HOME TEXTILE

Introduction

- Home textile = home + textile technology
- Home textile is a branch of technical textile containing application of textile in household purpose.
- Home textile are mainly used for their functional and aesthetic properties which provides us mood and also gives mental relaxation to the people.

What is technical textile?

- A technical textile is a textile product manufacture for non aesthetic purpose where function is the primary criterion.
- Technical textile is a very large and growing sector and supposed a vast array of other industries.

Fabric used in home textile?

- Polyester fabric
- Plastic fabric
- Leather fabric
- Satin fabric
- Organza fabric
- Organdy fabric
- Silk fabric
- Cotton fabric
- Jute fabric
- Wool fabric
- Rayon fabric
- Nylon fabric

Need of textile at home?

- Fabric affords sun and light control.
- Fabric prevents interior color from fading.
- Fabric prevents deterioration through sunlight.
- Protects eyes from glare.
- Protection from night blackness at evening and too-early sun in the morning.
- It can make summer room cooler and reduce air-conditioning load.
- Increase livability and workability of small space.
- It also reduces noise; make music even speech richer and more resonant.

List of home textile:

- Textiles for seating
- Window textile
- Sun filters
- Semi sheer
- Reflective textile
- Curtain fabrics and
- Drapes
- Blinds
- Bed textiles
- Sheet and pillowcases
- Blankets
- Quilted textiles
- Bed spreads
- Mattress covers
- Fabrics for wall
- Coverings
- Bathroom textiles
- Shower curtains
- Terry towels
- Table textile
- Tablecloth
- Tablemats

Classification of home textile?

Sheets and Pillowcases:

- References to sheets and pillowcases are generally related to fabrics woven with a plain weave of cotton, or more often, cotton/polyester blended yarns. If they have easy care, no-iron properties, they are likely to be so labeled. It may be noted that sheets and pillowcases are also made to a laminated extent of linen, silk, acetate, and nylon; the constructions vary from plain to satin weave or knitted.

Blankets:

- Blankets are made of various constructions and compositions, which provide different degrees of warmth, softness, and durability. They are usually woven, but can be knitted or stitch-knitted or by flocking fibres onto a polyurethane foam base. The yarns may be composed wholly or of blends of cotton, wool, nylon, acrylic, or polyester.

Terry Towels:

- The primary function of a terry towel is to absorb moisture from wet skin. It must, however, be strong enough to withstand the strain of the rubbing and pulling, twisting and tugging of the user, and of constant laundering. Terry towels are made either of all-cotton, or a combination of cotton and polyester. While polyester provides increased strength, lighter weight, faster drying after laundering and less shrinkage, all-cotton towels provide greater absorbency.

Table cloth:

- Table cloths are generally made of cotton, linen, rayon, polyester, or blends of any combination of these fibres. They are produced in various ways, designs, and patterns. Among the most popular are damask and lace constructions. Of the damask, linen is the most expensive and has set the mode or style frequently imitated with the less costly fibres. Although linen damask generally requires greater care of laundering and ironing than such easy care finished cloths as are made from cotton/polyester blends, linen damask tablecloths continue to enjoy a high status because of their beauty, luxuriousness, and durability.

Carpets and Rugs:

- Floor coverings have been made from textile fibres for more than five thousand years. Throughout civilization, rugs and carpets have formed a part of the history and culture of races and nations. Well chosen rugs and carpets serve as a colorful foundation for the decorative plan and color scheme of all rooms in the modern home including kitchen, bathrooms, patios and pool edges, as well as for schools, office buildings, and hospitals. Carpets also serve as heat and sound insulators.

Properties of home textile:

Excellent light fastness

Good fastness to sponging

Fastness to crocking (dry and wet)

Resistant to pilling

Resistant to snagging

Flame retardency

Stain repellency

Appearance retention


Thank you

Marine textiles

Introduction

- Activity of marine and human have existed long way back from the time before civilization and there has been continuous up gradations till date.

- Textiles used in the marine applications are sailcloth, ropes, boat coverings, awnings, flags, safety equipment including life jackets and inflatable life rafts, Boat covers, Decorative trim, exterior upholstery, flooring, headliners, Ropes, Nets, Fabric, Coated Fabric & composites etc.

✓Glass and carbon reinforcing fibers in an epoxy matrix are projected to weigh 75% less than the traditional steel shafts and offers,

✓The advantages of Fiber composites are corrosion resistance, low bearing loads, reduced magnetic signature, higher fatigue resistance, greater flexibility, excellent vibration damping and improved life-cycle cost.

✓Development of composite replace the heavy weight metal structures and complicated designing involving large man power.

✓Fiber-reinforced composites often aim to improve the strength to weight and stiffness to weight ratios.

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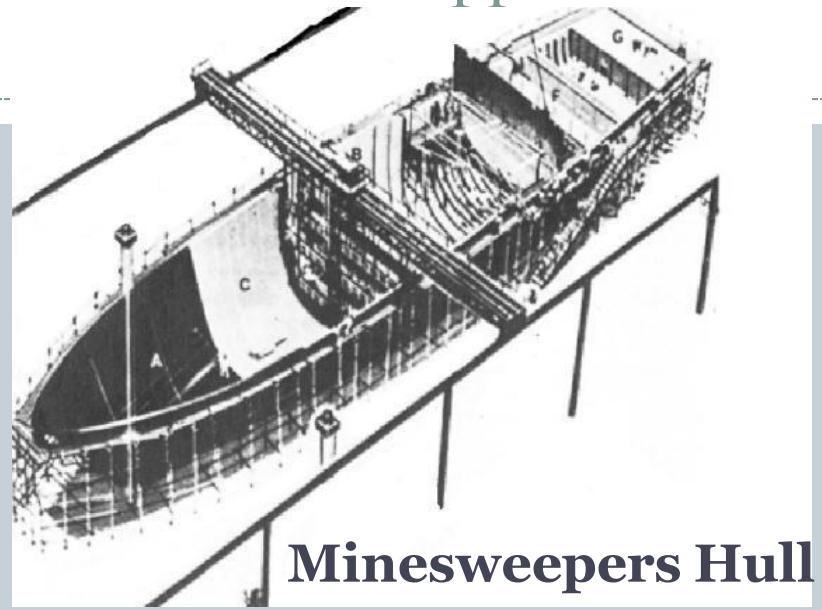
Fiber Properties Necessary for Marine application

- UV degradation
- Abrasion resistance
- flame resistance
- soil resistance (Easy to clean)
- Resistant to bacteria and microorganism
- high tear & tensile strength
- Softer handle and touch
- Very high bursting strength (sails)
- hydrophobicity
- Sea (salt) water resistance

vigneshdhanabalan@hotmail.com

Various Application of Textile in Marine Environment



Minesweepers Hull

- Glass reinforced polymers are well established in the boat-building industry, having been used since the late 1940's.
- Their characteristics of light weight and high strength, design flexibility, and low thermal conductivity are very advantageous in this application.
- maintenance and repair costs are reduced.

- The most important advantage is their excellent resistance to the marine environment.
- Kevlar (DuPont) is also used in combination with glass fiber.
- More preferred Fibers are(E-glass, C & S Glass, Carbon, Kevlar), Resins (Epoxy, Polyester)

vigneshdhanabalan@hotmail.com

Sails

- ✓ The first sails were made from woven natural fiber fabric sewn together.
- ✓ Synthetic fabrics were used because of their advantages of greater strength and resistance to micro-organisms and mildew, minimal water absorption and less distortion.

- ✓ Kevlar and even carbon fibers are also sometimes used for high strength with low weight.

The crucial requirements for sail cloth are:

- ❖ Lightweight, dimensional stability
- ❖ Puncture resistance, high tear, Burst, & seam strength,
- ❖ Low porosity (i.e. good cover) and low water absorbency
- ❖ Good resistance to microbes and UV degradation and smoothness

Inflatable craft

- Inflatable craft have become widely used since around 1960.
- They are used as pleasure craft, as freight carrying vessels, rescue crafts and life boats

- Good tear strength is important to prevent propagation of any damage.
- The skirt material (Nylon, Polyester, Aramid) fabric coated with a Hypalon polyurethane, polychloroprene , natural rubber ,PVC or combination blend compounded for water & oil resistance.
- Polyester‘s higher yarn modulus gives it more disadvantages than nylon. It is usually more difficult to bond rubber coating.
- Aramid fibers may be used if cost allows as significant amount of weight can be saved.

Hovercraft skirts

- ✓ Hovercraft skirt are similar as the Inflatable craft
- ✓ Nylon is the best overall fiber for this application.

Wasp and Paddle

- ➢ Wasp is especially safe and easy to paddle due the hull structure.
- ➢ To build Wasp with three layers of Kevlar & fiberglass.

