MEDICAL TEXTILES

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Abstract

Medical textiles are also known as Healthcare Textiles. Medical Textiles is one of the most rapidly expanding sectors in the technical textile market. Advanced medical textiles are significantly developing area because of their major expansion in such fields like wound healing and controlled release, bandaging and pressure garments, implantable devices as well as medical devices, and development of new intelligent textile products.

Keywords: Technical textiles, medical textiles, surgical, healthcare, wound dressing, nano-fibres.

I. Introduction

A nation's economic power and quality of life of the people depend on the ability of the industrialists to innovate and manufacture socially relevant products. One does not need to be a great scientist to innovate and discover new things; sometimes simple techniques developed using common sense can be used to make high value products. Medical Textiles is an exciting and rewarding field that has great potential to positively transform how people live their daily lives. Medical Textile industries in India are still taking baby steps, compared to the international scenario[1]. Medical textiles are also known as Healthcare Textiles. Medical Textiles is one of the most rapidly expanding sectors in the technical textile market. It is one of the major growth areas within technical textiles and the use of textile materials for medical and healthcare products ranges from simple gauze or bandage materials to scaffolds for tissue culturing and a large variety of prostheses for permanent body implants. Textile products are omnipresent in the field of human hygiene and medical practice. Their use is based on a number of typical basic textile properties like softness and lightness, flexibility, absorption, filtering, etc. Advanced medical textiles are significantly developing area because of their major expansion in such fields like wound healing and controlled release, bandaging and pressure garments, implantable devices as well as medical devices, and development of new intelligent textile products. Several researching works are going on all over the world in medical textile materials and polymers[2]. Nano-technique has acquired tremendous impulse in the last decade. Nano-fibre based products as well as nano-coated materials are present innovations in the field of medical. Nano fibres are very attracted due to their unique properties, high surface area to volume ratio, film thinness, nano scale fibre diameter porosity of structure, lighter weight. Nanofibres are porous and the distribution of pore size could be of wide range, so they can be considered as engineered scaffolds with broad application in the field of tissue engineering. Some other applications like wound dressings, bone regeneration and nano-fibres to be the carrier of various drugs to the specific sites, etc. Biomedical textiles are branch of technical textiles which are manufactured from wide range of processes. The main attribute of biomedical textiles is that it should fulfill the purpose for which it is designed. To fulfill this purpose various synthetic and natural fibres each with its unique properties are used to construct biomedical textiles. Polycaprolactone, polyglycolic acid and polylactic acid are some synthetic fibres used in sutures and tissue engineering structures. Natural biological fibres include chitin, collagen and alginate fibres. sorbalgon a non woven dressing material, obtained from alginate fibres facilitates a permeable moist wound treatment. Woven and knitted materials are used extensively in vascular grafts and hernia meshes. A specialized area of medical textiles is the extrusion of hollow fibre membranes used in extracorporeal devices. Braided textiles are used for sutures and to replace tendons and ligaments. Thus the textile sector has most commonly emerging advanced applications in medical textiles. The application of fibres has now been extended for the manufacturing of artificial internal organs like kidneys, lungs, heart valves, and threads for surgical purposes and other medical materials[1]. An innovative approach was made to utilize the eco-friendly renewable source of herbal treated medicated textiles material to simple products. The results proved that the herbal medicated products when used showed good impact of relief and signs of cureness[3].

II. Classification of Medical Textiles

Medical textiles can be classified into three viz. Surgical, Extracorporeal and Health Care & Hygiene

1. Surgical Medical Textiles:

They are mainly used for internal and external parts of the body. It is important that the textile material used should be compatible with the body parts where it is used and should not react with blood cells or corpuscles otherwise it can cause fatal death of the patient. They are further classified as implantable and non-implantable textiles[4,5].

a. Implantable: These materials are used in internal body parts for repairing or healing internal wounds like stitching the wound part during surgery. The common examples of such type of material are sutures, vascular grafts, artificial joints, etc. Sutures are located after a surgical operation has been performed so as to hold the basic structural elements in their required sites. These provide the necessary strength and the usually retained for a period of one to two weeks. They are both natural as well as synthetic ones. A suture should have the properties, like good tensile strength, easy handling, good knotting security and minimal reaction with the body area in contact. Two types of sutures are presently available. They are the assimilated type such as catgut and the non-assimilated type such as silk or polyester filament. Catgut, the most used assimilated type and the oldest one is made from collagen, extracted from Ox bones. Silk is another natural material, which is used due to its biocompatibility. Now a days synthetic polymers area also used as suture material.

