EUROPEAN CHITIN SOCIETY

NEWSLETTER

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EDITORIAL

It is the intention of the Board that there will be two Newsletters a year at roughly late June and late December. However in order to publish at this frequency it is absolutely crucial that members contribute to the contents.

The Society has suffered a serious loss in the recent death of Professor Henryk Struszczyk. He was a founding member of the European Chitin Society and was very active in it. In addition he was the main driving force in the setting up of the Polish Chitin Society which is perhaps the most thriving national Society within the ECS. He will be sorely missed within both the Polish and the international world of chitin. Our sympathy is with his wife and family. This issue contains an obituary of Professor Struszczyk by his colleague Professor Henryk Pospieszny, Vice-President of the Polish Chitin Society.

The Society, and the world of chitin in general, have suffered several losses from among its more established members in recent years as is, unfortunately, only to be expected. It is therefore always encouraging to see new researchers appear on the scene and so it good to see the abstracts of two new PhD theses being submitted for inclusion in the Newsletter. I would encourage all supervisors to try to convince their research students of the benefits of doing so.

George Roberts
Honorary Secretary

Prof. Henryk Struszczyk, Ph.D., D.Sc.
1946 - 2005

Professor Henryk Struszczyk, one of the pioneers of chitin science in Poland, passed away on April 15, 2005. He was born at Zgierz, Poland on November 20, 1946.

Professor Struszczyk started his scientific carieer being awarded an M.Sc. degree from the Technical University of Lodz, at the Institute of Man-made Fibres, Poland in 1970. In 1974 he was awarded a Ph.D. degree in the field of chemistry at the Technical University of Lodz. In 1979-1980 he worked as a researcher in the College of Forestry, University of Washigton, Seattle, WA, USA. In 1986-1987 he was a Visiting Researcher at the Finnish Research Center at Tampere, Finland. He was awarded his D.Sc. degree, habilitation, in 1988 at the Technical University in Szczecin, Poland and then as a Visiting Professor cooperated again with the Textile Department of Tampere University of Technology in Finland. He was also an Assistant Professor of the Institute of Chemical Fibres in Lodz, Poland from 1990 to 1993 and then an Associated Professor until 1998 when he was awarded with the title of Full Professor by the President of the Republic of Poland. From 1998 until his death Professor Struszczyk had the position of Professor in the Institute of Chemical Fibres in Lodz, Poland, being its Managing Director, and also Professor of the Textile Engeneering and Ecological Protection Faculty, Technical Academy at Bielsko-Biala, Poland.

From 1993 he was President of the Polish Chitin Society and from 1992 a member of the European Chitin Society of which he was a Vice President in 1999-2001and a member of the Society Board in 1992-2000. Professor Struszczyk was also a member of the Board of Engineering of the Academy of Poland in 1998-2000, a member of the Board of Lodz Division of the Polish Academy of Sciences, Vice President of Textile Section of the Polish Academy of Sciences from 1994, a member of the Polymer Commission of the Polish Academy of Sciences, a member of the Scientific Board and Kuratorium of Thüringischer Institute für Textil und Kunstoff – Forschung, Rudolstadt, Germany from 1993, a member of the American Chemical Society from 1992 and a member of the Polish Chemical Society. In 2004 he was a chairman of 6th Intrnational Conference of the European Chitin Society held in Poznan, Poland.

Professor Struszczyk was an outstanding scientist and specialist in, among others, biopolymer chemistry, modification and application of chitin and chitosan in medicine, agriculture, biotechnology, etc.

During his career Professor Struszczyk received many awards including:
Award of the Chancellor of the Technical University of Lodz, Poland
Gold Cross, Poland, for invention activity
Award of Ministry of Education
11 Gold and Silver Medals for Inventions, World Exhibitions on Inventions, "EUREKA", Brussels, Belgium
Chivalrous Cross of Belgium Kingdom for invention activity
Chivalrous Cross of Polonia Restituta for scientific activity

Professor Struszczyk was a co-author of over 220 publications and supervised the research of 5 PhD candidates.