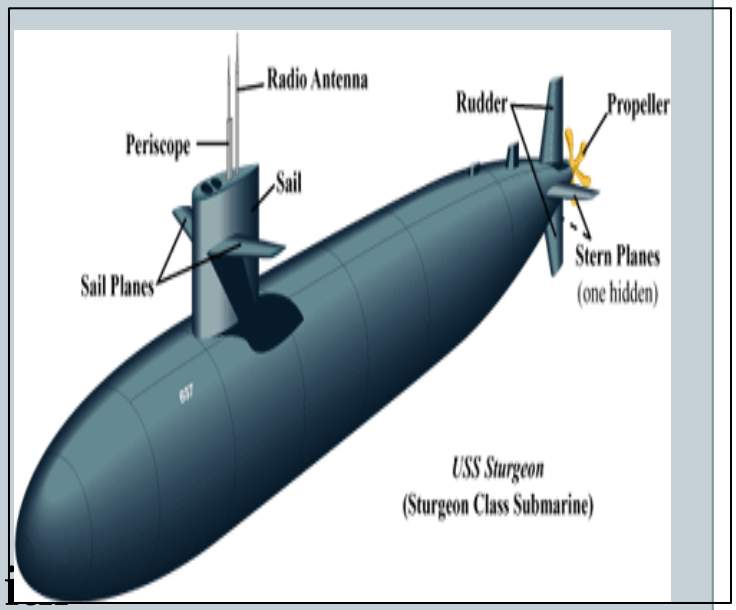
- ❖ Making a ultra lightweight paddle with composite materials.
- ❖ make a paddle with Fiberglass, carbon, foam, wood, & epoxy.
- ❖ Fig shown is made with carbon fiber composite paddle

Submarines

vigneshdhanabalan@hotmail.com

- The sub marine is classified with different as per the work end use they are.

1. Ballistic missile submarines,
2. Guided missile submarine,
3. Nuclear power attack submarine,
4. Diesel-electric attack submarine,
5. Non-nuclear submarine
6. Special mission submarines.



- All These all of submarine hull are made with the fiber (Glass or Carbon) composite material with different level of contribution as per the require end use purpose

- To minimize the evolution of toxic fumes by careful selection of materials.

Yacht

- The yacht used in the America's Cup races shown in the fig.

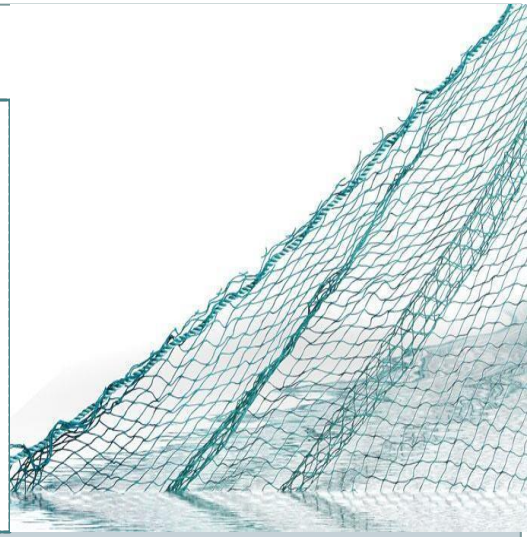
- Aramid honeycomb sandwich structure material were used for the hull.

Marine Upholstery

- ✓ Cruise ships can be regarded as floating hotels' and, therefore, textile properties requirements must be of contract standard.
- ✓ Furnishing, windows cover, bed sheets & spreads, carpets are required some important property's they are durable, FR, noise and vibration damping, excellent fast to light, rubbing and salt water , antistatic, etc.,.

Twines and Fish Net

- Nylon is used in first generation .
- In the second generation mostly using HPPE yarns because it have more property than first generation fibers like lesser weight, less elongation, UV resistant, seawater resistant, anti rot properties & good life long etc..,,



Marine Rope

- mid-twentieth century with the introduction of nylon ropes, followed by polyester. These ropes were about half the weight of steel ropes for about twice the diameter and the same strength.
- Ropes made from the second generation of synthetic fibers-aramid, Vectran, high-modulus polyethylene, and PBO, PBI -give diameters similar to steel but in one-tenth its weight.
- There is a range of ropes optimized for the different uses in climbing as per the end use purpose.

Oil Booms

- ✓ usually produced from woven nylon base fabric of about 175GSM coated with Hypalon, polychloroprene, PVC or PVC/nitrile rubber are inflated to a fairly low pressure.
- ✓ but they have to be oil resistant.

Life Rafts & Life Jackets

- ➢ The base fabric for life rafts & Jackets is generally woven polyamide with butyl or natural rubber, thermoplastic polyurethane or polychloroprene coatings.
- ➢ The Life Rafts is 230-685 gsm & Life jackets are 230-290gsm

Immersion Suit

- Retro-reflective tape on head, chest & arms.
- Immersion suit are made of synthetic fiber or high performance fibers and also treating with some finishes like water repellent, flame retardant finishes, etc..
- It will cover the whole body.

Canopies

- ✓ Marine canopies are mainly made with synthetic material base polyester, nylon, and some other synthetic fibers.
- ✓ Base material are coated or laminated with PVC, PTFE, or PU coating
- ✓ These marine canopies also have the required specific function like UV resistant, salt water resistant, etc

The following tests are required for marine textiles

- ✓ Peel bond adhesion
- ✓ Clean ability after soiling
- ✓ Dye fastness to perspiration
- ✓ Dye fastness to crocking (both dry and wet)
- ✓ Dimensional stability
- ✓ Flammability
- ✓ Tear/tensile strength
- ✓ Sewing seam strength
- ✓ Bursting strength
- ✓ Stretch and set test.
- ✓ UV Degradation test
- ✓ Water repellent test

Medical Textiles

- It has huge growth, the growth is due to constant improvements and innovations in both textile technology and medical procedures

- Textile materials and products that have been engineered to meet particular needs, are suitable for any medical and surgical application

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

Classification of Medical Textiles

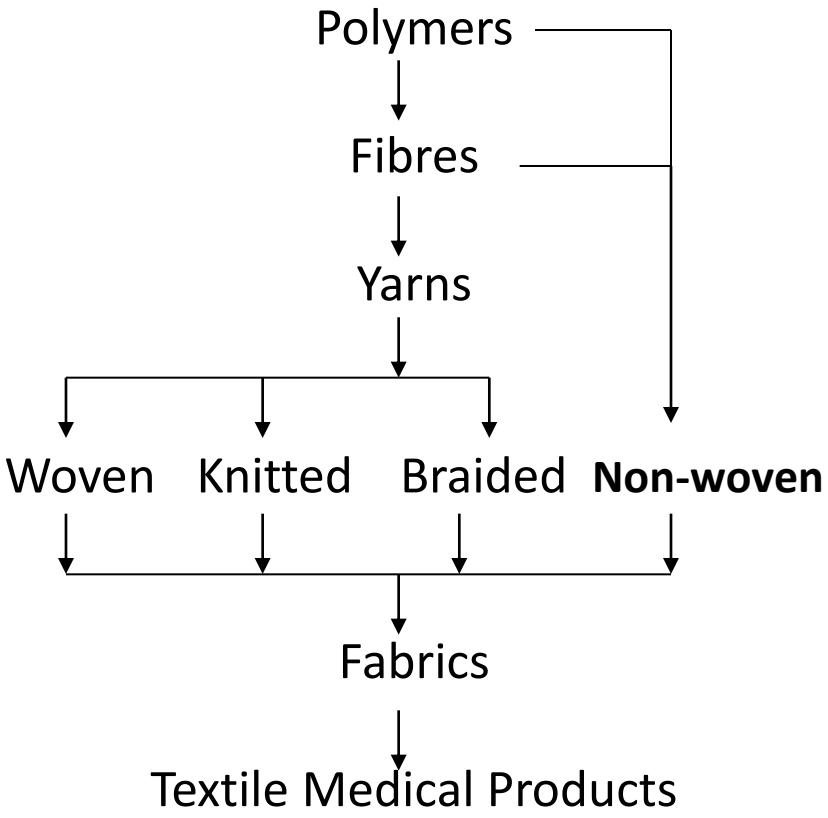
Non-Implantables	Healthcare Products	Implantables	Extra Corporeal
Absorbents with and without ex-ray detactable • Abdominal pad with /without x-Ray • Cotton & viscose gauze • Dressing packs • Wadding Gauze Bandages • W/W bandage (open bandages or gauze bandages) • Triangular & POP Bandages • Synthetic cast Extensible Bandages • Cotton crepe bandages • Elastic bandages (with rubber or lycra) • Compression bandages • Elastic adhesive & Cohesive bandages Tubular bandages • Knitted fabric in tubular form • Surgical hosiery Wound dressing and medicated bandages • Chlorhexidine gauze dressing • Elastic Adhesive dressing • Framycetin gauze dressing • Paraffin gauze dressing	• Surgical gowns • Surgical caps • Surgical mask • Surgical drapes • Wipes • Hospital bed sheets, pillows, pillow covers, blankets, mattresses • Patient clothing (summer & winter) • Burns clothing • Operation theatre clothing	• Sutures Biodegradable/ Non-biodegradable • Bifurcated arterial prosthetic graft • Artificial Joints • Dialysers • Artificial Tendon (Mesh) • Artificial Vascular Grafts • Artificial heart valve etc • Art. skin	• Art. Kidney • Art. Liver / Lungs

Uniqueness of Fibres used in Medical Textiles

- Pure and Hygienic
- Bio – degradable
- Fast & High absorbency
- Excellent Wicking performance
- Barrier to percolation
- Good Insulation
- High Strength
- Low Lint

