตรอะซิทีนให้ผลตรงกันข้าม นอกจากนี้ยังมี การศึกษาการเปลี่ยนแปลงของน้ำหนัก, ความกร่อน, ความบวมพอง, ความแข็ง และเวลาในการแตกตัวของยาเม็ดเคลือบด้วย และคุณสมบัติของแผ่นฟิล์มทางกายภาพ, แผนภูมิจากวิธี IR spectrometry และ X-ray diffraction, การพองตัวของแผ่นฟิล์ม, การดูดซับความชื้นและคุณสมบัติทางเทนไซล์ นำมาใช้ศึกษาคุณสมบัติของฟิล์มจากไคโตแซน และนำมาสัมพันธ์กับคุณสมบัติของฟิล์มบนยาเม็ดเคลือบ ความไม่เข้ากันระหว่างไคโตแซนกับ โพลีเอทรีลีน ไกลคอล 400 และ ไคโตแซน กับ ไตรอะซิทีนสามารถพบทั้งในแผ่นฟิล์มและบนผิวของเม็ดยาเคลือบ แผนภูมิ IR บ่งว่ามีไคโตแซนอะซิเตดเกิดขึ้น หลังจากทำให้สารละลายสำหรับเคลือบแห้งและการที่ตัวยา มีการปลดปล่อยช้าลงหลังเก็บทิ้งไว้ที่อุณหภูมิห้อง และหลังสัมผัสสภาวะแรง น่าจะเกิดจากการไฮโดรไลซิสของไคโตแซนอะซิเตด

ภาควิชา.....เภสัชอุตสาหกรรม.....
.....เภสัชอุตสาหกรรม.....
ปีการศึกษา.....2537.....

ลายมือชื่อนิติ.....
ลายมือชื่ออาจารย์ที่ปรึกษา.....
ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

C675193 : MAJOR MANUFACTURING PHARMACY

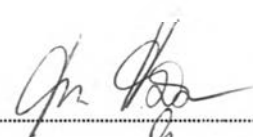
KEY WORD: CHITOSAN FILM/ MOLECULAR WEIGHT/ PLASTICIZER/ PROPRANOLOL HCl TABLET
THAWATCHAI PHAECHAMUD : EFFECT OF VARIABLES IN CHITOSAN FILM
FORMULATIONS ON PROPRANOLOL HYDROCHLORIDE TABLETS. THESIS ADVISOR :
ASSO. PROF. GARNPIMOL C. RITTHIDEJ, Ph.D., 265 pp. ISBN 974-631-
443-2

Chitosan of different molecular weight (L<M<H) in 1% w/w acetic acid solution giving apparent viscosity of 125 mPa.s at concentrations of 2.025, 1.75 and 0.825 respectively were used as coating solution. Propylene glycol, PEG400 and triacetin of 10, 20 and 30% w/w of chitosan were added as plasticizer. They could form glossy yellowish film coating upon propranolol HCl tablets with pan-spray method. The plasticized coated tablets with the higher M.W. of chitosan H exhibited slower drug release than those coated with plasticized the lower M.W. of chitosan M and L respectively. For plasticized coated tablets with propylene glycol, the coated tablets of plasticized combined chitosan L and H showed slowest drug release except plasticized coated tablets with propylene glycol 10%. For plasticized coated tablets with chitosan L, M and H, as the amount of propylene glycol increased, the drug release was faster, but the result was reversed in coated tablets with PEG400 and triacetin. The weight variation, friability, defects, hardness, disintegration time were also investigated. The physical appearance, IR spectra, X-ray diffraction, film swelling, moisture sorption and tensile properties of free films prepared from coating solutions were used to study the properties of chitosan free films and related to the properties of film on coated tablets. Incompatibility between chitosan and PEG400, and chitosan and triacetin were found in free films and on coated tablets. From IR spectra, they indicated that chitosan acetate might be formed after drying coating solutions. The dominantly slower drug release of coated tablets after kept at room temperature and exposure to accelerated condition might due to the hydrolysis of chitosan acetate.

