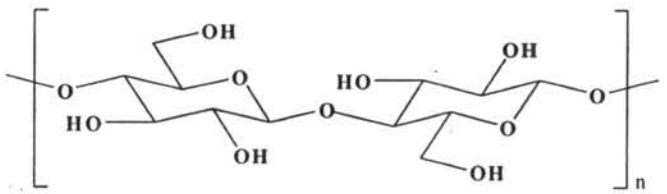
CHAPTER II
LITERATURE REVIEW

2.1 Chitin-Chitosan: The Structure and Specific Properties

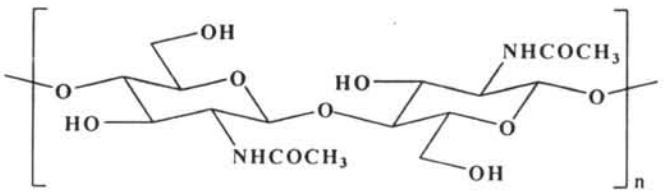
Chitin is the second most abundant polysaccharide next to cellulose, presenting in shells of crustaceans, cuticles of insects, and cell-walls of fungi and yeasts. Chitin is a linear polysaccharide consisting of β-(1-4)-2-acetamido-2-deoxy-β-D-glucose. Upon hydrolysis, chitin yields chitosan, β-(1-4)-2-amino-2-deoxy-β-D-glucose (Horton *et al.*, 1965). The term for chitosan is when the chitosan unit or the degree of deacetylation more than 70% (Sannan *et al.*, 1976). Generally, chitin and chitosan are existed as a random copolymer (Scheme 2.1).

Scheme 2.1 Chemical structures of (a) cellulose, (b) chitin, and (c) chitosan

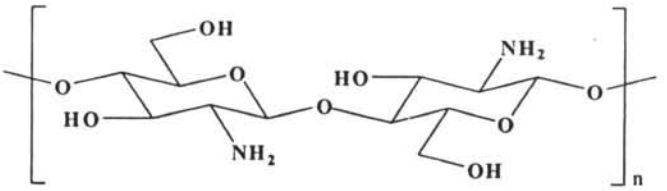
(a)



(b)



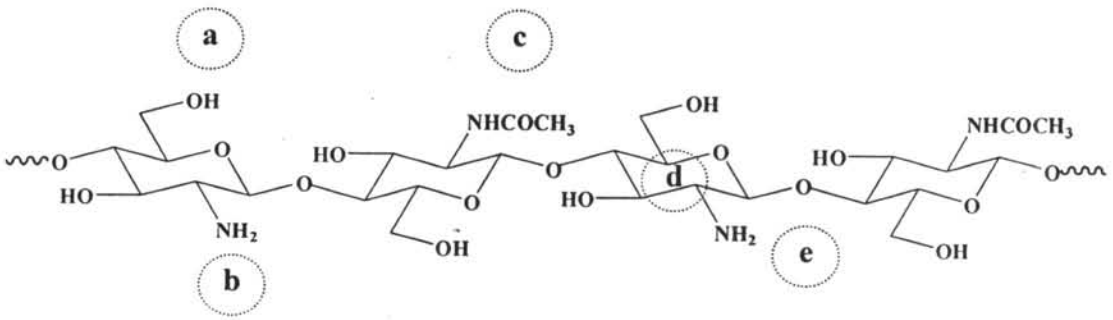
(c)



Chitin-chitosan is clarified as an aminopolysaccharide providing nitrogen atoms for unique properties such as metal ion chelation, protonation to cationic species, including the functionalizations. The applications, thus, are chelating agents (Sakaguchi *et al.*, 1981), high performance adsorbents (Kurita *et al.*, 1988b), ion exchange membranes (Pellegrino *et al.*, 1990), etc

Here, the structural based properties of chitin-chitosan are summarized as follows (Scheme 2.2).