He is survived by his wife Jadwiga, two children, Katarzyna and Marcin with his wife Joanna and granddaughter Kaja to whom we offer our sincere sympathy for their loss.

We have lost a great scientist, talented organizer, teacher, lecturer, colleague and friend.

Professor Henryk Pospieszny
Vice-President
The Polish Chitin Society

EUROPEAN CHITIN SOCIETY CONFERENCES

The 1st European Chitin Society Conference was held in 1995 [EUCHIS '95]. This was followed by three more EUCHIS conferences held at 2-yearly intervals. Since these conferences were held on 'odd' years they fitted in between the Asia-Pacific and the Ibero-American chitin conferences, both of which run on a two-year cycle on 'even' years. However the 5th EUCHIS conference, originally scheduled for 2003, was in fact held in 2002 in order to avoid a clash with the Montreal ICCC meeting that was also scheduled for 2003. Following this we have continued on a 2-year cycle but now on the 'even' years. This means that we coincide in timing with both the Asia-Pacific and the Ibero-American chitin conferences, leading to conference fatigue and financial stress every two years, interspersed with lean years. Thus there were three regular chitin/chitosan conferences in 2004, there are none scheduled for 2005, three again in 2006, one of which is the joint ICCC/EUCHIS meeting in Montpellier, and presumable none in 2007.

I think that the Society should return to holding the EUCHIS conferences on the 'odd' years, the question being how this is to be achieved. Currently the next two meetings are scheduled for France (EUCHIS '06) and Turkey (EUCHIS '08) and there are a number of possibilities.

1. Following the meeting in 2008 there could be a 1-year gap so that the 9th European Chitin Society Conference is held in 2009.
2. Following the meeting in 2008 there could be a 3-year gap so that the 9th European Chitin Society Conference is held in 2011.
3. With the agreement of the Turkish Organising Committee, the conference currently scheduled to be held in 2008 could be moved forward to 2007.
4. With the agreement of the Turkish Organising Committee, the conference currently scheduled to be held in 2008 could be moved back to 2009.
5. An alternative arrangement would be to change to a 3-year cycle following the 2008 EUCHIS meeting in Turkey.

Each of these possible courses of action has its advantages and disadvantages since it is necessary to have either two conferences in successive years or to have a three year gap in the sequence. However I think that it is necessary to chose one of these options; to continue on the present timing of conferences is not an option. While it is not possible to avoid an occasional clash with the ICCC meetings if they run on a 3-year cycle and the regional meetings run on a 2-year cycle, it should be possible to arrange that the ICCC meeting is always a joint meeting with the regional meeting of the host country.

Another important point is that on the current scheduling there will be ICCC conferences in 2006, 2009 and 2012 and EUCHIS conferences (and Asia-Pacific and Ibero-American conferences) in 2006, 2008, 2010 and 2012. There would be none scheduled for 2011 which is the 200th anniversary of the isolation of chitin by Braconnot. Such an anniversary should not go unrecognised.

Finally, while it is ultimately the responsibility if the Board of the European Chitin Society to decide on when and where the Society's conferences take place, it would be of help to the Board in making their decision to know the thoughts of the members as to which option they think preferable, or if they have other suggestions, or indeed if they are happy with the *status quo*.

