1.0 Introduction:

Nonwovens are developed to impart special properties to products. Here, the advantage of nonwovens compared with textiles, such as fabrics, is the high economic efficiency of production and their performance capability while at the same time offering lower weights. In order to be competitive today, nonwovens producers must show high productivity at low cost. At the same time, the market demands higher quality. In the medical and sanitary domain, the use of appropriate fibres is an important condition for obtaining the required properties. Products free of binder and chemicals are preferred in this particular branch of industry.

2.0 FIBERS USED

For the production of nonwovens for the medical and sanitary domain and for products in the personal and health care and the cosmetic area, mainly 3 fibre types are used: cotton, rayon and wood pulp, cotton linters.

Wood pulp fibres for impart the desired properties to the products and stand out for many advantages compared with synthetic fibres while the presence of medical and hygienic nonwovens. Since most of them are disposable products, the question of resources must stand at the beginning of our reflections.
2.1 COTTON

Cotton is the purest form of cellulose that can be found in nature and excels the physical and chemical homogeneity of any other vegetable fibre. Cotton is a highly absorbent fibre and therefore suited very well for absorption of body fluids such as urine, blood and other fluids. It is used for bandages and wound dressings, absorbent pads, tampons, sponges, swabs. Cotton also offers the positive property of being a naturally breathing fibre. I.e. it largely prevents the passage of fluids and water vapor pass. With this property cotton is also predestined for surgical gowns and drapes. Wet state, cotton has a higher strength favorable for health care applications requiring skin contact. The quick water absorption by cotton is caused by the structural network of micro fibrils; this makes cotton particularly interesting for applications were liquids have to be removed from surfaces. Moreover, cotton offers an excellent resistance to heat as well as dimensional stability and strength even at temperatures of up to 175°C. This fibre has renewable resources and is bio-degradable.

In the past, the use of cotton for the medical industry often failed because of the higher price as compared with viscose, for example. The price of cotton varies depending on quality and crop yield, as it is natural fibre. Cotton is characterized by the following excellent properties: absorbency, biodegradable, breathable, drape, easily sterilized, heat resting, high wet strength, insulating properties, non allergenic, renewable resource, softness and water retaining capacity.

Cotton with a staple length of 7-25 mm is used for nonwovens products. Where mainly volume and absorbency of the products are required, linters and comber noils are used. Bleached cotton is employed which provides the fibre with good absorbency, but makes it more difficult to handle on a card because the fibres can break and naps can form. In many cases viscose or polyester blended with cotton is therefore used. With all the above properties cotton is particulars suitable, for wiping cloths that are bonded by spunlacing technology; Because of its high absorbency, a good fabric – like structure with low linting tendency and its high wet strength cotton is highly suitable for the hospital and medical domain, for industry, cosmetics, consumer and wet wipes. Special applications such as in the computer industry, for cleaning of lithographic plates etc. enlarge the scope of applications.

Spunlaced cotton webs can very well be dyed, printed and finished. The repeated wash ability of cotton spunlace products also specks in favour of these webs. The spunlace technology is highly suited for the production of composites with fabric and woven goods or reinforcing scrims. The main cause for cotton being particularly well spunlaced is the low wet modulus of the fiber allowing it to easily react to the water jets. Cotton does not have a round smooth fibre cross- section. This results in additional frictional resistance which improves fibre adhesion after fibre entanglement. The use of unbleached cotton for the spunlace process offers advantages: The fibre is cheaper than a bleached quality and the spunlace process removes substances such as oils or wax from the fibre so that finished. Spunlaced cotton of a low micronaire obtains a higher tensile strength, but offers a stiffer touch than cotton of a high micronaire.

Cotton treated by the spunlace, process cannot only be used in the medical industry, but also with good results for semi durable sheets napkins and table cloths that can be washed 6-10 times. Spunlaced cotton nonwovens are very frequently produced in Japan with weights of 30-250 g /m² for wet wipes, medical applications, gauzes and cosmetics (Olikos, Miracle Cotton).