Scheme 2.2 Structural based properties of chitin-chitosan



a: Hydroxyl group. Chitin-chitosan has two types of hydroxyl groups, which are primary alcohol group at C-6 and second hydroxyl group at C-3. The primary hydroxyl group is more reactive than the second ary hydroxyl group; therefore, most chemical reactions take place at C-6. These hydroxyl groups impart hydrophilicity to chitosan chains and show the inclusion properties (Shimizu *et al.*, 1995 and Shan-Yang *et al.*, 1992). It can be, thus, formed inclusion and/or host-guest compound with ions or molecules, which is appropriate for industrial wastewater treatment. The lone pair electrons of oxygen atom also forms complex with metal ions, i.e. Ca^{2+}, Ni^{2+}, etc. (Nishi *et al.*, 1987). Chitin-chitosan possesses antimicrobial properties (Suzuki *et al.*, 1986) as the lone pair electrons of oxygen atom initiate the microorganism destruction.

b: Amino group. Comparing to cellulose, chitin-chitosan can be chemically modified, since it has the reactive primary amino group, which are more

reactive than hydroxyl groups. Moreover, a lone pair electrons of nitrogen atom tends to form bond with ions and metals. This brings the applications as wastewater treatment resin. The use as a coagulant is also based on the interaction of amino group with inorganic species, soil, mud, etc. to accelerate the precipitation (Penniston and Johnson, U.S. Patent). It is important to note that amino group can be protonated in the presence of proton species providing positively charged polymer ($-NH_3^+$, cationic polymer). The antibacterial and antiviral of chitin-chitosan are induced from the formation of ionic bond between the positively charged amino group and negative charged microorganism cell-wall, as a result the growth inhibition of bacteria and virus is achieved (Kendra and Hadwiger, 1984).

c: Acetamide group. The functions of acetamide group are mostly similar to those of amino group but acetamide group is rather inert for the chemical reaction. The acetamide group forms the strong hydrogen bond network leading to the high crystallinity of chitin. The acetamide group and its strong hydrogen bond also bring chitin to show poor solubility in almost all solvents.

d: Pyranose ring. Chitin-chitosan consists of pyranose ring either the *N*-acetyl–D-glucosamine or D-glucosamine. The glucosamine is reported for the detoxification and the combining with fatty acid for lowering cholesterol. Chitin-chitosan oligomer is known to activate the growth of tissue and the functions as a fibroblast for reconstruct collagen leading to an effective wound recovery. The activity of chitin-chitosan imparts the biocompatibility (Hirano *et al.*, 1988), bioactivity (Dumitriu *et al.*, 1989), and non-toxicity (Sugano *et al.*, 1978) under the structure of pyranose ring with *N*-acetyl–D-glucosamine or D-glucosamine.

e: glycoside linkage. Glycoside linkage or glucosidic bond (C-O-C) provides biodegradability (Mark *et al.*, 1985) via enzymatic hydrolysis, i.e. chitinase, chitosanase, and lyzozyme, which present in nature.

2.2 Materialization of Chitin-chitosan

Materialization of polymeric mterials can be achieved either by direct processing method from the molten stage or the resin or dissolving in the good solvent and preparing the product from the solution of the material. In former case,

the processing of commodity polymers, e.g. polyethylene, polypropylene, etc., by the techniques of blown film, injection, extrusion, etc., are good examples. In the later case, the techniques such as spray drying, wet spinning, film casting, and gel forming are the representatives. It should be noted that as chitin-chitosan is not dissolved in organic solvents and water, up to present the materialization methods are very limited.

2.2.1 Physical Modification of Chitin-chitosan

Considering the chemical structure of chitin-chitosan, the high molecular weight and strong inter- and intramolecular hydrogen bond network lead chitin-chitosan to the limitations about low solubility and chemically inert. Thus, most applications are based on simple physical modifications, such as solvent casting to form films, spray drying to obtain beads or spheres, crosslinking with dialdehyde into gels or membranes, and freeze drying to achieve scaffolds. The important physical modification can be raised as follows.

Bégin *et al.* (1999) prepared antimicrobial films from chitosan in hydrochloric, formic acid, acetic, lactic acid, and citric acid solution. The relationship between Young's modulus and volume of the counter ion was studied. The results showed that film properties are essentially governed by the volume of the counter ion and not by the interaction between this counter ion and the macromolecules The chitosan acetate has the maximum molecular volume above which the film strength decreases rapidly. The results also indicated that use of antimicrobial agents with molecular volume superior to that of acetic acid produces soft films which should be used in multilayer films or for coating. The chloride and formate salts of chitosan form hard films which may be used as biodegradable packaging or as antimicrobial agents contained films.