- Good thermal stability
- Soft feel
- Excellent drape ability
- Breathability
- Static Dissipation
- Engineered Specialties
  - Anti-bacterial properties
  - Medicinal clothings

Constituent Element of Medical Textile Product



Non Implantable materials

Table 15.1 Non-implantable materials

Product application	Fibre type	Manufacture system
Woundcare		
absorbent pad	Cotton, viscose	Nonwoven
wound contact layer	Silk, polyamide, viscose, polyethylene	Knitted, woven, nonwoven
base material	Viscose, plastic film	Nonwoven, woven
Bandages		
simple inelastic/elastic	Cotton, viscose, polyamide, elastomeric yarns	Woven, knitted, nonwoven
light support	Cotton, viscose, elastomeric yarns	Woven, knitted, nonwoven
compression	Cotton, polyamide, elastomeric yarns	Woven, knitted
orthopaedic	Cotton, viscose, polyester polypropylene, polyurethane foam	Woven, nonwoven
Plasters	Viscose, plastic film, cotton, polyester, glass, polypropylene	Knitted, woven, nonwoven
Gauzes	Cotton, viscose	Woven, nonwoven
Lint	Cotton	Woven
Wadding	Viscose, cotton linters, wood pulp	Nonwoven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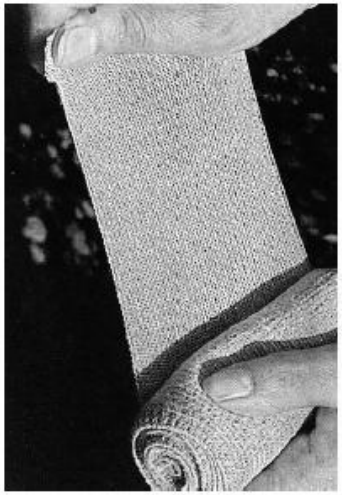
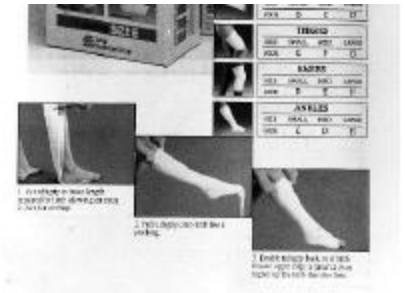
Bandages



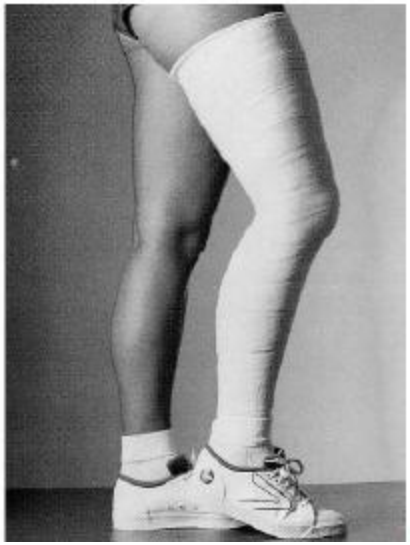
(a)

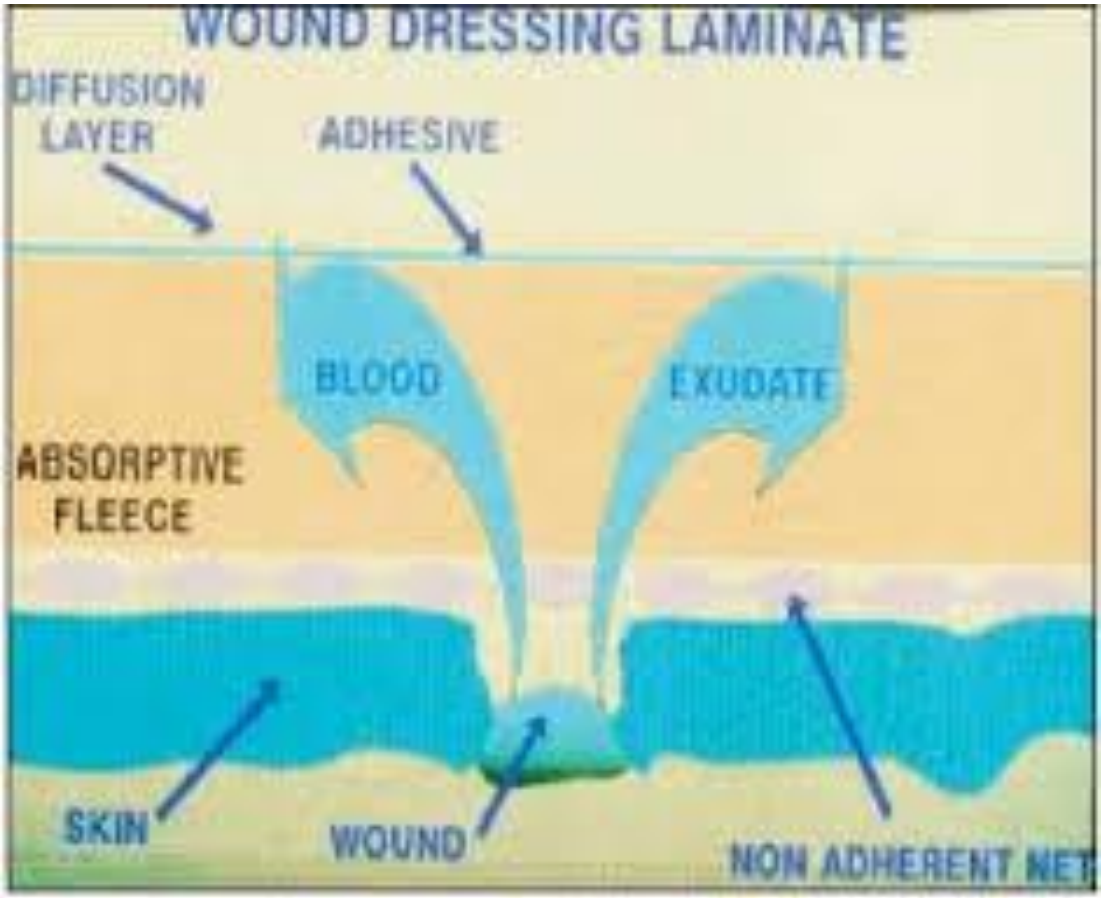
(b)

(c)



15.4 Different types of bandages and their application. (a) Elasticated flat bandage, (b) tubular finger bandages, (c) tubular elasticated net garment, (d) tubular support bandages, (e) and (f) orthopaedic casting bandage, (g) pressure gloves, (h) pressure garment, (i) hip spica, (j) lumbar/abdominal support, (k) anti-embolism stockings.




WOUND DRESSING LAMINATE
DIFFUSION LAYER
ADHESIVE
BLOOD
EXUDATE
ABSORPTIVE FLEECE
SKIN
WOUND
NON ADHERENT NET

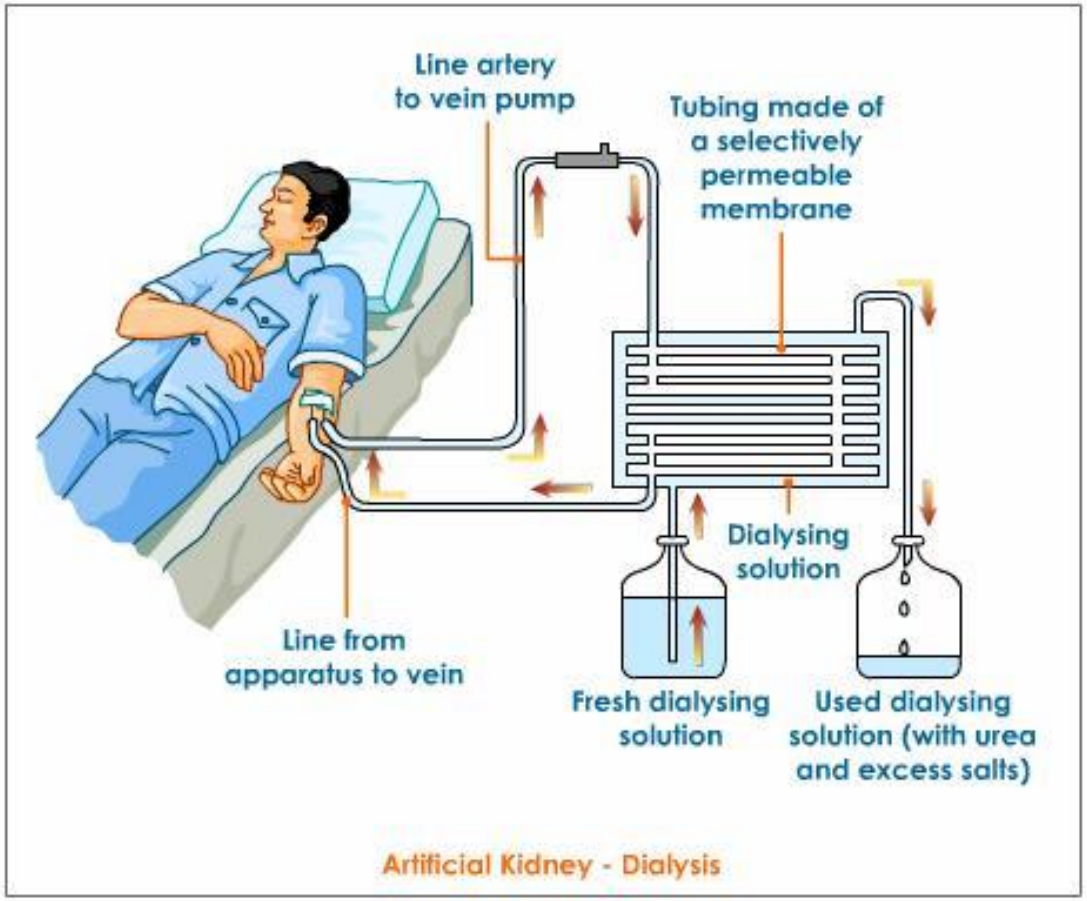
Extracorporeal devices

- These are mechanical organs, used for blood purification and include the artificial kidney, the artificial liver, and lung