Polygly colic acid is used to make the multifilament or blended type of suture. It is normally coated with a plasticizer. Currently, it is used for heart surgery in order to withstand the high pressure within the heart. The most popularly used suture is poly butylene terephthalate because of its acceptable strength and smooth surface.[6, 7, 8,9]Recently a bi-directional barbed suture has been developed which obviates the necessity to tie a knot. It has ability to put tension in the tissues with less suture slippage in the wound, as well as to more evenly distribute the holding forces there by reducing tissue distortion. The barbed suture with a steeper cutangle and a median cut depth have a higher tissue holding capacity than those with a moderate cutangle and a nominal cut depth[10]. Transplantation is not always possible due to some reasons like availability, performance requirements, etc. Therefore doctors and physicians have to go for artificial substitutes. A foreign or synthetic materials or parts which are used to replace a body part are referred to as prosthesis. Normally, the common prosthesis is artificial tendon, corneas and skin patches. Tendon helps in connecting muscle to bone while ligaments connect bone to bone. The expected properties of tendon are tensile strength compatibility, porosity and flexibility. Chitin fibre, a polysaccharide is also used in the manufacturing of non-woven fabric and it is used because of its good adhesion to human body and its value in stimulating new skin formation. It is used in area of cosmetic surgery in repairing breast abnormalities as well as the women who are suffering from breast cancer. With this new development, it is possible to control size as well as shape various body parts[4,5].

This category includes artificial bones implant, bone cement and artificial joints. Fracture of a bone sometimes may result in the implantation of a fixation device such as plate, screw, pin or rod to temporarily stabilize or fix the bone in the correct position. The fixation devices currently used are made of metals, which may damage the bone. Plastic material are now a days used which are reinforced by fibres to create a so-called fibre-reinforced plastic. Heart disease is the major cause of death in the developed world, which accounts for nearly half of all deaths. The heart has one-way valves to maintain the forward flow of blood as it is pumped out of the heart. These valves may be abnormal at birth, or it may become damaged as a result of damage such as rheumatic fever or calcification due to aging. In addition, it should be resistant to infection and linkage around the valve. A prototype prosthesis valve is developed in this regards and it is constructed using textile materials and textile processes already in use in other textiles prosthesis. The valve is designed to mimic the human heart valve as closely as possible. The performance test shows that the valvular action resembles the action of natural heart valve leaflets. It also produces better performance in low-pressure drop across the valve, high flow through the valve and large effective opening area. In the case of repair of the rotator cuff of the shoulder, knitted hoods made out of polyester are now days used but they are now slowly and steadily changing to woven ones.[11] Graft may be defined as an artificial veins or arteries which are used to replace segments of natural cardiovascular system that are blocked or weakened. They are inserted in order to bypass the blockages and restore the circulation. Fibres used for vascular grafts are polyester and polytetrafluroethylene in the form of knitted and woven structure and for heart valve polyester. Fibre is used in the form of knitted and woven structure.[8,9]

Table 1 Implantable materials[12]

Fibre Type	Fabric Structure	Applications
Collagen, catgut, polyglycolide, polylactide	Monofilam-ent braided	Biodegradable sutures
Polyester, polyamide, polypropylene, polyethylene	Monofilam-ent braided	Non-biodegradable sutures
Polyester, silk, collagen, polyethylene, polyamide, PTFE	Woven braided	Artificial tendon
Polyester, carbon, collagen	Braided	Artificial ligament
Chitin	Nonwoven	Artificial skin
Poly(methyl methacrylate), silicon, collagen		Eye-contact lenses and artificial cornea
Silicone, polyacetyl, polyethylene		Artificial joint/bones
PTFE, polyester,	Woven, knitted	Vascular grafts
Polyester	Woven, knitted	Heart valves

b. Non-Implantable:

These materials are used for external applications on the body with or without skin contact.[4,5]

Table 2 Non-Implantable materials[12]

Fibre Type	Fabric Structure	Applications
Cotton, viscose, lyocell	Nonwoven	Absorbent pad
Alginate, chitosan, silk, viscose, lyocell, cotton	Woven, nonwoven, knitted	Wound contact layer
Viscose, lyocell, plastic films	Woven, nonwoven	Base material
Viscose, lyocell, cotton, polyamide, elastomeric	Woven, nonwoven, knitted	Simple non-elastic and elastic bandages
Cotton, viscose, lyocell, elastomeric	Woven, nonwoven, knitted	High support bandages
Cotton, viscose, lyocell, elastomeric	Woven, Knitted	Compression bandages