2.2 VISCOSE

Viscose consists of cellulose like cotton. Cellulose is obtained from wood and is used for the production of rayon and cellulose acetate fibres. Hence rayon is synthetic fibre produced from regenerated cellulose. Considering the constantly growing environmental awareness, the possible decomposition of nonwovens gains more and more importance which also promotes the use of rayon. The product advantages are similar to those of cotton: skin tolerance, physiological safety, decomposable, good moisture absorbency and simple finished. For cotton products mostly blends of viscose and cotton are processed, for the production of tampons, but also 100% viscose fibres. For the use of viscose in the hygienic do main of for medical purposes further advantages can be made use of. These webs are lint free as opposed to cotton textiles for surgical gowns. In the field of wiping cloths viscose is of great importance. It is certainly the essential property of wiping cloths to absorb fluids and accumulate them, i.e. absorption and retaining capacity.
Depending on the field of application, Medical and hospital wipes, wet wipes. Refreshing tissues, household wipes and industrial wipes. In many cases blends with polyester or polypropylene are used to obtain certain characteristics. Absorbing gauze for medical and surgical applications the advantages of spun laced viscose fibre webs is also obvious. The market of needled and thermally bonded household wiping cloths made of spundyed viscose staple fibres should not be forgotten, nor did the technical non-woven make of modified viscose fibre type having antistatic, flame resistant or gas absorbing properties.

2.3 WOOD PULP

Wood pulp consists of cellulose fibres made from wood. This is the most frequently used fibre worldwide. In the wood pulp works the cellulose fibre is produced by alkaline cooking or cooking with acid sulfite. The fibres are gained by dissolving of lignin which keeps the fibres together and can then be used for the production of nonwovens. The fibres are dried to about 10% and sheeted in bales or supplied in rolls of so-called paper-board of various widths and diameters. Wood fibres are hydrophilic; a saturated fibre contains between 33 and 35% of water. This property again is decisive for use in the production of nonwovens for medical purposes. Cellulose pulp is used mostly. The main use of pulp is found in the production of absorbent disposables such as diapers, sanitary napkins, incontinence diapers. Another application is wiping cloths for the medical domain and industry, in particular for the graphic industry where also the absorbing property is desired. Another application is the consumer domain with the use of table cloths, napkins, tissue etc, and the hospital domain with surgical drapes, bed sheets, and surgical gowns. Often blends with synthetics used for the latter application. Pulp like cotton and rayon is a fibre type with renewable resources and excellent bio-degradability.

2.4 COTTON LINTERS:

Cotton linters can become an alternative for the disposables market. Considering the cost, cotton can certainly not replace pulp, but cotton could make a contribution in the future. When producing nonwovens from fibres, which are placed on belt while distributed in the air flow, also bicomponent fibres in short staple form could be used besides wood pulp and cotton linters.

3.0 MEDICAL TEXTILES

MEDICAL TEXTILES

- Implant able Medical Textiles
  - Materials used in repair to the body for dressing would closure or replacement surgery like vascular grafts, artificial ligaments etc.
  - Artificial skin, Eye contact lenses, Orthopedic implants Artificial joints / bones Heart valves.
- Non –Implantable Medical Textiles
  - Primary wound absorvent bandages
  - Protective eye pad adhesive tapes
- Extra corporal Devices
  - Artificial kidney products used in - Artificial heart - Mechanical lung
- Healthcare/ Hygiene products
  - Healthcare operation theatre, hospital wards for hygiene, care and safety of the staff and patients
3.1. IMPLANTABLE MEDICAL TEXTILES:

The materials are used in effecting repair to the body whether it is wound closure (sutures) or replacements. Surgery like vascular grafts, artificial ligaments, etc. There are of many shapes and sizes, for duplications as found in human body. Filament texturised yarns used nowadays, which are coated to prevent leakage of blood while tissue, is forming on the inner walls.

- Carbon fibre is a popular material for tissue repair.
- Suspensory and reinforcing surgical meshes are used in plastic surgery for repairing defects of the abdominal wall. Surgical treatments of hermia in Urology etc…
- Hydrophobic sanavel felt dressings are high porosity textiles made from man- made fibres designed for treatment of burns and different dermatological defects.