Table 15.2 Extracorporeal devices

Product application	Fibre type	Function
Artificial kidney	Hollow viscose, hollow polyester	Remove waste products from patients blood
Artificial liver	Hollow viscose	Separate and dispose patients plasma, and supply fresh plasma
Mechanical lung	Hollow polypropylene, hollow silicone, silicone membrane	Remove carbon dioxide from patients blood and supply fresh blood

Artificial kidney



Implantable materials

- *These materials are used in effecting repair to the body,*
- *wound closure (sutures) or replacement surgery (vascular grafts, artificial ligaments, etc.)*
- Biocompatibility is of prime importance

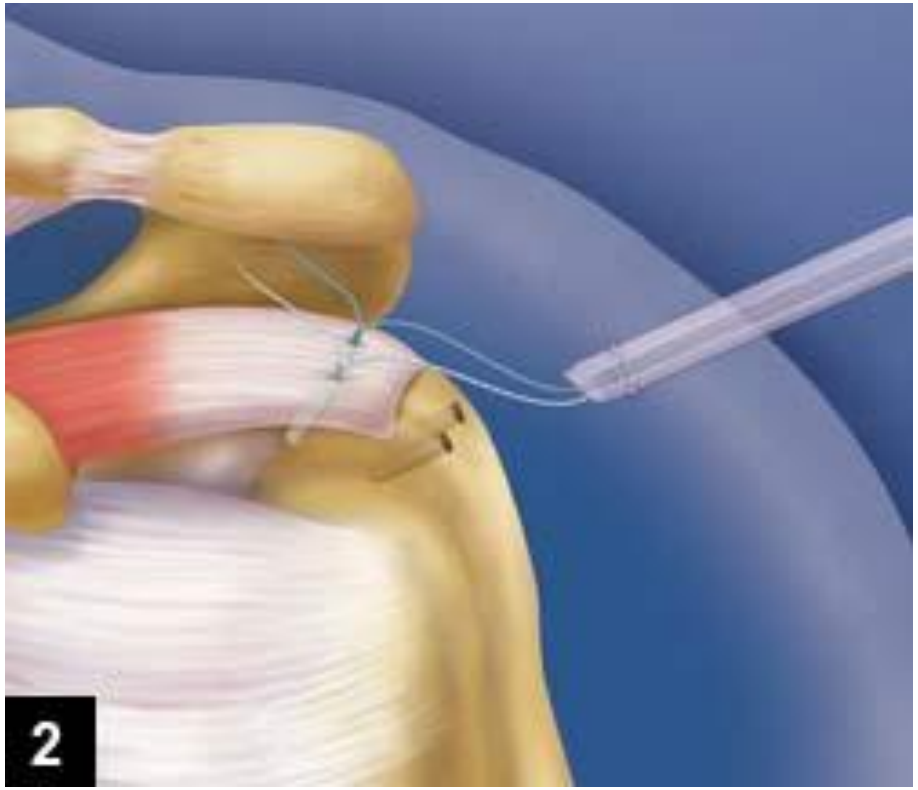
Table 15.3 Implantable materials

Product application	Fibre type	Manufacture system
Sutures		
biodegradable	Collagen, polylactide, polyglycolide	Monofilament, braided
non-biodegradable	Polyamide, polyester, PTFE, polypropylene, steel	Monofilament, braided
Soft-tissue implants		
artificial tendon	PTFE, polyester, polyamide, silk, polyethylene	Woven, braided
artificial ligament	Polyester, carbon	Braided
artificial cartilage	Low density polyethylene	Nonwoven
artificial skin	Chitin	
eye contact lenses/artificial cornea	Polymethyl methacrylate, silicone, collagen	
Orthopaedic implants		
artificial joints/bones	Silicone, polyacetal, polyethylene	
Cardiovascular implants		
vascular grafts	Polyester, PTFE	Knitted, woven
heart valves	Polyester	Woven, knitted

Factors determine how the body reacts to the implant.

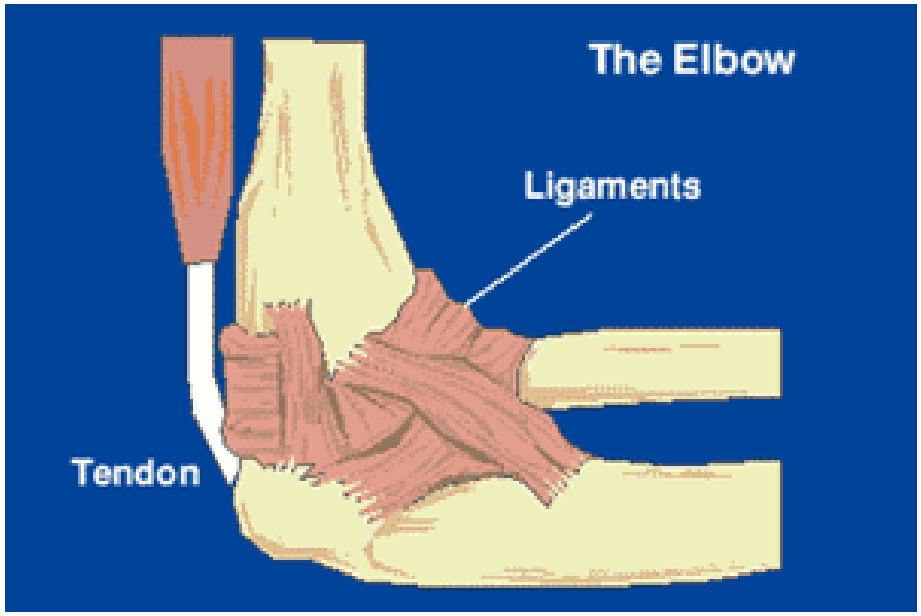
- The most important factor is porosity which determines the rate at which human tissue will grow and encapsulate the implant.
- Small circular fibres are better encapsulated with human tissue than larger fibres with irregular cross-sections.
- Toxic substances must not be released by the fibre polymer, and the fibres should be free from surface contaminants such as lubricants and sizing agents.
- The properties of the polymer will influence the success of the implantation in terms of its biodegradability

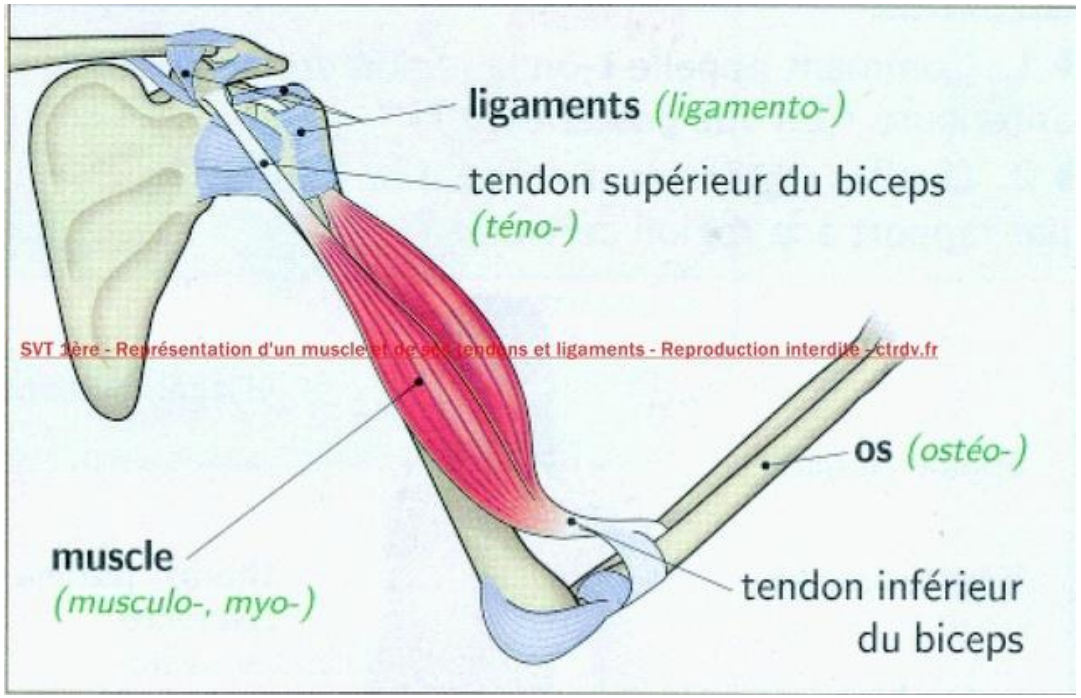
Suture



Artificial tendons

- Artificial tendons are woven or braidedporous meshes or tapes surrounded by a silicone sheath
- During implantation the natural tendon can be looped through the artificial tendon and then sutured to itself in order to connect the muscle to the bone