Aydin *et al.* (1996) prepared chitosan beads for the delivery of salmon calcitonin (sCT) by dropping the chitosan with sCT in acetic acid into tripolyphosphate solutions. The droplets instantaneously formed gelled spheres by ionotropic gelation.

Madihally *et al.* (1999) prepared porous chitosan materials by controlled freezing and lyophilization of chitosan solutions and gels. The results showed that the scaffold formed includes porous membranes, blocks, tubes, and

beads. Mean pore diameters could be controlled in micrometer by varying the freezing conditions.

2.2.2 Chemical Modification of Chitin-chitosan

Since the reactive amino as well as primary and secondary hydroxyl groups in chitin-chitosan are ready for chemical reaction, many efforts have been paid to chemical modifications of chitin-chitosan. It can be expected for not only to improve the solubility and overcome the rigid structure but also the property that never found in the original material. Considering the chemical structure, chitin-chitosan can react with other reactive functional groups, for instance acid chloride, aldehyde, alkyl halide and carboxylic acid or it can undergo crosslinking, esterification, etherification, and graft copolymerization reactions (Hun, 1992).

2.2.2.1 Chemical Modification at Amino Groups

For the past decade, much attention has been paid to modify chitin-chitosan at the amino group due to its reactivity to functionalize with other functional groups.

1. Increasing the solubility

As chitosan is hardly dissolved in most solvents, the substitution with bulky group at C-2 position is an effective way to obstruct the inter and intramolecular hydrogen bond to result the solubility.

Sashiwa *et al.* (1999) prepared a water soluble chitosan by introducing disaccharides, i.e. lactose, maltose, melibiose, and cellobiose, onto chitosan chain. The chitosan derivatives show solubility in water at all pH ranges.

Kurita *et al.* (1999) synthesized comb-shaped chitosan derivatives having oligo(ethylene glycol) side chains by the reductive alkylation technique. The products have high affinity for organic solvents as well as water and significant adsorption activity toward metal cations.

Nishimura *et al.* (1991) prepared *N*-phthaloylchitosan from the reaction of chitosan with phthalic anhydride in *N,N*-dimethylformamide (DMF) at 130 °C. The removal of two hydrogen atoms of amino groups by the introduction of phthalimido groups by chemical modification will cause destruction of its inherent crystalline structure resulting in the solubility improvement. The results showed that

N-phthaloylchitosan can dissolve in common organic solvents, such as DMF, *N,N*-dimethylacetamide (DMAc), dimethylsulfoxide (DMSO), and pyridine. *N*-phthaloylchitosan can be used as a starting material for preparation of several *O*-substituted derivatives.

2. Host-guest derivatization

Ouchi *et al.* (1998) prepared a highly water-soluble chitosan derivatives which have a low degree of substitution by using poly(ethylene glycol) grafted chitosan (PEG-g-Chitosan). The results showed that the aggregation properties in aqueous solution of PEG-g-Chitosans solution are different depending upon the degree of introduction of PEG in aqueous solution. The PEG-g-Chitosan aggregation could also uptake *N*-phenyl-1-naphthylamine (PNA) in neutral conditions.

2.2.2.2 Chemical Modification at Hydroxy Groups

In general, the reactions onto hydroxyl group are conjugation and coupling reaction. There are two types of hydroxyl group on pyranose ring, i.e. the primary alcohol at C-6 and the secondary alcohol at C-3. Alcohol group allows chitosan exhibits itself as a alcohol-based material to react with alkyl halides, carbonyl compounds, ethers, alkenes, ethers, etc. Most reactions have been paid on the primary hydroxyl groups at C-6 due to it is more reactive than secondary hydroxyl groups.