ภาควิชา..... เภสัชอุตสาหกรรม

สาขาวิชา..... เภสัชอุตสาหกรรม

ปีการศึกษา..... 2537

ลายมือชื่อนิสิต..... 

ลายมือชื่ออาจารย์ที่ปรึกษา..... 

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....



Acknowledgements

I would like to express my sincere gratitude and appreciation to my advisor, Associate Professor Dr. Garnpimol C. Ritthidej for her invaluable advices, attention and encouragement throughout this study.

I am very grateful to Assistant Professor Dr Chamnan Patarapanich, Dr. Mitr Pathipvanich and Assistant Professor Dr. Usa Glagasigij, Department of Pharmaceutical Chemistry, Faculty of Pharmaceutical Science, Chulalongkorn University for the time they devoted to assist help the discussion and suggestion on this study.

I also wish to express my gratitude to all Graduate Committee for their helpful comments, and to Assistant Professor Dr. Poj Kulvanich, Head of the Department of Industrial Pharmacy, for his encouragement and providing me with the opportunity to study this program.

A special appreciation is extended to The Institute of Polymer Service, Faculty of Science, Mahidol University for their support in providing some laboratory facilities.

My grateful appreciation is also expressed to Mrs. Archara Sangariyavanich and Mr. Suriya Puncha, Physic Division, Office of Atomic Energy for Peace for their generous assistance in evaluation X-ray diffraction results.

I am indebted to the graduate school, Chulalongkorn University for granting partial support to fulfill this project.

Contents

	Page
Thai Abstract	IV
English Abstract	V
Acknowledgement	VI
List of Tables	VIII
List of Figures	XI
Chapter	
I. General Background	I
II. Experiment	41
III. Results	57
IV. Discussion and Conclusion	163
References	176
Appendices	195
Vitae	265

LIST OF TABLES

Table		Page
1	The advanges of the film coating compared to the sugar coating.....	3
2	Types of the equipment for tablet coating.....	5
3	The polymeric film evaluation.....	22
4	The coated tablet evaluation.....	23
5	Method of determination the molecular weight of chitosan.....	27
6	Method of determining the degree of deacetylation.....	29
7	Solubility of chitosan in various acids.....	30
8	The compositions of propranolol HCl core tablet.....	44
9	Some properties of chitosan L, M, and H.....	47
10	Formulation of film coating solutions.....	50
11	The relative viscosity of chitosan solutions.....	58
12	The apparent viscosity of chitosan solutions.....	59
13	The pH values of chitosan solutions.....	62
14	The data of weight and thickness increase, and tablet appearence and defects.....	65
15	The uniformity of content of core and coated tablets after exposure to accelerated condition.....	124
16	The color, transparency, bleeding and detachability of free films.....	126

Table	Page
17 The differences of absorption bands observed in IR spectra.....	135
18 Peak height ratios from the IR spectra.....	136
19 The summary of melting point peaks and weight loss of chitosan powders and free films.....	152
20 The moisture sorption of free films.....	154
21 The ultimate tensile strength and percentage of elongation of free film.....	162
22 Calibration data of propranolol HCl in dilute (1:100) solution at 289 nm.....	197
23 Calibration data of propranolol HCl in absolute methanol at 290 nm.....	198
24 The data of efflux time and density of deionized water and chitosan solutions.....	199
25 The weight variation of core and coated tablets(cont.).	205
26 The thickness of core and coated tablets.....	209
27 The percentage of friability of core and coated tablets.	213
28 The hardness of core and coated tablets.....	214
29 The disintegration time of core and coated tablets.....	217
30 Dissolution data of propranolol HCl from core and coated tablets.....	221
31 The data of film swelling in deionized water(swelling index (w)).....	229
32 The data of film swelling in dilute HCl solution(swelling index (w)).....	232

Table	Page
33 The data of film swelling in deionized water (swelling index(v)).....	235
34 The data of film swelling in dilute HCl(1:100) solution (swelling index(v)).....	247
35 The ultimate tensile strength and percentage of elongation of free films.....	259