George Roberts

Thesis Abstracts

1. Alexandra MONTEMBAULT

Name of Birth: CLAYER

PhD. Thesis: Elaboration of chitosan physical hydrogels: application to tissue engineering for cartilage regeneration

Laboratory of Polymer Materials and Biomaterials, University of Lyon 1, France

Defense on December 6, 2004

Supervisor: Prof. Alain DOMARD
Co-trainer of thesis: Dr. Christophe VITON

First Part: Physical gelation of chitosan

1. PHYSICO-CHEMICAL STUDIES OF THE GELATION OF CHITOSAN IN A HYDROALCOHOLIC MEDIUM [(2)]

The formation of chitosan physical hydrogels without any external cross-linking agent was studied. This gelation took place in an acetic acid-water-propanediol solution. Thus, chitosan was dissolved in an acetic acid aqueous solution. Acetic acid was added to achieve the stoechiometric protonation of the $-NH_2$ sites. After complete dissolution, 1,2-propanediol was added. The mixture was stirred and let to evaporate up to gelation. The role of the alcohol was to reduce the dielectric constant of the medium and possibly to participate in the formation of hydrophobic junctions between polymer chain segments. In these conditions, the acetate salt of chitosan was less formed. Since acetic acid is not highly soluble in such a solvent, evaporation contributed to eliminate both water and acetic acid. The consequence was a decrease of the apparent charge density of chitosan chains up to a critical value of gelation. At the end, the hydrogel was neutralised and washed thoroughly with water to eliminate acetic acid and 1,2-propanediol. The final gel only contained water and chitosan.

Static light scattering was used to detect the gel point and then, to study the gelation for different initial conditions. Thus, we investigated the influence of the degree of acetylation, the gelation temperature and the nature of the initial solvent. The variation of the solvent composition during gelation was determined from a simple weighing, and the ionisation state of the polymer at the gel point, by pH titrations.

We showed that it was possible to form a chitosan physical-hydrogel, whatever the degree of acetylation. Provided the initial polymer concentration was over the critical concentration of chain entanglement C*, each set of experiment contributed to show that, on a pure thermodynamic point of view, the critical value of the balance between hydrophobic and hydrophilic interactions played the major role.

Acetyl groups played an important role in the formation of hydrophobic interactions, mainly responsible for gelation. Interactions between acetyl groups and alcohol molecules probably occurred, and the presence of 1,2-propanediol prevented the polymer chains from strong hydrogen bonding and thus, from precipitation.

Finally, three parameters had an important role on this mechanism of gelation.

A first concerned the apparent charge density of the polymer that was modified by: the degree of neutralisation, the dielectric constant of the solvent, which depended on both the ratio between water and alcohol in the solvent and the degree of acetylation.

The hydrophobic character of both the solvent and the polymer structure is a second very important parameter related to the same parameters as above and also of temperature.

The third key parameter was the molecular mobility, depending on possible changes of conformation with the above mentioned parameters, the steric hindrance brought about by the NAG residues and the viscosity of the media with possible intra- and inter-molecular interactions depending on the whole studied parameters.

2. RHEOMETRIC STUDY OF THE GELATION OF CHITOSAN IN A HYDROALCOHOLIC MEDIUM [3]

The extensive kinetics study of the formation of chitosan gels from acetic acid/water/propanediol solutions allowed us to obtain some interesting new results.
Rheological experiments confirmed and completed the results of our previous work. The time to reach the gel point was determined by rheometry and gelations from different initial conditions could be compared. The influence of different parameters on gelation such as the polymer concentration, the degree of acetylation (DA) of chitosan and the composition of the initial solvent were investigated.
Initially, for a given condition with a DA of 40.4%, a temperature of 22°C and an initial proportion water/alcohol of 50/50, when the polymer concentration is above the critical concentration of chain entanglement C* (0.1%) and below 1.5%, the number of chain entanglements is generally insufficient as well as the number of physical junctions of hydrophobic nature. It is then necessary to increase this number to induce gelation. Thus, when the initial concentration becomes over 1.5%, we essentially observe the kinetics of the replacement of entanglements by stable physical junctions and much less the increase of their number. For these initial conditions, we could predict a C** close to 1.5% as a second critical concentration.