Viscose, lyocell, cotton, polyester, polypropylene, polyethylene	Woven, nonwoven	Orthopedic bandages
Cotton, viscose, plastic films, polyester, glass, polypropylene,	Woven, nonwoven, knitted	Plasters
Cotton, viscose, lyocell, alginate, chitosan	Woven, nonwoven, knitted	Gauze dressing
Cotton	Woven	Lint
Polylactide, polyglycolide, carbon fibre	Spunlaid, needle-punch nonwoven	Scaffold

Wound dressings: For many reasons, dressings have been a center of particular interest of medical services as well as the producers of dressing material. Dressings that adhere to the wound have a big influence upon the way and time of wound healing and also upon the psyche and general feeling of patients, resulting from the degree of arduousness of keeping these dressings and changing them. A dressing should possess the following properties:

- Healing properties, regulated mainly with the substances which are applied to dressing.
- Causing no mechanical injury of a granulating wound.
- Decreased adherence surface.
- Eliminating a possibility of loose fibres getting caught in the wound.
- Stable and spatial structure
- Easy penetration of wound secretion to the absorbing dressing.
- Not- interrupted process of wound healing - as only the outer gauze compress is changed.
- Painless changing of the dressing.

Wound dressing are used for protection against infection, absorption, exudation of blood and excess fluids, healing and medication. Traditionally, wound dressings are often made of cellulosic fibres such as cotton and viscose rayon fibres in the form of woven or non-woven gauzes. The advantage was that they were highly absorbent. But since the fibres structure is chemically, physically and biomedically inert to the wound-healing environment, the fibres remain integral during the course of the treatment. Due to rapid progress in the textile field, now days a number of natural polymers such as chitin, chitosan, alginate, pectin, etc. are used.

Sorbalgon is a supple, non-woven dressing made from high-quality calcium alginate fibres with excellent gel-forming properties. The dressing offers a number of practical therapeutic advantages for wound healing over any other commonly used textile material.

Figure 1 Sorbalgon dressing

Sorbalgon dressings absorb approximately 10 ml exudate per gram dry weight and are thus provided with a very high absorption capacity. They in addition differ from textile dressings with respect to the applied mechanism of absorption. Whereas, cotton gauze holds the absorbed fluid mainly between the fibres, the calcium alginates take up wound secretions directly into the fibres, i.e. using intracapillary forces. Germs and detritus are retained within the gel structure as the fibres swell during subsequent gelatinisation. The wound is thus effectively cleansed and a con-siderable reduction of micro-organisms can be attained. The gel remains

permeable to gas so that sorbalgon represents a dressing material that facilitates a permeable moist wound treatment. Sorbalgon may generally be used for the treatment of all external wounds, but its application is mainly recommended for bleeding and secreting injuries that support the wound-healing effects of gel formation. sorbalgon offers an especially painless and atraumatic dressing change, which is of great importance with this type of wounds.

Bandages: Bandages are mainly used for orthopedic purpose. There is a wide range of bandages available for various purposes. Although bandage tension and sub-bandage pressure are determined in the initial stages by the user during the time of application, the ability of a bandage to maintain this tension is determined by electrometric properties under normal conditions of use.

Protective Clothing: Prevention of anthrax: Textile materials can be used as a protective medium to prevent the infection due to the anthrax. Anthrax infection requires spores to be carried in ambient air and inhaled into the lungs or are prevent on surface which can be easily picked up by skin contact and then enter the body through small cuts in the skin. Protective clothing of textile material has been developed for people who usually come into contact with harmful bacteria, viruses or chemicals. Mostly protective clothing includes suites, gloves, boots and hoods. Protective suits, which are impermeable to air, and water vapors have been developed but suffers from the limitation that sweat and therefore heat cannot be removed from the surface of the skin. The alternatives are most fabrics, which are permeable. The common example is of battledress over garments (BDO), which consists of two different layers. The outer layer is made of 50% nylon and 50% cotton. While the inner layer is made of polyurethane foam impregnated with activated carbon and laminated on the inner side with nylon-tricotton knit.[13]

2. Extracorporeal

Extracorporeal mainly deals with artificial organ, which are made from specialized textile implants that can function as a part of human body. The kidney, heart and lung are the main area of this category.

Table 3 Extracorporeal devices[12]

Fibre type	Applications	Function
Hollow polyesre, hollow viscose	Artificial kidney	Remove waste products from patients blood
Hollow viscose	Artificial lever	Separate and dispose of patient's plasma and supply fresh plasma
Hollow polypropylene, hollow silicone membrane	Mechanical lung	Remove CO_2 from patients blood and supply fresh oxygen

3. Healthcare Products

The protective health care textiles include operating and emergency room textiles, barrier products, breathable membranes, surgeons and nurse's masks, uniforms, footwear, coats, etc.

