BOTM: June 2009

Chitosan

The Biomaterial of the Month is chitosan, a derivative of the natural polysaccharide chitin. Chitosan is a copolymer of N-acetyl-glucosamine and N-glucosamine units and has been widely researched for a variety of biomedical applications such as such as wound healing, drug delivery systems, ophthalmology, implant coatings and tissue engineering/regeneration due to its demonstrated biocompatibility, bio-degradability, nontoxic, nonacidic degradation products, ease of chemical and physical manipulation and ability to promote healing. It is currently used clinically as a hemostatic dressing, HemConÂ® (HemCon Medical Technology Inc., OR). Here, chitosan microspheres approximately 800-900 microns in diameter can be formed into a variety of complex shapes to fill gaps in bone lost due to disease, injury or birth defects. The chitosan microsphere based scaffolds exhibit approximately 30-40% completely interconnected porosity with pores sizes in the 100-500 micron range which is appropriate for blood vessel and bone tissue ingrowth. The chitosan-based microsphere based scaffolds support bone cell growth and matrix production in vitro and osteoconduction in vivo.

More:
Chitosan is a derivative of the natural polysaccharide, chitin. Chitin is second to cellulose as the most abundant biopolymer in the biosphere. Chitin is the basic high modulus fibrous component of the exoskeleton of arthropods including crab, shrimp and lobsters, as well as some fungi. It is a linear highly crystalline polymer, nominally composed of isotactic poly-N-acetyl-D- glucosamines linked in Î² (1-4) glycosidic bonds (Figure 1A). Generally, chitin is obtained from arthropods by crushing and washing shells, removing calcium minerals with acid and then removing proteinaceous material with alkali. Additional treatment with NaOH removes acetyl side groups [â€“C(=0)-CH3] and yields a copolymer of N-acetyl-glucosamine and N-glucosamine units (Figure 2B). When more than 50% of the acetyl groups are removed, the polymer is called chitosan. The ratio of glucosamine to N-acetyl glucosamine is referred to as the degree of de-acetylation, DDA and typically ranges from 50-100%. The DDA affects many physical and chemical properties of the polymer. For example, chitosan is soluble in dilute acids at pH < 6 due to protonation of amino groups, making it highly versatile and flexible for chemical and physical modification, whereas chitin is generally insoluble in aqueous solutions making processing difficult. In general, polymer crystallinity, resistance to degradation, tensile strengths and wettability also increase with DDA. Because of its solubility in aqueous/dilute acid solutions, chitosan is easily processed in to a variety of forms such as films, gels, fibers, tubes, beads and porous structures.

Chitosan has been widely researched for biomedical applications such as wound healing, drug delivery systems, and tissue engineering due to its demonstrated biocompatibility, bio-degradability, nontoxic, nonacidic degradation products, and ability to promote healing. It is currently used clinically as a hemostatic dressing, HemConÂ®. In particular for bone applications, chitosan has also been shown to be osteoconductive. Using a microsphere approach that provides a 3D negative template for bone formation1, chitosan microspheres approximately 800-900 microns in diameter can be formed into a variety of shapes to fill complex gaps in bone lost due to disease, injury or birth defects2-4. The chitosan microsphere based scaffolds exhibit approximately 35-40% completely interconnected porosity with pores sizes in the 100-500 micron range which is appropriate for blood vessel and bone tissue ingrowth 2-4. Scaffolds support bone cell growth and matrix production in vitro (Figure 2) and were osteoconductive in vivo2,6. The microspheres may be combined with other polymers and or calcium phosphate mineral to enhance mechanical strength as well as promote cell attachment and growth2-6. The chitosan microspheres may also be loaded with bioactive and or therapeutic agents and used a dual scaffold/local drug delivery construct3. Chitosan is a highly versatile and promising material and with many potential biomedical applications. Suggested resources are listed below.

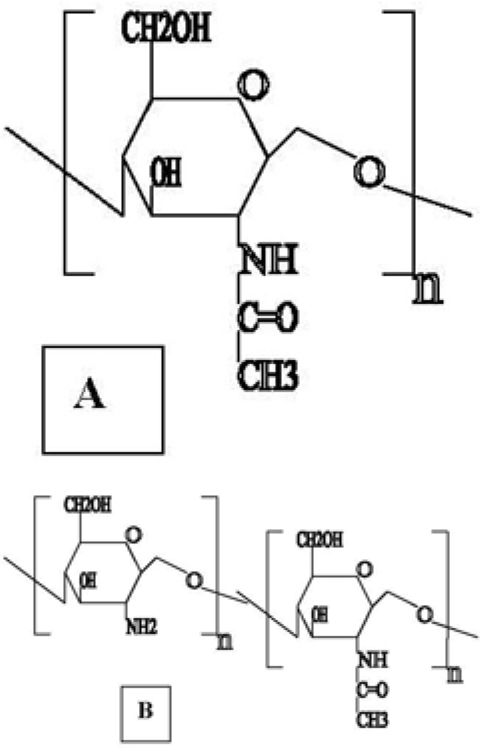

Figure 1: Chemical structure of N-acetyl-glucosamine repeat units for chitin (A) and N-acetyl-glucosamine and N-glucosamine repeat units for chitosan (B)

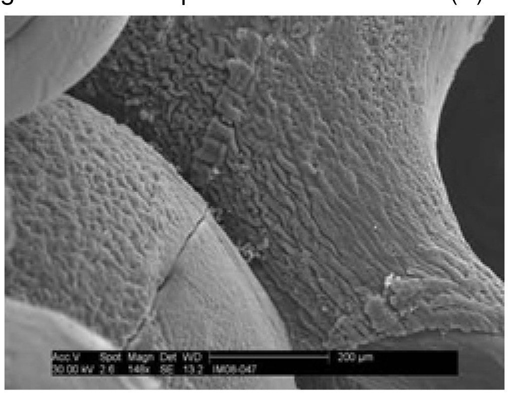

Figure 2: SEM photomicrograph of extensive extracellular matrix produced by bone cells on chitosan-nano-calcium phosphate composite scaffolds.

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Resources:

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