1. Increasing the reactivity and organo-solubility

Yoksan *et al.* (2004) proposed the method to introduce alkylamine groups onto γ-ray irradiated chitosan at hydroxyl group (C-6 and/or C-3) using carbonyl imidazole as a conjugating agent. The product shows fair solubility in organic solvents, such as DMSO, DMAc, DMF, and pyridine.

2. Macrocyclic conjugation

Tan *et al.* (1999) showed the crosslinked dibenzo-16-crown-5 acetate crown ether chitosan and 3,5-di-tert-butyl dibenzo-14-crown-4 diacetate crown ether chitosan, which could be used in hazardous aqueous waste remediation as toxic metal-binding agents. The derivatives not only shows the adsorption capability for Pb^{2+} and Cu^{2+} but also the high selectivity for Pb^{2+} and Cu^{2+} in the coexistence of Ni^{2+}.

3. Enhancing enzyme stability

Chiou *et al.* (2004) proposed an enhancement of enzyme stability against changes of pH and temperature by immobilizing *Candida rugosa* lipase to chitosan beads via the hydroxyl groups of chitosan using carbodiimide conjugating reagent.

2.3 Nanomaterialization

In recent years, much attention has been paid to nanomaterials or the materials with the size in nanometer range, due to its attractive characteristics, such as the effectiveness in functionalization at molecular level, the large surface area, and the significant mechanical performances (Huang *et al.*, 2003). In general, there are two approaches to challenge the development of nanomaterial, i.e. (i) the development at molecular level from the molecules in angstrom size to the molecules with functioning system at nanometer level, and (ii) the development at millimeter or micrometer level to nanometer level by reducing the size of the material via either chemical or physical process.

2.3.1 Development at Molecular Level

Generally, the development of nanomaterial from molecules in angstrom level can be achieved via (i) a molecular assembly of the individual small molecules, and (ii) a chemical reaction of the individual small molecules to form macrocyclic molecules, such as crown ether, cyclodextrin, and calixarenes. The nanomaterials obtained are called supramolecules, providing cavities which can form complexation with other molecules in term of inclusion compound or host-guest compound.

2.3.1.1 Supramolecules via Molecular Assembly

The molecular assembly of individual small molecules is achieved via non-covalent bonds, i.e. hydrogen bonding, coordinating bonds, aromatic π-stacking interactions, electrostatic and charge-transfer attractions. The supramolecule obtained gives a superior properties which has ever achieved from the individual one.

Some current unique researches are as follows. Ghadiri *et al.* (1993) prepared the self-assembly cyclic peptide subunits into crystalline nanotubular array. The eight residue peptide cyclo[-(D-Ala-Glu-D-Ala-Gln)$_2$-] self assembled to form crystalline nanotubes with a uniform 7.5 Å internal diameter. The Nanotube formation was introduced by using the ionization state of the glutamic acid side chain as a proton trigger.

Sun *et al.* (2003) proposed the method to synthesize [Zn(picoH)$_2$.2H$_2$O] (**1**), [Mn(picoH)$_2$.2H$_2$O] (**2**), and [Cu(picoH)$_2$.2H$_2$O] (**3**), where HpioH = 3-hydroxypicolinic acid, as single crystals via hydrothermal reaction. The result showed that the complex **1** and **2** were isomorphous and have rich of hydrogen bonds formed by the coordination water molecules with the carboxylate groups and the hydrogen atoms of the pyridine rings, respectively. The hydrogen bonds leaded to the formation of supramolecules with three-dimension network structure.

Huang *et al.* (2006) proposed the method to synthesize highly emissive compounds containing pyridine (or pyrimidine) and cyano ligands via palladium catalyzed cross-coupling reaction. These ligands were ready to react with Re(CO)$_3$(THF)$_2$Br to form cyclic supramolecules by self-assembly processes. The results showed that these supramolecules were emissive at room temperature, and the emission was ligand-localized.

2.3.1.2 Supramolecules via Macrocyclic Structures

Macrocyclic molecules can be achieved via the chemical reaction of individual small molecules. The individual molecules will form covalent bonds to each others providing cavities which can form complexation with other molecules, e.g. cation, anion, and neutral molecule. Supramolecular chemistry has been received much attention for several decades. The current work are as following example.