The Elbow
Ligaments
Tendon

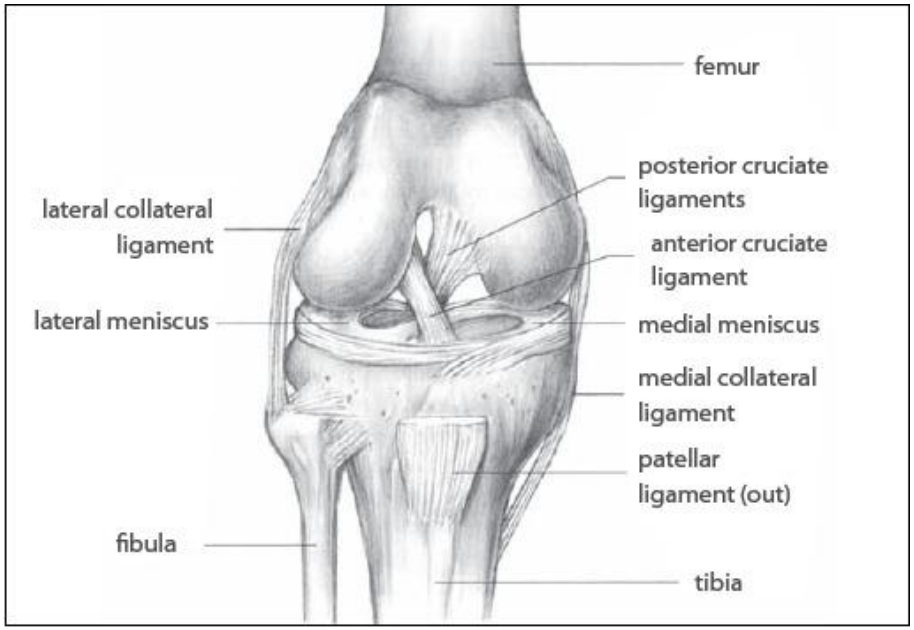

ligaments (ligamento-)
tendon supérieur du biceps (téno-)
SVT 1ère - Représentation d'un muscle et de ses tendons et ligaments - Reproduction interdite - ctrdv.fr
os (ostéo-)
muscle (musculo-, myo-)
tendon inférieur du biceps

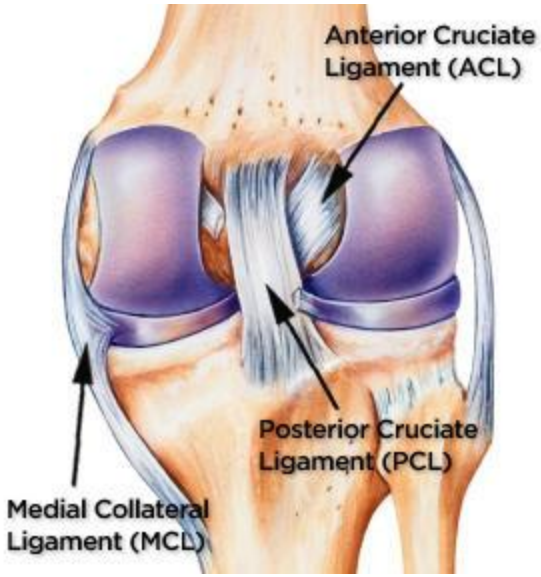
- Braided polyester artificial ligaments are strong and exhibit resistance to creep from cyclic loads

- Braided composite materials containing carbon and polyester filaments have also been found to be particularly suitable for knee ligament replacement

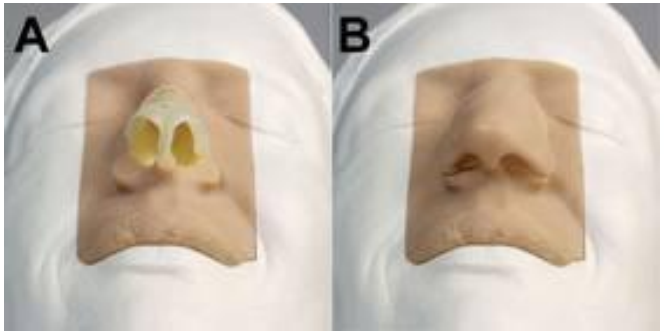
- Low density polyethylene is used to replace facial, nose, ear, and throat cartilage

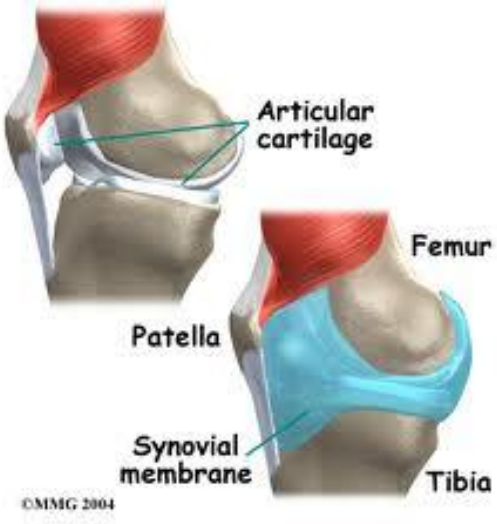
Artificial Lig





Artificial cartilage and Skin



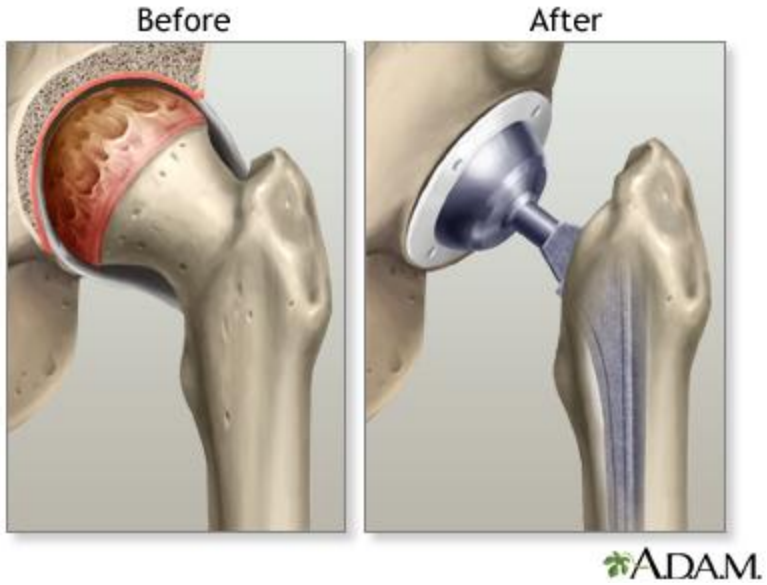


Orthopaedic implants

- Orthopaedic implants are those materials that are used for hard tissue applications to replace bones and joints.
- Also included in this category are fixation plates that are implanted to stabilise fractured bones
- Fibre-reinforced composite materials may be designed with the required high structural strength and biocompatibility properties needed for these applications and are now replacing metal implants for artificial joints and bones

- To promote tissue in growth around the implant a nonwoven mat made from graphite and PTFE (e.g. Teflon) is used, which acts as an interface between the implant and the adjacent hard and soft tissue

Orthopaedic implants



Cardiovascular implants

- Vascular grafts are used in surgery to replace damaged thick arteries or veins 6 mm, 8 mm, or 1 cm in diameter
- Commercially available vascular grafts are produced from polyester (e.g. Dacron) or PTFE (e.g. Teflon) with either woven or knitted structures
- Straight or branched grafts are possible by using either weft or warp knitting technology
- Polyester vascular grafts can be heat set into a crimped configuration that improves the handling characteristics

- Knitted vascular grafts have a porous structure which allows the graft to become encapsulated with new tissue.
- but the porosity can be disadvantageous since blood leakage (haemorrhage) can occur through the interstices directly after implantation