Generally the following bonding processes are used for nonwovens made of pulp fibres: thermal bonding, binder bonding, combined bonding, spunlace bonding.

**Table 3.1.**

<table>
<thead>
<tr>
<th>Products</th>
<th>Collagen, polyactide, polyglycoide</th>
<th>Mono filament braided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sutures</td>
<td>Collagen, polyactide, polyglycoide</td>
<td>Mono filament braided</td>
</tr>
<tr>
<td>Bio – degradable</td>
<td>Polyamide fiber, polyamide fiber,</td>
<td></td>
</tr>
<tr>
<td>Non- Bio degradable</td>
<td>Polytetrafluoroethylene, polypropylene fiber, steel, polyethylene</td>
<td></td>
</tr>
<tr>
<td>Soft – issues</td>
<td>Polytetrafluoroethylene fiber</td>
<td>Woven</td>
</tr>
<tr>
<td>Artiﬁcial tendon</td>
<td>Polyester fiber, polyamide fiber</td>
<td>Braided</td>
</tr>
<tr>
<td>Artificial ligament</td>
<td>Carbon fibre</td>
<td></td>
</tr>
<tr>
<td>Artiﬁcial skin</td>
<td>Silicon, nylon, polypeptides, silicon, collagen / glycosaminoglycans/ hybrid skin equivalents</td>
<td></td>
</tr>
<tr>
<td>Eye contact lenses /</td>
<td>Polyamide fiber, polyamide fiber</td>
<td></td>
</tr>
<tr>
<td>Artificial lumen</td>
<td>Natural skin equivalent (dried pig skin, collagen, chittia)</td>
<td></td>
</tr>
<tr>
<td>Orthopedic implants</td>
<td>Polyamide fiber, polyamide fiber</td>
<td></td>
</tr>
<tr>
<td>Artificial joints /bones</td>
<td>Carbon fibre, polyethylene terephthalate glass ceramic</td>
<td></td>
</tr>
<tr>
<td>Cardio vascular implants</td>
<td>Polyester fibre</td>
<td></td>
</tr>
<tr>
<td>Vascular grafts, heart</td>
<td>Polytetrafluoroethylene fiber,</td>
<td></td>
</tr>
<tr>
<td>valves</td>
<td>Polyester fibre</td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

3.2. NON – IMPLANTABLE MATERIALS:

These materials are used for external applications on the body and may or may contact with skin. They are made form co-polymer of two amino acids. They are employed as covering, absorbent, protective and supports for injured or diseased part. They are different types.

3.2.1 PRIMARY WOUND DRESSINGS:

Placed next to the wound surface. Nonwoven with a binder content of 60% and made from cellulose fabrics are being used.

3.2.2 ABSORBENT:

Similar to wound pads used in surgery. Manufactured from well-bleached, carded and cleaned cotton fabrics.
3.2.3 BANDAGES:

These are narrow cotton or linen, plain weave cloth of low texture, either woven or knitted. Ex: Plaster of Paris Bandage, orthopaedic bandage, crepe Bandage.

3.2.4 PROTECTIVE EYE PAID:

Scientifically shaped 2 ¾” x 2 ¾” x to fit over the eye used in outpatient clinic and industrial medical department.

3.2.5 ADHESIVE TAPES:

It is narrow, plain weave fabric having a coating of adhesive paste. It is used with other pads to conform them to the injury.

Table 3.2

<table>
<thead>
<tr>
<th>NON – IMPLANTABLE MEDICAL TEXTILES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound care absorbent pad</td>
</tr>
<tr>
<td>Wound contact layer base materials</td>
</tr>
</tbody>
</table>

| Bandages | Simple inelastic/ Elastic light support Compression | Cotton viscose polyamide fiber, Elastomeric-fiber yarns, cotton, viscose, electrometric fiber, electrometric fiber yarns | Woven, knitted, Non – woven Woven, knitted woven Knitted |
| Orthopedic | Cotton, viscose Polyester fibre, Polypropylene fibre, polyurethane foam | Woven , non-woven |
| Plasters | Viscose, pastes film, polyester fibre, glass fiber, polypropylene fibre | Knitted woven Non woven |
| Gauze’s | Cotton, viscose | Woven, non-woven |
| Lint | Cotton | Woven |
| Wadding | Viscose, cotton, linters, wood pulp | Non-woven |

3.3. EXTRA CORPOREAL DEVICES:

Extra corporal devices are mechanical organs that are used for blood purification and include the artificial kidney, the artificial liver and the mechanical lung.
3.3.1. ARTIFICIAL KIDNEY:

- Tiny instrument, about the size of a two-cell flashlight.
- Made with hollow hair-sized cellulose fibres or hollow polyester fibre slightly latest than capillary vessels.
- Fabric which is used to remove waste products from patient’s blood.