Majerski *et al.* (2002) proposed the method to prepare *N*-adamantylaza-crown ethers based on the coupling reactions of aza-18-crown-6 with corresponding adamantine derivatives. The results showed that the derivatives obtained had high extraction efficiency for K^+ and Rb^+ as compared to those of parent aza-18-crown-6 and *N*-benzylaza-18-crown-6.

Demirel *et al.* (2003) prepared the chiral diaza 18-crown-6 ethers from chiral amines. The results of molecular recognition of the chiral crown ethers for amino acids potassium and sodium salts were the selectivity in order of Phe>Thr>Ala.

Peng *et al.* (1998) synthesized crosslinked-crown ethers by the reaction of crosslinked chitosan with 4′-formyl benzo-15-crown-5 and 4′-formyl benzo-18-crown-6. The experimental results showed that they did not only show good adsorption capacity for Ag^{+} and Pd^{2+} but also high selectivity for the adsorption of Ag^{+} or Pd^{2+} with the coexistence of Pb^{2+} and Cr^{3+}.

Yang *et al.* (2000) prepared synthesized mesocyclic diamine-grafted chitosan-crown ether by using mesocyclic diamine crown ether as the grafting agent. The product showed high selectivity for the adsorption of Cu^{2+} in the presence of Pb^{2+}, Cu^{2+} and Cd^{2+}, and its adsorption selectivity was better than that of chitosan.

Yang and Yuan (2001) studied on static adsorption properties of chitosan hydroxyl azacrown ether for Ag^{+}, Cd^{2+}, Pd^{2+} and Cr^{3+}. The derivative was synthesized by reaction of hydroxyl azacrown ether with epoxy-activated chitosan, and exhibited good adsorption capacity and high selectivity for Ag^{+} in the coexistence of Pb^{2+} and Cd^{2+}.

Wan *et al.* (2002) investigated the adsorption capacity and selectivity of *N*-benzylidene chitosan (CTB), chitosan-dibenzo-18-crown-6 crown ether bearing Schiff-base group (CTBD) and chitosan-dibenzo-18-crown-6 crown ether (CTSD) for Ag^{+}, Cu^{2+}, Pb^{2+} and Ni^{2+}. The results showed that CTBD had better adsorption properties and higher selectivity for metal ions than CTSD.

Tanida *et al.* (1998) proposed a convenient method for introducing a β-cyclodextrin residue into high molecular weight chitosan by using amination as a key reaction. The experimental results showed that the product showed an inclusion ability with *p*-nitrophenolate. It might be useful for cosmetic or pharmaceutical industries.

Tujima *et al.* (1998) proposed an α-cyclodextrin-linked chitosan derivative prepared via reductive amination. The product showed an

inclusion formation with *p*-nitrophenolate which would be useful in cosmetic and pharmaceutical industries.

2.3.2 Development at Millimeter or Micrometer Level to Nanometer Level

Considering the size reduction, the physical treatments, such as grinding, emulsion processing, electrospinning, and dissolving in solution combining with lyophilization, are the basic approach proven to be practical for most water soluble and organo soluble cases. The oligomerization or the depolymerization of polymers by chemical treatment (acid or base hydrolysis), and chemical modification are effective methods to achieve the chain or particles in nanometer size.

2.3.2.1 Size Reduction via Physical Treatment

Physical treatment is a practical method to reduce molecular size of molecule which can dissolve in water and/or organic solvents.

1. Preparing nanoparticles via desolvation process

Balthasar *et al.* (2005) prepared gelatin nanoparticles by dissolving gelatin in water and following by adding acetone in the system. The nanoparticles obtained were stabilized by glutaraldehyde crosslinker before modifying with biotinylated anti-CD-3 antibodies via avidin-biotin-complex formation. The results showed that the nanoparticles was a promising receptor mediated cellular uptake in lymphocytic cells.