Cardiovascular implants

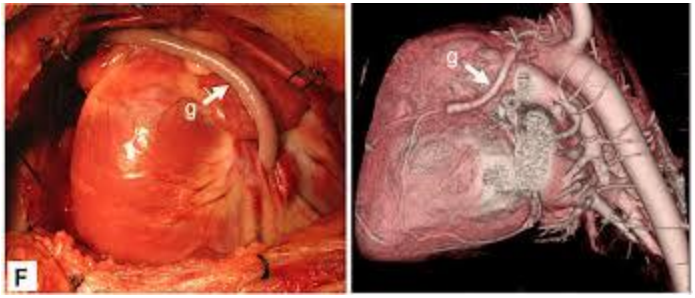
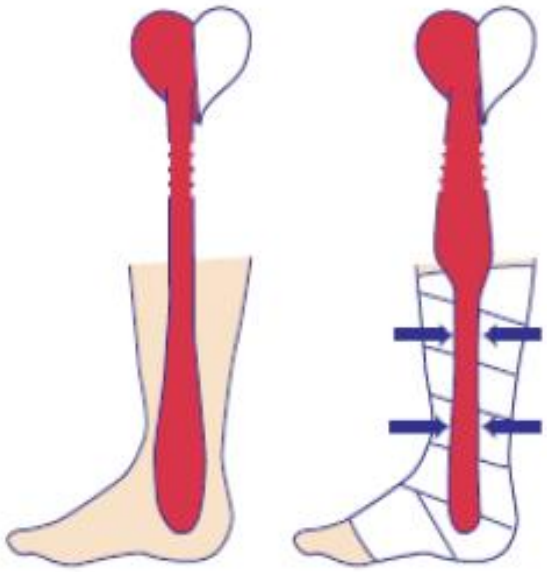


Figure 2.Vascular Grafts



Healthcare/hygiene products

Table 15.4 Healthcare/hygiene products

Product application	Fibre type	Manufacture system
Surgical clothing		
gowns	Cotton, polyester, polypropylene	Nonwoven, woven
caps	Viscose	Nonwoven
masks	Viscose, polyester, glass	Nonwoven
Surgical covers		
drapes	Polyester, polyethylene	Nonwoven, woven
cloths	Polyester, polyethylene	Nonwoven, woven
Bedding		
blankets	Cotton, polyester	Woven, knitted
sheets	Cotton	Woven
pillowcases	Cotton	Woven
Clothing		
uniforms	Cotton, polyester	Woven
protective clothing	Polyester, polypropylene	Nonwoven
Incontinence diaper/sheet		
coverstock	Polyester, polypropylene	Nonwoven
absorbent layer	Wood fluff, superabsorbents	Nonwoven
outer layer	Polyethylene	Nonwoven
Cloths/wipes	Viscose	Nonwoven
Surgical hosiery	Polyamide, polyester, cotton elastomeric yarns	Knitted

Sports Textiles

Introduction

- *Waterproof breathable fabrics are designed for use in garments that provide protection from the environmental factors like wind, rain and loss of body heat*
- *The term breathable implies that the fabric is actively ventilated*
- *Breathable fabrics passively allow water vapour to diffuse through them yet prevents the penetration of liquid water*

- *Water-resistant and moisture-permeable materials may be divided into three main categories*
- *high-density fabrics*
- *resin-coated materials*
- *film-laminated materials*

Densely woven water breathable fabrics

- *The densely woven waterproof breathable fabrics consist of cotton or synthetic microfilament yarns with compacted weave structure*
- *Usually combed yarns are weaved parallel to each other with no pores for water to penetrate*
- *When fabric surface is wetted by water the cotton fibres swell transversely reducing the size of pores in the fabric and requiring very high pressure to cause penetration.*
- *Therefore waterproof is provided without the application of any water repellent finishing treatment*
- *Densely woven fabrics can also be produced from micro-denier synthetic filament yarns*

Laminated waterproof breathable fabrics

- *They are made by application of membranes into textile product*
- *These are thin membrane made from polymeric materials*
- *They offer high resistance to water penetration but allow water vapour at the same time*

Types of membranes

they are two types

- ***Micro porous membranes***
  - The micro porous membranes have tiny holes on their surface smaller than a rain drops but larger than water vapour molecule
  - Some of the membranes are made from Polytetrafluoroethylene PTFE polymer , Polyvinylidene fluoride PVDF

- ***Hydrophilic membranes.***

  - *They are thin films of chemically modified polyester or polyurethane*

  - *constitutes the hydrophilic part of the membrane by forming amorphous region in the main polymer system.*

  - *This amorphous region acts as intermolecular pores allowing water vapour molecules to pass through but preventing the penetration of liquid water due to the solid nature of the membrane.*

Coated waterproof breathable fabrics

- *They consist of polymeric material applied to one surface of fabric*
- *Polyurethane is used as the coating material*
- *The coatings are of two types*
  - *Micro porous membranes*
    - In microporous membrane the coating contains very fine interconnected channels much smaller than finest raindrop but larger than water vapour molecules
  - *Hydrophilic membranes.*
    - transmits vapour through mechanism involving adsorption-diffusion and de-sorption.

Desirable properties of sports wear

- *Optimum heat and moisture regulation*
- *Good air and water vapour permeability*
- *Rapid moisture absorption and conveyance capacity*
- *Absence of dampness*
- *Rapid drying to prevent catching cold*
- *Dimensionally stable even when wet*
- *Durable*
- *Easy care*
- *Lightweight*
- *Soft and pleasant touch*
- *Low water absorption of the layer of clothing just positioned to the skin*

MOISTURE TRANSPORT MECHANISM

The mechanism by which moisture is transported in textiles is similar to the wicking of a liquid in capillaries.

- *Capillary action is determined by two fundamental properties of the capillary:*
  - *Its diameter;*
  - *Surface energy of its inside face*

- *The smaller the diameter or the greater the surface energy, the greater the tendency of a liquid to move up the capillary*

- *the narrower the spaces between these fibres, the greater the ability of the textile to wick moisture*

- *Constructions include fabrics made from micro fibres, which are packed closely together*

The surface energy in a textile structure is determined largely by the chemical structure of the exposed surface of the fibre, as follows.

- Hydrophilic fibres have a high surface energy. Consequently, they pick up moisture more readily than hydrophobic fibres

- Hydrophobic fibres, by contrast, have low surface energy and repel moisture.

FACTORS AFFECTING MOISTURE TRANSPORT

- *Fibre type*
- *Cloth construction or weave*
- *Weight or thickness of the material*
- *Presence of chemical treatments*

- *It is generally agreed that fabrics with moisture wicking properties can regulate body temperature, improve muscle performance and delay exhaustion.*

- *natural fibres such as cotton may be suitable for clothing worn for low levels of activity,*

- *Synthetic fabrics made of nylon or polyester are better suited for high levels of activity.*

- *The main parameters for comfort and functionality are:*

  - *Water and wind proof, breathability and comfort*
  - *Moisture/Sweat management*
  - *Warmth/temperature control*
  - *Easy-care performance*
  - *Smart and functional design.*

- ***Polyester***
  - *dimensional stability and offer excellent resistance to dirt, alkalis*
  - *Being durable, yet lightweight, polyester has elasticity and a comfortable smooth feel or "soft hand".*
  - *Excellent heat resistance or thermal stability is also an attribute of polyester*
  - *It is the fibre used most commonly in base fabrics for active wear because of its low moisture absorption, easy care properties and low cost.*

- ***Polypropylene***

  - *Polypropylene cannot wick liquid moisture. However, moisture vapour can still be forced through polypropylene fabric by body heat*

  - *its hydrophobic nature and has very good thermal characteristics, keeping the wearer warm in cold weather and cold in warm weather*

- ***Nylon***

  - *lightweight, high strength and softness with good durability*
  - *Nylon has a much higher moisture regain than polyester and therefore has better wicking behaviour*
  - *It is most often used in tightly woven outerwear, which can trap heat because of low air permeability*

- ***Cotton***
  - *Cotton garments provide a good combination of softness and comfort*
  - *When wet, cotton garments cling to the skin. Causing discomfort*
  - *The slow-to-dry and cold-when-wet characteristics of cotton make this material unsuitable in conditions in which there are high levels of moisture-either perspiration or precipitation-and where the ambient temperature is low.*

- ***Viscose Rayon***
  - *viscose rayon is not preferred next to skin as it holds water in sportswear*
  - *viscose rayon, which absorbs 2-3 times more moisture than cotton*

DEVELOPMENTS IN ACTIVE SPORTSWEAR

- *In 1980s simple microfibres and coated fabrics were developed which have met the needs of many sports garments*

- *Nowadays, from very simple microfibres to much more complex fabrics are effectively used in active sportswear*

Sweat absorption and fast drying property

- *Moisture handling properties of textiles during intense physical activities have been regarded as major factor in the comfort performance*

- *Actually the comfort perceptions of clothing are influenced by the wetness or dryness of the fabric and thermal feelings resulting from the interactions of fabric moisture and heat transfer related properties*

- *the garment that is worn next to skin should have:*
  - *a) good sweat absorption and sweat releasing property to the atmosphere*
  - *b) fast drying property for getting more tactile comfort*

SPECIAL FIBRES USED

- ***Hygra***
  - *Unitika Limited has launched Hygra which is a sheathcore type filament yarn composed of fibre made from waterabsorbing polymer and nylon*
  - *The water-absorbing polymer has a special network structure that absorbs 35 times its own weight of water and offers quick releasing properties*