This kinetics was also influenced by the DA or the initial proportion water/alcohol. The role of acetyl groups was again underlined. They play an important role in the formation of hydrophobic interactions, mainly responsible for gelation. The study of the influence of the gelation media revealed two critical points at 40 and 70% of water in the initial solvent, probably due to conformational changes and then to different modes of gelation.
These physical hydrogels being used for cartilage regeneration, their final rheological properties were studied as a function of their degree of acetylation, the polymer concentration and the solvent composition in the initial solvent. Our results allowed us to define an optimal gelation condition for our application, corresponding to: DA=40%, a proportion water/alcohol of 50/50 and a polymer concentration of 1.5%.

3. RHEOMETRIC STUDY OF THE GELATION OF CHITOSAN IN AQUEOUS SOLUTION WITHOUT CROSS-LINKING AGENT [4]

New physical hydro-gels were formed without any organic solvent, directly formed from an aqueous chitosan solution. Three conditions had to be observed to induce chitosan gelation.

First, the initial polymer concentration had to be over C*. Indeed, in these conditions, the chain entanglements could be used to give rise to physical junctions responsible for the formation of precursors of a three-dimensional network of polymer chains. Then, the balance between hydrophilic and hydrophobic interactions had to reach a critical value to allow the gelation. This value could be achieved thanks to a decrease of the polymer ionization and thus a decrease of its apparent charge density. Moreover, this perturbation had to occur simultaneously within a layer constituting the sol/gel transition interface.
The three conditions necessary to observe a percolating gelation were put together when a solution of chitosan was subjected to gaseous ammonia. Indeed, in these conditions, a gelation could occur, corresponding to the progressive displacement of an inter-phase of a sol/gel transition from the surface of the sample to the bottom of the reactor. At the end, the hydrogel was washed thoroughly with water in order to eliminate ammonium acetate and the excess of ammonia. Thus, the final gel only contained water and chitosan.

The time to reach the gel point was determined by rheometry and gelations according to different initial conditions were compared. Thus, we investigated the influence of the polymer concentration and the degree of acetylation (DA) of chitosan on gelation.

The time to reach the gel point decreased with both higher DAs and concentrations. The role of acetyl groups in physical gelation of chitosan was again underlined. For a chitosan of DA=36.7%, a second critical initial concentration close to 1.8% (w/w) was observed. Above this concentration, the decrease of the time to reach the gel point was higher and less additional junctions had to be formed to induce gelation, suggesting probably, the presence of gel precursors due to a reorganization of the solutions to lower the energy, inducing a faster construction of a physical network. Therefore, it would be interesting to consider a second critical concentration C** corresponding to the presence of nano-objects in the initial solution which size increases with time up to their collapse.

To optimise these physical hydrogels, to be used for cartilage regeneration, their final rheological properties were studied as a function of their degree of acetylation and their polymer concentration. A DA near 40% seemed to be optimal if we considered the value of G_e, since gels made from a chitosan of higher DA could encounter problems of re-dissolution at pH of a biological medium. Consequently, the following characteristics for the final gel were chosen: a DA near 40% and a final polymer concentration close to 1.5% (w/w).

Second Part: Application to tissue engineering: "A chitosan physical hydrogel as a decoy for cartilage tissue engineering"

The cartilage tissue has a limited self-regenerative capacity. Tissue-engineering for the cartilage regeneration is an approach gaining wide attention. We developed a bioresorbable formulation by combining a chitosan physical hydrogel and isolated differentiated chondrocytes for the regeneration of the cartilage tissue.