LIST OF FIGURES

Figure	Page
1 Film cracking, edge splitting and bridging of the intagliation.....	11
2 The lubricity theory of plasticization. A. polymer-polymer bonds are preferred B. polymer-plasticizer bonds are preferred.....	16
3 Sources of free volume for plasticization.....	16
4 The stress strain curve of a polymer film.....	22
5 Structure formula of chitosan.....	25
6 The predicted structure of Cu- chitosan complex.....	31
7 The structure formula of propylene glycol.....	37
8 The structure formula of triacetin.....	38
9 The structure formula of propranolol HCl.....	39
10 The plots between $\ln \eta_{rel}/conc$ and conc of chitosan solutions.....	58
11 The plot between the apparent viscosity and concentration of chitosan solutions.....	60
12 The pH concentration profiles of chitosan solutions.	63
13 The percentage of friability of core and coated tablet (key:A-After coating, B-After kept at different condition).	68
14 The hardness of core and coated tablets(key:A-After coating, B-After kept at different condition).....	69
15 The disintegration time of core and coated tablets (key:A-After coating,B-After kept at different condition).	71

Figure	Page
16 The dissolution profiles of propranolol HCl from core, LO, M0, H0 and LH0.....	74
17 The dissolution profiles of propranolol HCl from coated tablets plasticized with propylene glycol (key:A-10%, B-20%, C-30%).....	75
18 The dissolution profiles of propranolol HCl from coated tablets plasticized with PEG 400(key:A-10%, B-20%, C-30%).....	76
19 The dissolution profiles of propranolol HCl from coated tablets plasticized with triacetin (key:A-10%, B-20%, C-30%).....	77
20 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan L(key:A-10%, B-20%, C-30%).....	80
21 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan M(key:A-10%, B-20%, C-30%)	81
22 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan H(key:A-10%, B-20%, C-30%).....	82
23 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan L (key:A-propylene glycol, B-PEG400, C-triacetin)..	85
24 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan M (key:A-propylene glycol, B-PEG400, C-triacetin).	86
25 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan H (key:A-propylene glycol, B-PEG400, C-triacetin)....	87

Figure	Page
26 The dissolution profiles of propranolol HCl from tablets coated with unplasticized and plasticized chitosan LH.	88
27 The dissolution profiles of propranolol HCl from INDERAL and core tablet after kept at different condition.....	88
28 The dissolution profiles of propranolol HCl from coated tablet after kept at different condition(key: A-L0, B-M0, C-H0).....	90
29 The dissolution profiles of propranolol HCl from coated tablet after kept at different condition(key:A-LH0, B-LA10).....	91
30 The dissolution profiles of propranolol HCl from coated tablet after kept at room temperature for 1 week.	92
31 The dissolution profiles of propranolol HCl from coated tablet after exposure to accelerated condition.....	92
32 The appearance of coated tablet(LHO)(key:A-low magnification, B-high magnification, C-in deionized water for 5 minutes).....	94
33(1) The appearance of coated tablet(LHO)(key:A-after kept at room temperature for 1 week, B-after exposure to accelerated condition, C-after exposure to accelerated condition and dissolution test).....	95
33(2) The appearance of coated tablets after exposure to accelerated condition and dissolution test(key:A-L0, B-M0, C-H0, D-LA10).....	95
34 The photomicrographs of core tablet(key:A-crown*75, B-crown*2000, C-edge*75).....	97
35 The photomicrographs of coated tablet(key:A-C(L0) (A-crown*75, B-crown*2000, C-edge*75), D-F(LA10) (D-crown*75, E-crown*2000, F-edge*75)).....	98