3.3.2. ARTIFICIAL LIVER:

Made with hollow viscose to separate and dispose patients plasma and supply fresh plasma.

3.3.3 ARTIFICIAL HEART:

- An 8-ounce plastic pump lined with dacrom velour to reduce damage to blood and is a chambered apparatus about the size of a human heart.
- Silastic backing makes the fabric imperious to emerging gas that is not desirable in the blood.

3.3.4 MECHANICAL LUNG:

- Made with hollow polypropylene fibre or a hollow silicone membrane.
- Used to remove carbon-di-oxide from patient’s blood and supply fresh oxygen.

3.4. HEALTH CARE TEXTILES

An important area of the textiles is the health care and hygiene sector among other medical applications. The range of products available for health care and hygiene is vast, but they are typically used either in the operation theatre or in the hospital wards for hygiene, care and safety of the staff and patients.

Table 3.4.

<table>
<thead>
<tr>
<th>HEALTH CARE/ HYGIENE PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Application</td>
</tr>
<tr>
<td>Surgical clothing</td>
</tr>
<tr>
<td>Gowns caps masks</td>
</tr>
<tr>
<td>Surgical covers</td>
</tr>
<tr>
<td>Drapes cloths</td>
</tr>
<tr>
<td>Bedding blankets</td>
</tr>
<tr>
<td>Sheets pillow cases</td>
</tr>
<tr>
<td>Clothing uniforms</td>
</tr>
<tr>
<td>protective clothing</td>
</tr>
<tr>
<td>Incontinence diaper / sheet</td>
</tr>
<tr>
<td>cover stock</td>
</tr>
<tr>
<td>absorbent layer other layers</td>
</tr>
<tr>
<td>Cloths / wipes</td>
</tr>
<tr>
<td>Surgical hosiery</td>
</tr>
</tbody>
</table>

Generally the following bonding process is used for nonwovens made of pulp fibres. Thermal bonding, binder bonding, combined bonding, spunlace bonding.
4.0 PRODUCTS USED FOR MEDICAL SURGICAL DRESSINGS

4.1. Wound care products:

A wound dressing is used for many purposes including protection against infection, absorption and exudation of blood and excess fluids, healing and application of medication ideally a wound dressing should be soft pliable pad the wound to protect it from further injury, be easily applied and removed, be sterile lint free and non – toxic. The wound dressing should not adhere to the wound allowing easy removal without disturbing new tissue growth.

An absorbent cotton swab placed at the wound and tied with gauze forms the oldest form of wound dressing. However, this traditional method of wound covering is found to stick to the wound and does not provide a moist microclimate to the wound conducive to its faster healing.

The modern wound dressing is usually made of three layers-

(a) **Wound contact layer**: - It should not stick to the wound or cause maceration of the skin if the dressing is not changed. It can be woven, knitted or non-woven made from silk, viscose, polyamide or polyethylene.

(b) **Middle absorbing layer**: - If has to absorb blood or liquids while providing a cushioning effect to protect the wound. It is generally a non-woven composed of cotton or viscose.

(c) **Base Material**: It provides a means by which the dressing is applied to the wound. The material is coated with acrylic adhesive to hold the dressing in place, eliminates the need for bandage.

Because sterilization is a major concern for surgical dressings, nonwovens are considered. Nonwovens can be smooth and lint-free for the most part. This allows lesser chance for debris to be left at the wound. Nonwoven can be made softer and more absorbent by latex or thermal calendaring.

