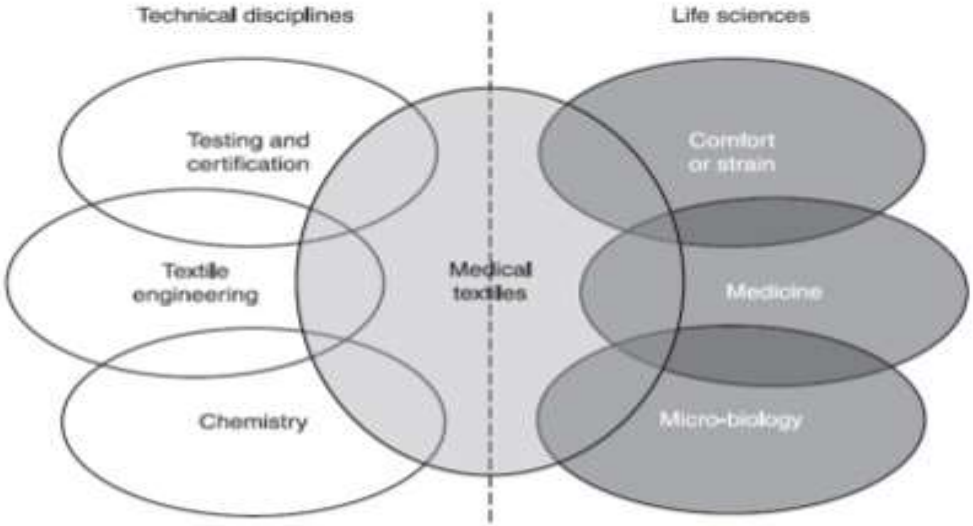
MEDICAL TEXTILES:

INTRODUCTION

WHAT ARE MEDICAL TEXTILES?

Combination of textile technology and medical sciences has resulted into a new field called medical textiles. Textile materials and products that have been engineered to meet particular needs are suitable for any medical and surgical application where a combination of strength, flexibility and sometimes moisture and air permeability are required. Materials used include mono-filament and multi-filament yarns, woven, knitted, non-woven fabrics and composite structures.



The number of applications are huge and diverse, ranging from a single thread suture to the complex composite structures for bone replacement; from simple cleaning wipe to advanced barrier fabrics used in operating rooms.

APPLICATIONS OF TEXTILES IN MEDICAL FIELD

1. Repair or replacement of injured tissue
- prostheses of bone, joint or tooth
- artificial: heart value, blood vessel or skin
- contact lens

2. Assist/ temporary substitution for psychological functions of a failed organ
- artificial heart/lung/kidney/liver or pancreas

3. Disposable article in a daily medical treatment
- tubing, syringe, suture, catheters tube inserted into a body cavity to remove fluid etc.

CHITOSAN:

Chitosan is a linear polysaccharide composed of randomly distributed linked D-glucosamine (deacetylated unit) and *N*-acetyl-D-glucosamine (acetylated unit). It is made by treating the chitin shells of shrimp and other crustaceans with an alkaline substance, like sodium hydroxide.

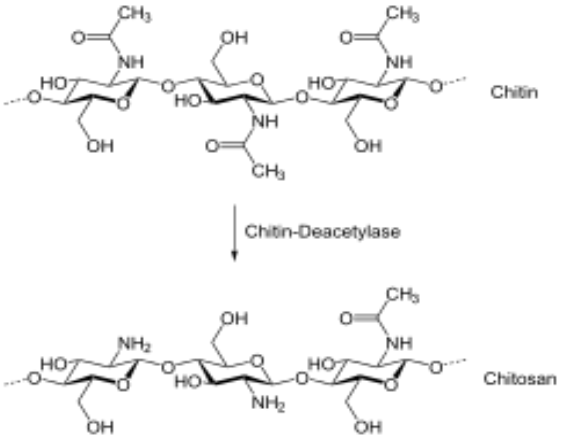
Chitosan has a number of commercial and possible biomedical uses. It can be used in agriculture as a seed treatment and biopesticide, helping plants to fight off fungal infections. In winemaking, it can be used as a fining agent, also helping to prevent spoilage. In industry, it can be used in a self-healing polyurethane paint coating. In medicine, it may be useful in bandages to reduce bleeding and as an antibacterial agent; it can also be used to help deliver drugs through the skin.

More controversially, chitosan has been asserted to have use in limiting fat absorption, which would make it useful for dieting, but there is evidence against this.

Other uses of chitosan that have been researched include use as a soluble dietary fiber.