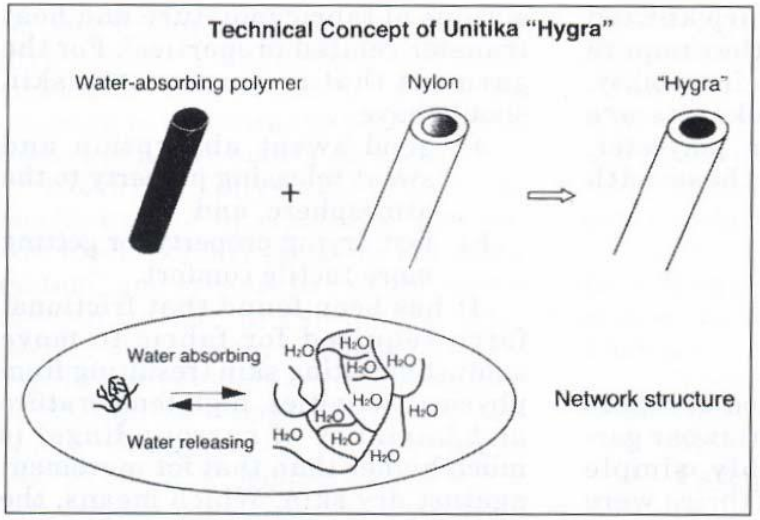


Fig 1 : Hygra sheath-core type fibres

- ***Lumiac***
  - *It is a collection of polyester filaments having different fineness (0.5 - 2.0 denier per filament) and irregular cross sections.*
  - *Hygra - Lumiace combination in knitted fabric is very popular in top Japanese athletes.*
- ***Dryarn***
  - *It is a completely recyclable polypropylene microfibre*
  - *lightweight and comfortable and used in different sports*
  - *Bacteria cannot settle on smooth surface of the fibre which avoids unpleasant odour associated with decomposition of bacteria*

- ***Killat N***
  - ***It*** *is a nylon hollow filament*
  - *The hollow portion is about 33 per cent of the cross section of each filament due to which it gives good water absorbency and warmth retentive property*
  - *bicomponent filament technology used for Killat N*

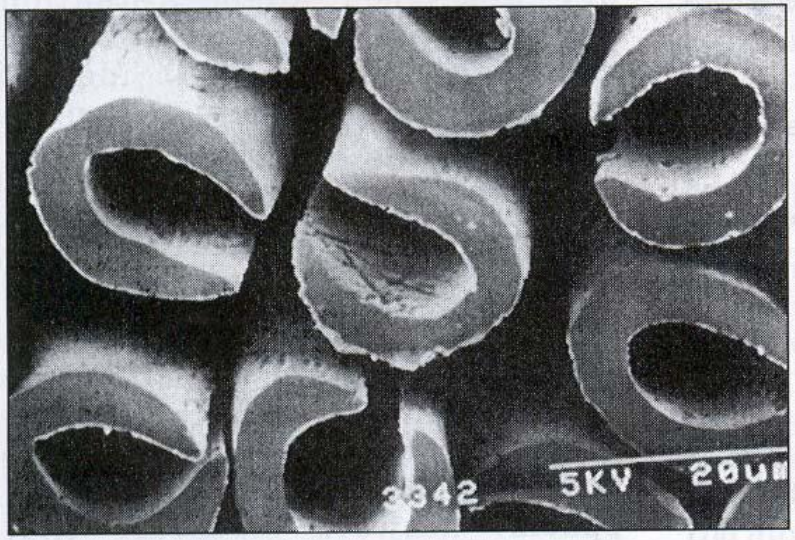


Fig 2 : Killat N hollow nylon fibre

Branded synthetic fibres for sportswear[11]

Brand	Fibre	Property Claimed
Sillook Royal S	Polyester	Three petal cross-section, silk-like fabric, including traditional 'rustle'
Malor	not given	Continuous filament, textured, random crimp along filament
UTS	not given	Smooth touch, textured fibre, 2 μm microfiber
Reebarg P	not given	Rustling sound
Sillok Chatelaine	not given	Dry touch of fabric; microgrooved cross-section allowing water absorption
Cheddy	not given	Dry touch of fabric; microcaters on surface of fiber, which when rubbed together give silky-dry handle
CEOx	not given	Water-absorbency based on capillary tubes of up to 10 μm between single filament yarns in a multifilament arrangement, ultra fine and ultra thick fibres interspersed
Rirancha	not given	Slab-shaped yarns
Sillook Airly	not given	Crinkling, dry touch, air-hole, highly modified cross-section (hollow?)
Sillook Sildew	not given	
Belima-X	Polyester /polyamide core	Consisting of polyester and polyamide 6, splittable

MULTI-LAYERING OF FIBERS

- Blends in form of layering of fibres are capable of offering the best properties of each

- Bicomponent knits such as polyester/wool or polypropylene/wool blends provide nwicking and insulation properties in a single layer

- ***Push-pull fabrics***
  - bicomponent materials composed of a non-absorbent hydrophobic material on the inside-worn next to the skin
  - Absorbent hydrophilic material on the outside

Sportswool

- which has been engineered to manage moisture

- it is a hybrid material composed of a fine Merino wool sub-layer for Insulation and a polyester exterior which draws moisture away from the wool layer to the surface

- The wool fibre next to the skin attracts perspiration vapour molecules

Dri-release

- It is a wicking performance yarn developed by US-based Optimer
- It is blend of 85-90% hydrophobic low moisture-absorbing staple fibre-such as polyester-and 10-15% hydrophilic wicking staple such as cotton.
- Dri-release is incorporated in athletic wear, socks
- Dri-release was shown to dry four times faster than cotton and as fast as, or faster than, other performance polyesters-particularly after several washes

Toray industries-entrant

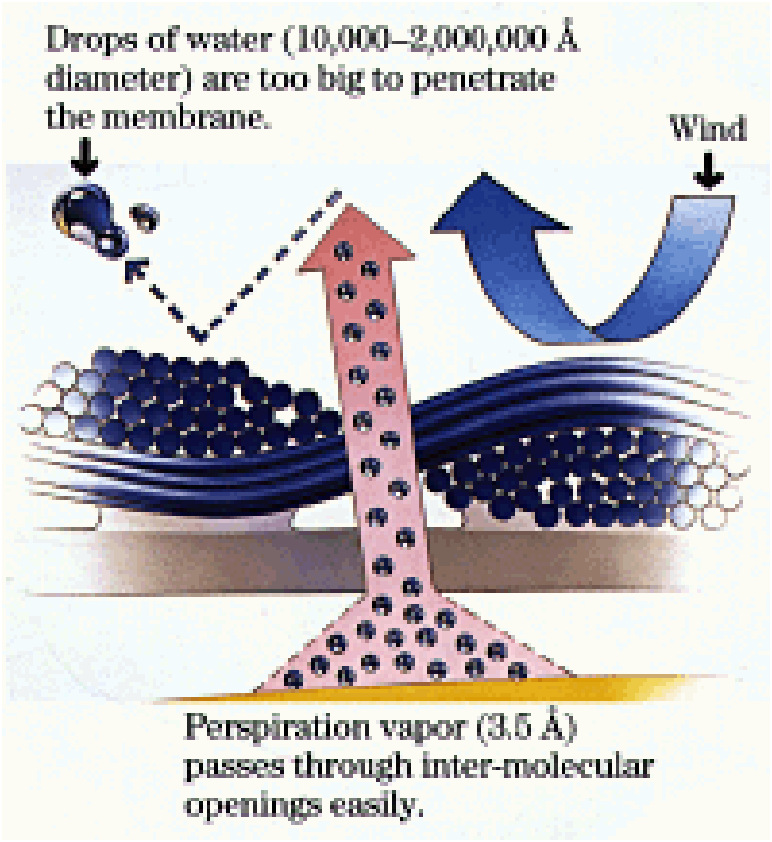
- There are three main versions of “Entrant” and they are as follows
  - Entrant Dermizax EV
  - Entrant HB
  - Entrant DT

Entrant Dermizax EV

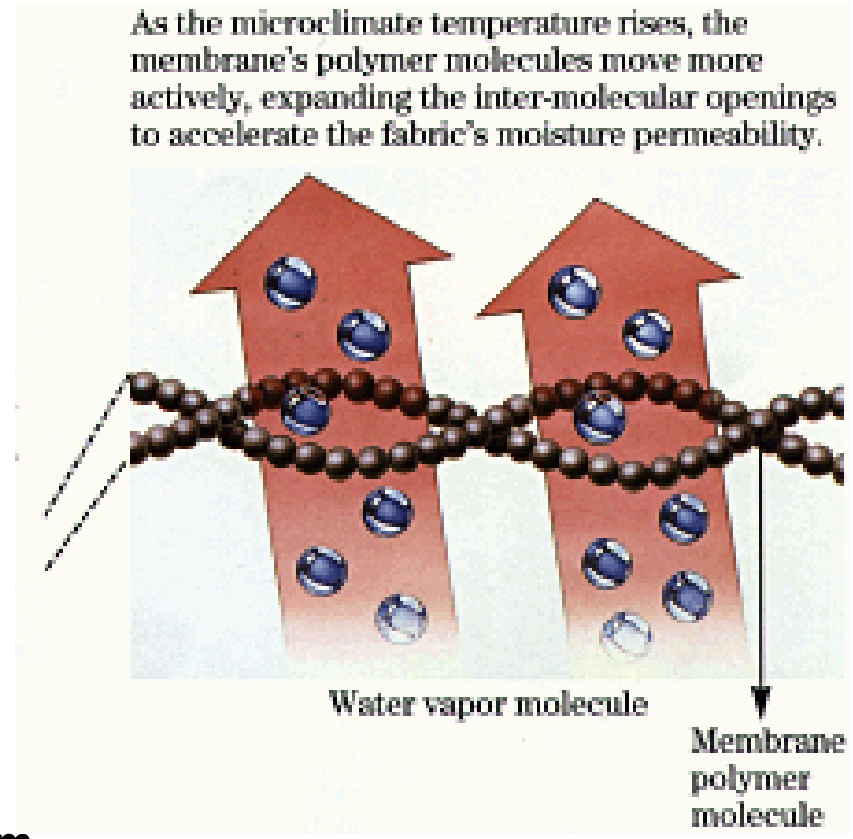
- It is a lightweight fabric having a feather smooth texture with excellent waterproof/moisture permeability

- It has durable water repellency such as 20,000mm of water pressure resistance and moisture permeability of 30,000 g/m2/24 hrs.