Table 4 Healthcare/hygiene products[12]

Fibre Type	Fabric Structure	Applications
Cotton, polyester, polypropylene	Woven, nonwoven	Surgical glowns

Viscose, Polyester, glass	Nonwoven	Surgical mask
Viscose	Nonwoven	Surgical caps
Polyester, polyethylene	Woven, nonwoven	Surgical drapes and cloths
Cotton, polyester, polyamide, elastomeric	Knitted	Surgical hosiery
Cotton, polyester	Woven, knitted	Blankets
Cotton	Woven	Sheets and pillows
Cotton, polyester	Woven	Uniforms
Polyester, polypropylene	Nonwoven	Protective clothing, incontinence
Superabsorbent fibres	Nonwoven	Absorbent layer
Polyethylene	Nonwoven	Outer layer
Viscose, lyocell	Nonwoven	Cloths/wipes

III. Requirements of Textile Material for Medical Applications

- Biocompatible
- Good resistance to alkalis, acids and micro-organisms
- Good dimensional stability
- Elasticity Free from contamination or impurities
- Absorption / Repellency
- Air permeability

Due to progress in Medical sciences, average age is rapidly increasing. Elder people also would like to spend an active life despite their age. Various new medical technologies are coming up to enhance function and independence of senior citizens of the country- such as smart prosthesis, monitoring devices. These technologies are likely to be expensive. But Medical textile products, such as adult diapers, are quickly gaining popularity among older persons so that they remain independent and functionally active. One challenging problem is how to develop an adult diaper, which is low weight and retain fluids for at least one whole day, without causing discomfort to the user[15].

IV. Trends in World Trade of Medical Textiles

The market for medical textiles is being driven by a number of factors:

- Population growth rates, particularly in newly developing global regions.
- Changes in demographics, including the ageing of the populations in the Western European market.
- Changes in Living standards
- Attitude to health risks: increased awareness of the risks to health workers from health threats from blood borne diseases and airborne pathogens
- The growing dominance of purchasing which demands increasing value of the money.
- The increasing share of nonwoven on the medical world market in relation to traditional textile materials

These trends will be further fed by the increasing development of the medical textile market and industry.

Table 4 Estimated market sizing for Meditech (2012-13)[17]

Sr. No.	Item Description	Domestic Consumption

		(estimated) Rs. in Crores
1	Surgical Disposables	42
2	Surgical Dressings	1000
3	Sutures	415
4	Artificial implants	249
5	Baby Diapers	193
6	Incontinence Diapers	46
7	Sanitary Napkins	1300
	Total Value	**3245**

V. Conclusions

Medical textiles are one of the most dynamically expanding sectors in the technical textile market. Medical Textile Competence Centers are being established to make the most of knowledge, expertise and existing collaboration with medical researchers, microbiologists, physiologists and textile scientists. Each country has its own regulations and standards for medical textiles. As medical procedures continue to develop, the demand for textile materials is bound to grow.

VI. References

[1]. http://web.iitd.ac.in/~sghosh08/images/medical_textiles_kanpur.pdf
[2]. *Man–Made Textiles in India*, Vol. XLIV, November 2001.
[3]. *Man–Made Textiles in India*, Vol. XLI (4), April 2013.
[4]. *Man-Made Textiles in India*, Vol. XLIII, April 2000.
[5]. *Man-Made Textiles in India*, Vol. XLI, June 1998.
[6]. *Man-Made Textiles in India*, Vol. XLIII, January 2000.
[7]. Hongu, T.; Philips, G. O., "New Fibres", 2nd Edition, p 130-142
[8]. *The Indian Textile Journal*, Vol. CXI, November 2000.
[9]. *Textile Asia*, Vol. XXXII, October 2001.
[10]. www.fibre2fashin.com
[11]. *Textile Asia*, Vol. XXXII, November 2001.
[12]. Textile Progress, 2002.
[13]. *Textile Progress*, Vol. 29, 1999.
[14]. http://textilelearner.blogspot.in/2012/02/introduction-of-medical-textiles.html)
[15]. http://web.iitd.ac.in/~sghosh08/images/medical_textiles_kanpur.pdf
[16]. NWDA Northwest Textile Cluster, Mapping Project, DRA, 2001.
[17]. http://technotex.gov.in/Health%20care%20Industry.pdf