MANUFACTURE AND PROPERTIES:

Chitosan is produced commercially by deacetylation of chitin, which is the structural element in the exoskeleton of crustaceans (such as crabs and shrimp) and cell walls of fungi. The degree of deacetylation (%DD) can be determined by NMR spectroscopy, and the %DD in commercial chitosans ranges from 60 to 100%. On average, the molecular weight of commercially produced chitosan is between 3800 and 20,000 Daltons. A common method for the synthesis of chitosan is the deacetylation of chitin using sodium hydroxide in excess as a reagent and water as a solvent. The reaction occurs in two stages under first-order kinetic control. Activation energy for the first step is higher than the second; its value is an estimated 48.76 kJ/mol at 25–120 °C. This reaction pathway, when allowed to go to completion (complete deacetylation) yields up to 98% product.



The amino group in chitosan has a pKa value of ~6.5, which leads to a protonation in acidic to neutral solution with a charge density dependent on pH and the %DA-value. This makes chitosan water-soluble and a bioadhesive which readily binds to negatively charged surfaces such as mucosal membranes. Chitosan enhances the transport of polar drugsacross epithelial surfaces, and is biocompatible and biodegradable. It is not approved by FDA for drug delivery though. Purified quantities of chitosans are available for biomedical applications.

Chitosan and its derivatives, such as trimethylchitosan (where the amino group has been trimethylated), have been used in nonviral gene delivery. Trimethylchitosan, or quaternised chitosan, has been shown to transfect breast cancer cells, with increased degree of trimethylation increasing the cytotoxicity; at approximately 50% trimethylation, the derivative is the most efficient at gene delivery. Oligomeric derivatives (3–6 kDa) are relatively nontoxic and have good gene delivery properties.

Nanofibrils have been made using chitin and chitosan.

BIOMEDICAL USES:

Chitosan's properties allow it to rapidly clot blood, and has recently gained approval in the United States and Europe for use in bandages and other hemostatic agents. Chitosan hemostatic products have been shown in testing by the U.S. Marine Corps to quickly stop bleeding and to reduce blood loss, and result in 100% survival of otherwise lethal arterial wounds in swine. Chitosan hemostatic products reduce blood loss in comparison to gauze dressings and increase patient survival. Chitosan hemostatic products have been sold to the U.S. Army and are currently used by the UK military. Both the US and UK have already used the bandages on the battlefields of Iraq and Afghanistan. Chitosan is hypoallergenic and has natural antibacterial properties, which further support its use in field bandages. Chitosan's hemostatic properties also allow it to reduce pain by blocking nerve endings.

Chitosan hemostatic agents are often chitosan salts made from mixing chitosan with an organic acid (such as succinic or lactic acid). The hemostatic agent works by an interaction between the cell membrane of erythrocytes (negative charge) and the protonated chitosan (positive charge) leading to involvement of platelets and rapid thrombus formation. The chitosan salts can be mixed with other materials to make them more absorbent (such as mixing with alginate), or to vary the rate of solubility and bioabsorbability of the chitosan salt. The chitosan salts are biocompatible and biodegradable making them useful as

absorbable haemostats. The protonated chitosan is broken down by lysozyme in the body to glucosamine and the conjugate base of the acid (such as lactate or succinate), substances naturally found in the body. The chitosan salt may be placed on an absorbable backing. The absorbable backing may be synthetic (for instance made from existing absorbable suture materials e.g. Tephaflex polymer) or natural (e.g. cellulose or gelled/solidified honey). In addition to salts, hydrogel-based chitosan bandages have been developed to treat burn wounds. Burns are similar to other wounds, but are problematic because they are associated with membrane destabilization, energy depletion, and hypoxia, all of which can cause severe tissue necrosis if not treated properly or quickly enough. Chitosan-gelation bandages using nanofibrin have been shown to be more durable than ointments, while still allowing gas exchange at the cell surface.

Chitosan's properties also allow it to be used in transdermal drug delivery; it is mucoadhesive in nature, reactive (so it can be produced in many different forms), and most importantly, has a positive charge under acidic conditions. This positive charge comes from protonation of its free amino groups. Lack of a positive charge means chitosan is insoluble in neutral and basic environments. However, in acidic environments, protonation of the amino groups leads to an increase in solubility. The implications of this are very important to biomedical applications. This molecule will maintain its structure in a neutral environment, but will solubilize and degrade in an acidic environment. This means chitosan can be used to transport a drug to an acidic environment, where the chitosan packaging will then degrade, releasing the drug to the desired environment. One example of this drug delivery has been the transport of insulin.

Chitosan can also be combined with other materials. For example, a composite with hydroxyapatite was effective as a temporary post-operation bone filler, which was gradually biodegraded and replaced by native bone tissue.