For post–operative dressing, sophisticated nonwoven structures such as perforated films on absorbent base, polymers/nonwoven welded laminate and metalised nonwoven are used. Polypropylene is promoted as most unwettable fibre, but it can also be quite wettable if converted to a fibrous web by melt blowing. In melt blowing a stream of molten polymer is subjected to blasts of air which form tiny fibrils that fall randomly as a web. This gives polypropylene a role of absorbable dressing’s material. Traditionally polypropylene is used in wound dressings in fibre or fabric form, coupled with absorbent material.

Polysaccharide based dressings have increasingly become viable alternative to biologically incompatible and often problematic cotton and viscose gauzes used for wound dressings. Abundantly available alginites and their relatively ease of solubility in particular have been instrumental in developing these fibres and their applications as vehicles for drug delivering. The other polysaccharide is Branan ferulate that is gel spun. It is extracted from corn bran and has water soluble properties. This polysaccharide can infiltrate the biological activities in the body and hence accelerate wound healing.

4.2. BANDAGES:

Bandages are designed to perform a whole variety of specific functions depending upon the final medical requirement. They can be woven, knitted, non – woven or composite in structure. They can be classified into various classes depending upon the function they serve as.

(a) **Simple bandages** – These are fixation bandages that can be elastic or inelastic in nature. Adhesive bandage, cohesive bandages and tubular bandages belong to this class. A simple non – elastic bandage is required to the dressing in proper place over the wound. One such bandage is simple, open weave cotton or viscose fabric cut into strips which have been scoured, bleached and sterilized. The problems of fraying in the plain woven bandage are overcome by use of non-fraying cotton leno bandage. The structure of bandage is more stable with crossing warp threads in the leno woven structures. These can be further coated with paraffin to prevent sticking of the bandage to the wound. Further some ointment dressing can
also be given along with paraffin to aid faster healing of the wound. Elasticated yarns are incorporated into bandages to form elastic bandage for providing support and comfort.

(b) **Light support bandages** – Woven light support bandages are used for sprains or strains. Elastic crepe bandages are used for sprained wrist or ankle support. The elasticated properties of these bandages are obtained by weaving cotton crepe yarns that have twist content. Similar properties can also be achieved by combination of two warp sets with normal and high tension. Stretch and recovery properties of these bandages apply sufficient tension to support the sprained limb.

(c) **Compression bandages** – Compression bandages are used to exert a certain compression for the treatment and prevention of deep vein thrombosis, leg ulceration and varicose veins. Depending upon the compression they provide, compression bandages are classified as light, moderate, high and extra – high compression bandages. They can be woven, warp or weft knitted from cotton and elastomeric yarns.

(d) **Orthopaedic bandages** – These bandages are used under plaster casts and compression bandages to provide padding and prevent discomfort. Non – woven orthopaedic cushion bandages are made from polyester or polypropylene and blends of natural and synthetic fibres. Polyurethane foam can also be used. Light needle punching gives bulk and left to the structure for greater cushioning effect.

Knitting is commonly used for manufacture of bandages in tubular form with varying diameters. The weft knitting machine is chiefly used for production of two classes of medical textiles. Viz., support bandages and elastic bandages. Tubigrip is an example of circular weft knitted cotton fabric with rubber yarn laid – in, manufactured in tubular lengths of different diameters. Since these garments are to be continuously worn, the seams should be strong enough to resist strong transverse forces. Also the seam should have high extensibility and recovery to allow for body movement.

Similarity, the warp knitting machines is used to manufacture mainly the wound dressings, bandages and vascular grafts. The tubular structures can best be produced on circular warp knitting machines. However, these are traditionally produced on double bar Rachel machines due to the limitation of patterning on these machines. With the new developments of electronically controlled flexibility in production of various tubular medical devices has been achieved.

Fabric shaping can be controlled by modifying the structure of fabric within the garment or altering the stitch length. In bandage applications control of elasticized yarn can be made using such electronically controlled pattern ring to alter the underlap or the stitch length being knitted. Circular warp knitting machines can be used for making stockings that can be sued provide pressure gradients along the leg after surgery aiding blood circulation. Electronic speed monitoring and variable speed drive to the let – off for the feed packages have helped to obtain consistent yarn quality. Spacer knitted fabrics can be used as bandages in normal or composite form.