2. Preparing nanoparticles via a double emulsion method

Avgoustakis *et al.* (2002) prepared PLGA-mPEG nanoparticles by dissolving poly(lactic-co-glycolide)-monomethyl-poly-(polyethylene glycol) (PLGA-mPEG) copolymers in dichloromethane following by transferring to an aqueous solution of sodium cholate. The emulsion formed was gently stirred at room temperature until the evaporation of the organic phase was complete. The nanoparticles were purified by centrifugation and reconstitution with deionized and distilled water followed by filtering through a pore of 1.2 μm. The result showed that the nanoparticles obtained were spherical and rather homogeneous in size with an average diameter in a range of 133 to 163 nm as observed by SEM.

3. Preparing non-woven nanofibers by electrospinning technique

Ohgo *et al.* (2003) applied electrospinning technique to prepare non-woven nanofibers of *Bombyx mori silk*, and *Samia Cynthia ricini* silk by using hexafluoroacetone (HFA) as solvent. The nanofibers obtained showed a homogeneous fibers with diameters of 100 nm as observed by SEM.

2.3.2.2 Size Reduction via Chemical Treatment

Chemical treatment is an attractive size reduction method to achieve the nanomaterial due to the size of the nanomaterial obtained is closed to molecular level.

1. Cellulose whiskers

It is known that the cellulose chains are biosynthesized and self-assembled into microfibrils. These microfibrils are constituted by amorphous and crystalline domains. Acid hydrolysis of native cellulose leads to aqueous suspension of cellulose microcrystals, so-called "cellulose whisker", due to the present of negative charges on the surface of microcrystallites during the hydrolysis process. The cellulose whiskers obtained are rod-like shape particles and the dimensions depend on the cellulose origin.

Dong *et al.* (1996) prepared cellulose whiskers from Whatman No. 1 filter paper by hydrolyzing in sulfuric acid solution at 45 °C for 1 h. The whiskers showed rod-like morphology with the length of 70-170 nm and width of ~ 7 nm.

Heux *et al.* (2000) prepared cellulose from two materials, i.e. Whatman No. 1 filter paper, and tunicate compound by treating in sulfuric acid aqueous solution. The results showed that cotton whiskers obtained had the length and width about 300 nm and 10 nm, respectively. At the same time, the tunicin whiskers obtained from tunicate showed the length and width about 1000 nm and 15 nm, respectively.

2.4 Chitin-chitosan Nanomaterialization

Based on the attractive properties of chitin-chitosan, i.e. biocompatibility, bioactivity, biodegradability, non-toxicity, and high reactivity, recently,

nanomaterialization of chitin-chitosan has been variously proposed as potential materials in various applications, such as reinforcing agents for nanocomposites (Nair and Dufrensne, 2003), nanoscaffold for tissue engineering (Bhattarai *et al.*, 2005), nanoparticles for drug carrier (Yoksan *et al.*, 2004 and Min *et al.*, 2004) and drug targeting (Grenha *et al.*, 2005) in biomedical and pharmaceutical applications.

1. Chitin whiskers

Chitin has been known to form microfibrilar arrangements embedded in a protein matrix, and these microfibrils have diameters ranging from 2.5 to 2.8 nm. Crustacean cuticles possess chitin microfibrils with diameter as large as 25 nm. In general, chitin particles can be prepared by excluding the low crystalline region by acid to obtain the water-insoluble highly crystalline particles. The particles are stable in suspension form.

Paillet *et al.* (2001) prepared chitin whiskers from squid pen by treating in a specific condition of hydrochloric acid solution. The whiskers obtained showed a rod-like morphology with a length ranging from 50 to 300 nm, a width of 10 nm, and the aspect ratio is around 15.

Morin *et al.* (2002) prepared chitin whiskers from *Raftia* tubes by acid hydrolysis under the controlled reaction conditions. The whiskers obtained show a needle-like morphology having a broad distribution in size with a length of 500 nm-10 μm and the aspect ration of 120.

Nair and Dufrensne (2003) prepared chitin whiskers by treating chitin flakes from crab shells in 3N HCl under the specific conditions. The whiskers obtained showed a needle-like morphology with an average length and width of 240 and 15 nm, respectively. The aspect ratio was around 16 and was applied as a reinforcing agent in rubber composites.

The chitin whiskers obtained are needle-like polymer single crystals, the dimensions of which depend on the original chitin. Chitin whiskers have been used as a new kind of nanofillers as a reinforcing phase in composites.