Our chitosan physical hydrogels appeared as particularly interesting since they could constitute decoys of biological media, both by their physical form - the cartilage tissue is constituted of a complex physical hydrogel - and also by their chemical structure. Chitosan is completely absent in mammals. Nethertheless, the N-acetyl-D-glucosamine residue and the $\beta,(1 \rightarrow 4)$ glycosidic linkage are largely present in glycosaminoglycan and glycoconjugate structures of extra-cellular matrixes. In contrast, the D-glucosamine residue is always absent. Chitosan is then partially recognized by living media, the polymer is thus not responsible for important rejection phenomena when it is exposed to living media. Thus the conjunction of both known and ignored chemical structures in decoys of biological media could be at the origin in some cases, as here, of very interesting responses.
Hydrogels were put in contact with rabbit chondrocytes. The optimal biological response was obtained with hydrogel fragments concentrated at 1.5% (w/w) of polymer made from a chitosan with a degree of acetylation near 30-40%. The cells maintained their phenotype and were surrounded by functional cartilage-type matrix proteins: type II collagen, aggrecan and proteoglycans of high molecular weight. The presence of our decoy material induced the binding of the cells to hydrogel fragments favouring then the accumulation of extra-cellular matrix. Progressively, the hydrogel induced the production of proteoglycan-like material, in particular proteoglycans of high molecular weight, by all the cells of the micromass.

In vitro experiments were then done with human chondrocytes with the optimal formulation. These experiments gave promising results: after 22 days in culture, the human chondrocytes kept their phenotype and synthesized a mainly proteic matrix.

Finally, the biological response could be described as the concept of reverse encapsulation, in contradiction with the theory of the scaffold. The polymer fragments were encapsulated by the living medium. Our decoy material could participate actively in *in vitro* tissue regeneration with no need of entrapment of cells inside a network of polymer chains.

LIST OF PUBLICATIONS

(1) Atypical polysaccharide physical gels: structure/properties relationships; A. Clayer, L. Vachoud, C. Viton, A. Domard, *Macromolecular Symposia,* 2003, 200 (Functional Networks and Gels), 1-8.

(2) Physico-chemical studies of the gelation of chitosan in a hydroalcoholic medium; A. Montembault, C. Viton, A. Domard, *Biomaterials*, 2005 ; 26 : 933-943.

(3) Rheometric study of the gelation of chitosan in a hydroalcoholic medium; A. Montembault, C. Viton, A. Domard, *Biomaterials*, 2005 ; 26 : 1633-1643.

(4) Rheometric study of the gelation of chitosan in aqueous solution without cross linking agent; A. Montembault, C. Viton, A. Domard, *Biomacromolecules*, accepted.

2. Ubhayasekera, W., 2005, *Structural Studies of Cellulose and Chitin Active Enzymes*. Doctoral dissertation
ISSN: 1652-6880, ISBN: 91-576-7017-X
Serial publication number: 2005:18

Cellulose and chitin, the main ways of storing biological energy in nature, also play a vital role in the structures of many organisms. Cellulose is the main structural component in plants whereas chitin is found in invertebrates and fungi. Gaining a better understanding of the degradation of these polymers can have direct or indirect economic impact. This thesis summarizes the structural perspectives of the cellulose and chitin degradation machinery.

The white-rot fungus *Phanerochaete chrysosporium* has six cellobiohydrolases, which are expressed differentially with varying stimuli and time intervals. X-ray crystal structures of one of the six isozymes (Pc_Cel7D) suggested that it uses a retention mechanism and acts from the reducing end of cellulose chain. Homology modeling of the other enzymes supported the same sort of mechanism for all except one (Pc_Cel7B) and considerably different dynamic properties for two isozymes (Pc_Cel7A and Pc_Cel7B).

Piromyces sp. strain E2 Cel9A and Cel6A as well as *Piromyces equi* Cel6A are modular structures, which function as parts of the fungal cellulosome of the respective organisms. Homology modeling supported the conclusion that Cel9A is an endoglucanase having a wide active site cleft and a conserved calcium-binding site with an inverting catalytic mechanism, whereas the Cel6As are processive cellobiohydrolases that act via an inverting mechanism that releases cellobiose from the non-reducing end of the cellulose chain.

Brassica juncea endo acting chitinase is a pathogenesis-related protein that acts in defense of the plant. A homology model of the catalytic module was useful in designing mutants that helped us to understand the substrate binding and catalytic processes. X-ray crystal structures of the catalytic module and a mutant extended the knowledge of how the enzyme acts during the catalysis, with conformational changes opening and closing the enzyme.