**4.2.1. PRESSURE GARMENTS FOR HYPERTROPHIC SKIN**

This is a special class of bandages used for healing wounds caused by burns. Pressure garments are made by using a variety of elastic fabrics and can be simple tubes to fit individual limbs or full garments if the burn area is large. These garments are useful for the care of burnt skin area for cuing of scars. The generated pressure on the affected area should help alleviate the itching of the scars. The average pressure to be applied to the treated tissue area is about 25 mm of Hg. During this burns rehabilitation process the pressure garment has to be worn continuously may be for periods as long as 12 months. There is a wide range of pressure garments due to the varying size of the patients and the different methods of fitting the garments by the therapists. So it is best for the hospitals to buy the pressure fabrics and make garments to suit the patient’s needs.
Two main types of fabrics are currently used for making pressure garments.

- Firm elastic fabric containing elastane yarns is used for making pressure garments. This fabric is usually warp knitted.

- Tubigrip is a circular weft knitted cotton fabric with rubber yarn laid in, tubular lengths of different diameters. Since these garments are to be continuously worn, the seams should be strong enough to resist strong transverse forces. Also the seam should have high extensibility and recovery to allow for body movement.

In the various suitable fabric structures and garment constructions, the following have been established:

'Fabrics with low coefficient of friction are more comfortable than those with high coefficient of friction and are less likely to cause maceration. Hence, powernet, sleeknit fabrics are found to be more suitable as compared to weft or warp knit fabrics. However, the deviation in the coefficient of friction was found to be quite high for almost all fabrics. The face side of all fabrics was rougher than the reverse side. Hence an optimum construction is to be arrived at for comfort and recovery of the patient.

4.3. GAUZE:

Gauze and paraffin coated gauzes are the most commonly used dressing. Most gauze is made up from cotton in the form of a loose plain weave. The typical yarn density per inch is 12 – 19 for warp and 8 – 15 for the weft. 44ºNe warp and 54ºNe carded weft yarn is generally used. Gauze is mostly used as a direct dressing for wounds or may be used in internal pads and general swabbing applications. The burns and skin grafts have their dressings changed frequently and the difficulty with this gauze is that its fibres stick to the wound. The removal is not only painful, but also destroys the regenerating tissues. This leads to delay in healing process and also leaves scars behind. The problems associated with the traditional woven cotton gauze are as below:

- A possibility of loose fibres getting caught in the wound
- A large adherence surface
- Irritation or mechanical injuring of the wound when the dressing is changed.
- Prolonged time of wound healing

Paraffin – coated gauze is usually multi-layered, is a little easier to remove, but it does not rapidly absorb the wound liquids. Also this being a petroleum based coating can liquefy at body temperature and introduced foreign matter into the wound. It is used to treat burns and scalds.

4.4. PLASTER:

Plasters are made up of three layers – 1) Plaster fabrics, 2) adhesive and 3) – wound pad. A simple plaster cast consists of gauze impregnated with plaster of Paris. The modern plaster fabric is made from spun bonded nonwovens of cotton, viscose, polyester or glass fibre. The adhesive used for plaster fabric is acrylic that doesn't stick to the skin. The cushioning wound pad is made from knitted viscose fabric impregnated with an antiseptic. The highly absorbent wound pad helps in rapid absorption of secretion from the wound.

4.5. OTHERS DRESSINGS:

The other surgical dressings include wadding and lint. Wadding is an absorbent material to prevent adhesion to wound or fibre loss, it is covered with a non – woven fabric. Lint is a plain weave cotton fabric that is frequently used in treatment of mild burns.
5.0. CONCLUSION:

Form the above depiction of the various available for medical purposes, it can be seen that there are a wide variety of fibres used for the purpose. The technology of manufacture also ranges from woven, knitted, non-woven and composites. The improvements in the non-implantable products have been directed towards faster healing of the wound and minimising discomfort to the patient. The uses of haemostatic fibres like polysaccharides help faster wound healing. The present day wound covering doesn’t stick to the wound and hence prevents its maceration.

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