2. Chitin-chitosan nanofibers

Min *et al.* (2004) prepared chitin nanofibers by depolymerizing chitin via gamma irradiation to improve its solubility before dissolving in 1,1,1,3,3,3,-hexafluoro-2-propanol (HFP) as a spinning solvent and fabricating by electospinning

method. Chitin nonofibers was chemically treated with 40% NaOH solution at 60 °C (for 1day) or at 100 °C (for 150 min) to obtain chitosan nonofibers with degree of deacetylation (DD) ~ 85% without dimensional change (shrink). The chitin and chitosan nonofibers obtained showed the broad fiber diameter distribution with diameters of 40-640 nm.

Bhattarai *et al.* (2005) proposed the chitosan-based nanofibers by electrospinning solutions containing chitosan, polyethylene oxide, and Triton X-100™. The product obtained showed the ability to deposit either as a non-woven membrane or as a highly aligned bundle with an average diameter from a few microns down to 40 nm. The in vitro studies showed that the product promoted the attachment of human osteoblasts and chondrocytes cells, and maintained the characteristic cell morphology which might be a candidate for bone tissue engineering.

3. Self-assembled nanoparticles chitosan

Park *et al.* (2006) proposed self-assembled nanoparticles by conjugating fluororecein isothiocyanate or doxorubicin (hydrophobic part) onto the backbone of glycol chitosan (hydrophilic part). The results showed that the products obtained had a narrow size distribution of self-aggregates with a sphere shape and a diameter of 300 nm in phosphate buffer solution at pH 7.4. The results also revealed that the self-aggregates loaded with doxorubicin might be a potential carrier for hydrophobic drug.

4. Ionotropic nanoparticles chitosan

Grenha *et al.* (2005) proposed chitosan/tripolyphosphate nanoparticles by dissolving chitosan and tripolyphosphate in purified water. The nanoparticles were spontaneously formed upon incorporation of 1.2 mL of tripolyphosphate in 3.0 mL of chitosan solution, under mild magnetic stirring at room temperature. The nanoparticles was in the sizes of 300-390 nm and showed a positive zeta potential from +34 to +45 mV, with the lowest size and zeta potential also being obtained for the highest tripolyphosphate concentration (chitosan/tripolyphosphate = 3.6:1). The nanoparticles were further encapsulated with protein to produce microsheres as carrier of protein-loaded nanoparticles to the lung.

2.5 Points of the Present Work

The present work stands on the novel chitin-chitosan nanomaterial. As the approaches to achieve the material in nano scale can be either from the chemistry to develop the supramolecular structured compound or the physico-chemistry to initiate the size reduction of the general materials to nanometer sized compound, the present work covers both approaches including the potential applications for the nanomaterial obtained.

In the first part (Chapter III), the work concentrates on how we can achieve a supramolecular structured chitosan by using low molecular weight chitosan. Here, we originally propose the conjugation of polyether onto chitosan and expect the supramolecular formation based on the pseudocyclic crown on chitosan. The work shows the synthesis pathway to coupling various types of crown from oxy-alkyl chain and aza-alkyl chain including the structural characterization of the compounds obtained. As crown-supramolecules are known for the inclusion of metal ion, the studies on ion interaction properties of our supramolecular structured chitosan are extended.

In the second part (Chapter IV-VI), the work demonstrates the way to obtain chitosan nanomaterial via the depolymerization of chitin combining with the deacetylation. As Nair and Dufrensne (2003) reported that chitin changes its morphology from flakes to whiskers in the specific acid condition, the present work, thus applied that condition followed by treating the whisker with base. It is for the first time to find that chitosan can be obtained from chitin whisker and at that time the morphology of chitosan is in nanoscaffold. In order to apply the merits of nanomaterials obtained, the work demonstrates the surface functionalization of chitin whisker and chitosan nanoscaffold. For nanowhisker chitin, the grafting with poly(ethylene glycol) on the whisker surface is focused. In the case of chitosan nanoscaffold, the introduction of disaccharides onto nanoscaffold to obtain material for drug targeting is demonstrated.