The homology model of yam, *Dioscorea opposita*, class IV endochitinase suggests that this enzyme catalyzes chitin cleavage via an inverting mechanism. Deletions in class IV chitinases compared to class I/II cluster at the ends of the substrate-binding cleft, shortening it by one glycosyl unit at each end. The shorter cleft might be expected to recognize and grasp a small section of exposed chitin on a fungal hyphal wall, more effectively attacking it.

Keywords: cellobiohydrolase, cellulase, cellulose, chitin, chitinase, endoglucanase, homology modeling, pathogenesis-related protein, structural studies, X-ray crystallography

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Electronically published at: http://diss-epsilon.slu.se/archive/00000772/

New book: “Polysaccharides – Structural diversity and functional versatility”.

Title: Polysaccharides – Structural diversity and functional versatility (2. edition)
S. Dumitriu. (editor)
Marcel Dekker, New York, 2005 (1204 pages, $269.95).
ISBN: 00-8247-5480-8

Relevance to chitin and chitosans.

Kjell M. Vårum
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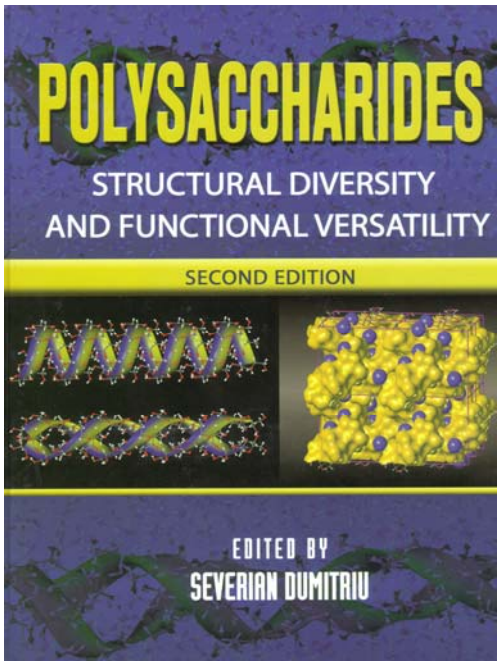
This new edition of the book was available in the spring of 2005 (the first edition was published in 1998), and contains 49 chapters written by invited contributors from 17 different countries. The book covers the current state of knowledge of polysaccharides, with emphasis on structures, methods of structural analysis, and functions and properties of bacterial polysaccharides, hemicelluloses, ionic polysaccharides (including chitosans), cellulose and starch. A complete list of the chapters can be found at:
http://www.uea.ac.uk/cap/carbohydrate/cccintranet/carbbooks.

Information relevant to research on chitin and chitosan is found in a number of chapters, e.g. ‘Progress in Structural Characterisation of Functional Polysaccharides’, ‘Interactions between Polysaccharides and Polypeptides’, ‘Stability and Degradation of Polysaccharides’, and ‘Structures and Functionalities of Membranes from Polysaccharide Derivatives’.

Four chapters of the book are exclusively devoted to chitin and chitosan, and their content will therefore be described and briefly commented on here. Two of the chapters (Chapter 27 and 28) are focused on biomedical applications, and the two other chapters (26 and 29) also contain significant sections devoted to applications of chitosan in pharmacy and medicine. This fact reflects that much of the research focus, and presumably also future applications of chitosans, will be related to this field. However, also in more traditional high volume applications such as water treatment, chitosans can be expected to replace synthetic polycations and find new applications due to increased environmental concerns. The book should be especially useful to those working on biomedical applications of chitin/chitosan.