Figure	Page
36 The photomicrographs of coated tablet(key:A-C(LA20) (A-crown*75, B-crown*2000, C-edge*75), D-F(LA30) (D-crown*75, E-crown*2000, F-edge*75)).....	99
37 The photomicrographs of coated tablet(key:A-C(LB10) (A-crown*75, B-crown*2000, C-edge*75), D-F(LB20) (D-crown*75, E-crown*2000, F-edge*75)).....	100
38 The photomicrographs of coated tablet(key:A-C(LB30) (A-crown*75, B-crown*2000, C-edge*75), D-F(LC10) (D-crown*75, E-crown*2000, F-edge*75)).....	101
39 The photomicrographs of coated tablet(key:A-C(LC20) (A-crown*75, B-crown*2000, C-edge*75), D-F(LC30) (D-crown*75, E-crown*2000, F-edge*75)).....	102
40 The photomicrographs of coated tablet(key:A-C(M0) (A-crown*75, B-crown*2000, C-edge*75)), D-F(MA10) (D-crown*75, E-crown*2000, F-edge*75)).....	104
41 The photomicrographs of coated tablet(key:A-C(MA20) (A-crown*75, B-crown*2000, C-edge*75), D-F(MA30) (D-crown*75, E-crown*2000, F-edge*75)).....	105
42 The photomicrographs of coated tablet(key:A-C(MB10) (A-crown*75, B-crown*2000, C-edge*75), D-F(MB20) (D-crown*75, E-crown*2000, F-edge*75)).....	106
43 The photomicrographs of coated tablet(key:A-C(MB30) (A-crown*75, B-crown*2000, C-edge*75), D-F(MC10) (D-crown*75, E-crown*2000, F-edge*75)).....	107
44 The photomicrographs of coated tablet(key:A-C(MC20) (A-crown*75, B-crown*2000, C-edge*75), D-F(MC30) (D-crown*75, E-crown*2000, F-edge*75)).....	108
45 The photomicrographs of coated tablet(key:A-C(H0) (A-crown*75, B-crown*2000, C-edge*75), D-F(HA10) (D-crown*75, E-crown*2000, F-edge*75)).....	109

Figure	Page
46 The photomicrographs of coated tablet(key:A-C(HA20) (A-crown*75, B-crown*2000, C-edge*75), D-F(HA30) (D-crown*75, E-crown*2000, F-edge*75)).....	110
47 The photomicrographs of coated tablet(key:A-C(HB10) (A-crown*75, B-crown*2000, C-edge*75), D-F(HB20) (D-crown*75, E-crown*2000, F-edge*75)).....	111
48 The photomicrographs of coated tablet(key:A-C(HB30) (A-crown*75, B-crown*2000, C-edge*75), D-F(HC10) (D-crown*75, E-crown*2000, F-edge*75)).....	112
49 The photomicrographs of coated tablet(key:A-C(HC20) (A-crown*75, B-crown*2000, C-edge*75), D-F(HC30) (D-crown*75, E-crown*2000, F-edge*75)).....	113
50 The photomicrographs of coated tablet(key:A-C(LH0) (A-crown*75, B-crown*2000, C-edge*75), D-F(LHA10) (D-crown*75, E-crown*2000, F-edge*75)).....	114
51 The photomicrographs of coated tablet(key:A-C(LHA20) (A-crown*75, B-crown*2000, C-edge*75), D-F(LHA30) (D-crown*75, E-crown*2000, F-edge*75)).....	115
52 The photomicrographs of coated tablet(key:A-C(L0 S) (A-crown*75, B-crown*2000, C-edge*75), D-F(L0 S after dissolution test)(D-crown*75, E-crown*2000, F-edge*75)).....	118
53 The photomicrographs of coated tablet(key:A-C(LA10 S) (A-crown*75, B-crown*2000, C-edge*75), D-F(LA10 S after dissolution)(D-crown*75, E-crown*2000, F-edge*75)).....	119
54 The photomicrographs of coated tablet(key:A-C(M0 S) (A-crown*75, B-crown*2000, C-edge*75), D-F(M0 S afterdissolution)(D-crown*75, E-crown*2000, F-edge*75)).....	120