Chapter 26. Structure-Property Relationship in Chitosans

K.M. Vårum and O. Smidsrød

This chapter focuses on structure-property relationship, particularly the effect of the degree of acetylation and the molecular weight on the physical and biological properties of chitosans. The chapter is organized in the following sections:

106 references

The authors conclude that despite an enormous number of suggested applications, the commercial use of chitosan is still in its infancy, and that the diverse physical and biological properties of this polysaccharide has a potential, especially in biomedical applications, that is at least comparable with that of other polysaccharides of marine origins, such as alginates, carrageenan, and agar. However, this will require a systematic search for optimum performance in each potential application as well as focusing on the regulatory requirements for approval.

Chapter 27. Chitosan as a Delivery System for the Transmucosal Administration of Drugs

Lisbeth Illum and Stanley S. Davis

The uptake of drugs is discussed in general, and specifically the influence of pharmaceutical excipients such as chitosan for the uptake by "opening" of tight junctions, a mechanism that according to the authors has yet to be fully understood. The enhancing effect of chitosan in relation to transport of drugs across mucosal membranes is due to a combination of bioadhesion and opening of the tight junctions. The chapter has been organized in the following sections:

133 references

The authors conclude that chitosan is unusual in being a positively charged polysaccharide with a good safety profile . According to the authors nasal products containing chitosan as an excipient/absorption enhancer are expected to appear on the market in the near future.

Chaper 28. Pharmaceutical Applications of Chitosan and Derivatives

M. Thanou and H.E. Junginger

This chapter covers an area that is also partly covered by the preceeding chapter, although the authors discuss in more detail such topics as chitosan derivatives, chitosan in wound healing, technologies related to drug delivery systems and gene delivery.
The following topics are covered:

I. Introduction
II. Chitinous materials and physicochemical and biological properties
III. Chitosan as biomaterial in wound healing
IV. Chitinous materials in drug delivery
    A. Controlled-Release Dosage Forms
    B. Dosage Forms for Peroral Administration
    C. Dosage Forms for Local Administration in the Oral Cavity
V. Technologies for injectable chitosan drug delivery systems
VI. Chitosan as a functional material in drug delivery systems
    A. Mucoadhesion, Permeation Enhancement, and Enzyme Inhibition Properties for the Delivery of Hydrophilic Macromolecular Drugs
    B. Chitosan Delivery Systems for Colon Targeting
    C. Mucosal Vaccination Using Chitosan Solutions and Microparticulate Forms
    D. DNA and Oligonucleotide Delivery Using Chitosan as Complexing Agent
VII. Summary and perspectives for future chitosan technologies

141 references

In the summary, one of the the authors' conclusion is that there is a need for more data on the immunological and toxilogical profiles in relation to regulatory authorities.

Chapter 29. Macromolecular Complexes of Chitosan

N. Kubota and K. Shimoda

This chapter is updated from the first edition of the book. Macromolecular complexes involving chitosan are important for the use of chitosans for e.g. membranes, gene delivery, encapsulation of drugs, immobilization of enzymes and cells, and biomaterials.
The chapter is organized in the following sections:

151 references

Macromolecular complexes of chitosan are a field of growing interest, and where a rapid technological development can be foreseen related to e.g. DNA-chitosan interactions in relation to gene delivery, nanoparticles a

FORTHCOMING CONFERENCES

The 7th Asia-Pacific Chitin and Chitosan Symposium

Bexco, Busan, Korea

April 24th-26th, 2006

The 7th APCCS will be held in Korea next April in BEXCO which is a newly built international exhibition and convention centre. The facilities at the convention centre are excellent and it is conveniently linked to the transportation services. Busan is the second largest city in Korea with a population of about 4 million. It is located on the SE coast and is Korea's major port.

The Symposium will consist of invited lectures and both oral and poster presentations and the official language of the Symposium will be English. Further information can be obtained from the Secretariet : E-mail: apccs@coexkorea.co.kr or from the Chairman of the Local Organising Committee, Professor Dr. Se-Kwon Kim. E-mail: sknkim@pknu.ac.kr