Figure	Page
55 The photomicrographs of coated tablet(key:A-C(H0 S) (A-crown*75, B-crown*2000, C-edge*75), D-F(H0 S after dissolution)(D-crown*75, E-crown*2000, F-edge*75)).....	121
56 The photomicrographs of coated tablet(key:A-C(LH0 S) (A-crown*75, B-crown*2000, C-edge*75), D-F(LH0 S after dissolution)(D-crown*75, E-crown*2000, F-edge*75)).....	122
57 The prepared free films(key:A-L0, B-M0, C-H0).....	127
58 IR spectra or chitosan powders(key:A-L(J), B-L, C-M, D-H).....	129
59 IR spectra(key:A-acetic acid, B-triacetin).....	130
60 IR spectra(key:A-propylene glycol, B-PEG400).....	131
61 IR spectra of free films(key:A-L0, B-LA20, C-LB20, D-LC20).....	132
62 IR spectra of free films(key:A-M0, B-MA20, C-MB20, D-MC20).....	133
63 IR spectra of free films(key:A-H0, B-HA20, C-HB20, D-HC20).....	134
64 X-ray diffractograms of chitosan powders(key:A-L, B-M, C-H).....	138
65 X-ray diffractograms of unplasticized free films (key:A-L0, B-M0, C-H0, D-LH0).....	139
66 X-ray diffractograms of chitosan L powder and unplasticized and plasticized free films with propylene glycol(key:A-L, B-L0,C- LA10, D-LA20, E-LA30)...	140

Figure	Page
67 X-ray diffractograms of chitosan L powder and unplastized and plasticized free films with PEG-400 (key:A-L, B-L0,C- LB10, D-LB20, E-LB30).....	141
68 X-ray diffractograms of chitosan L powder and unplastized and plasticized free films with triacetin (key:A-L, B-L0,C- LC10, D-LC20, E-LC30).....	142
69 X-ray diffractograms of chitosan M powder and unplastized and plasticized free films (key:A-M B-M0,C- MA20, D-MB20, E-MC20).....	143
70 X-ray diffractograms of chitosan H powder and unplastized and plasticized free films (key:A-H, B-H0,C- HA20, D-HB20, E-HC20).....	144
71 X-ray diffractograms of chitosan LH free films (key:A-LH, B-LHA20).....	145
72 DTA thermograms of chitosan L powder and free films (key:A-L, B-L0, C-LA20, D-LB20, E-LC20).....	149
73 DTA thermograms of chitosan M powder and free films (key:A-M, B-M0, C-MA20, D-MB20, E-MC20).....	150
74 DTA thermograms of chitosan H powder and free films (key:A-H, B-H0, C-HA20, D-HB20, E-HC20).....	151
75 The weight swelling index(w) of free films determined by measurement the weight difference(key:A-in deionized water, B-in dilute HCl(1:100) solution).....	156
76 The volume swelling index(v) of free films determined by measurement the volume difference(key:A-in deionized water, B-in dilute HCl(1:100) solution).....	158
77 The ultimate tensile strength of free films(key:A - LA, LB, LC, MA, MB, MC free films, B-HA, HB, HC, LHA free films).....	160

Figure		Page
78	The percentage of elongation of free films(key:A-LA, LB,LC, MA, MB, MC free films, B-HA, HB,HC,LHA free films).	161
79	The stress-strain curves of free films(key:A-L0, E-M0, C-H0).....	162
80	Calibration curve of propranolol hydrochloride in dilute HCl(1:100) solution at 289 nm.....	197
81	Calibration curve of propranolol hydrochloride in absolute methanol at 290 nm.....	198

LIST OF ABBREVIATIONS

μ	=	micrometer
$^{\circ}\text{C}$	=	degree centigrade
A	=	propylene glycol
avg	=	average
B	=	PEG400
C	=	triacetin
cm	=	centimeter
cps	=	centripoise
DTA	=	differential thermal analysis
Fig	=	figure
g	=	gram
H	=	chitosan H
IR	=	infrared spectra
Kg	=	kilogram
Kp	=	kilo pound
L	=	chitosan L
L(J)	=	chitosan L from Japan
L0	=	unplasticized free film of chitosan L
LA10	=	plasticized free film of chitosan L with propylene glycol 10% w/w
LH0	=	unplasticized free film of combined chitosan L and H
M	=	chitosan M
mg	=	milligram
min	=	minute
ml	=	mililitre
mm	=	millimeter
mPa.s	=	millipascal second
PEG	=	polyethylene glycol
R	=	after kept at room temperature for 1 week
r.p.m.	=	revolutions per minute condition
S	=	after exposure to accelerated condition
SD	=	standard deviation
SEM	=	scanning electron photomicrograph