- It is an excellent and original active sportswear fabric with globally top class water proof/moisture permeability, as well as excellently durable water repellency



Waterproof, moisture permeable mechanism



Water vapor permeating mechanism

Entrant HB

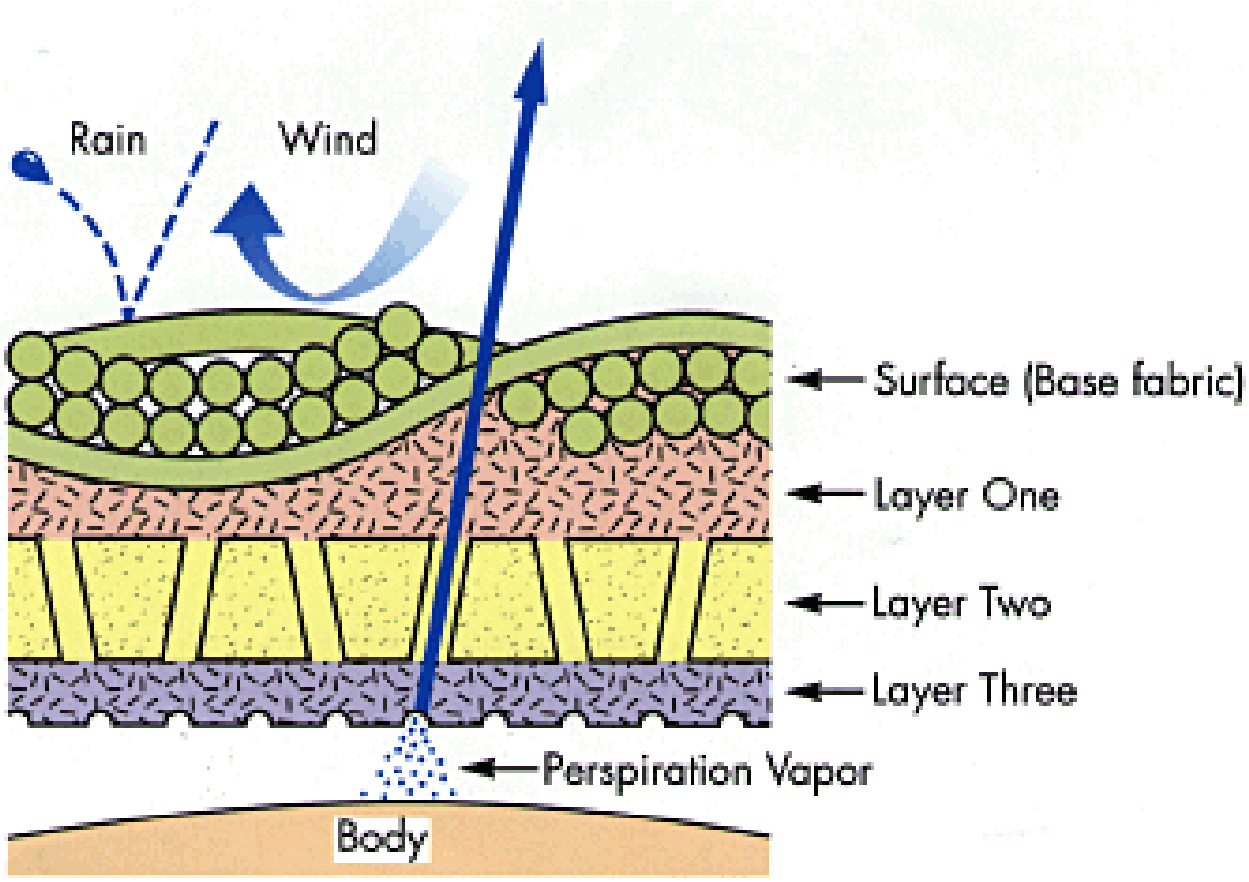
- It is a new generation fabric with hybrid structure that synergistically integrates the advantages offered by a coating

- It has high resistance to water pressure and high durability against repeated washings

- Its main application is outdoor wear

Entrant DT

- It is a microporous coated fabric offering a smoother and refreshing dry
- touch as well as attractive appearance through an innovative inner surface treatment technology.
- It has patterns printed on a coated membrane and a dry touch obtained by improving the coated membrane


Rain
Wind
Surface (Base fabric)
Layer One
Layer Two
Layer Three
Perspiration Vapor
Body

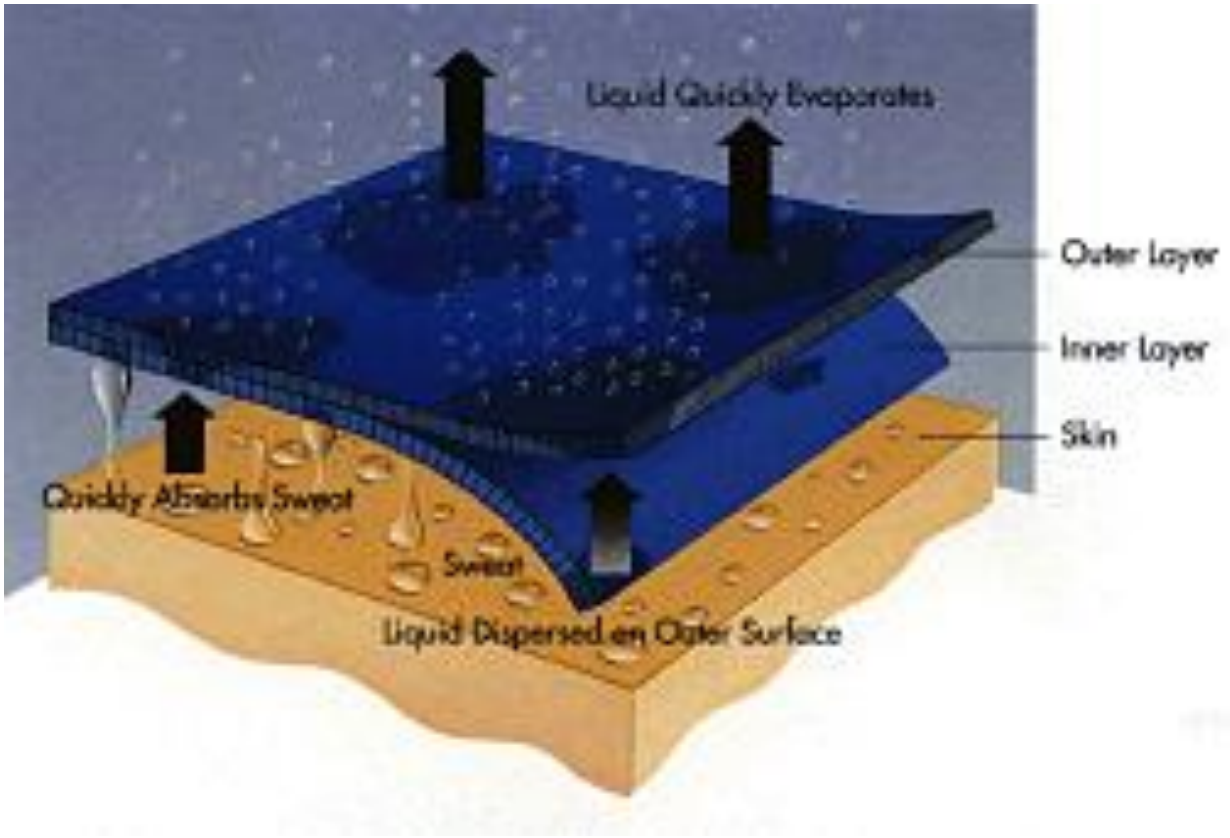
ENTRANT DT

H2OFF

- It is made up of polyester microfiber fabric with a unique high-density weave structure comprising millions of microcrimped fiber loops

Field Sensor

- It is a very popular high performance fabric from Toray
- which employs a multi. layer structure that not only absorbs perspiration quickly but also trans. ports it up to the outer layer of fabric very rapidly using principle of capillary action
- It is composed of coarser denier yarn on the inside surface fine denier hydrophobic polyester yarn in a mesh construction on the outer surface to accelerate quick evaporation of sweat


Liquid Quickly Evaporates
Outer Layer
Inner Layer
Skin
Quickly Absorbs Sweat
Sweat
Liquid Dispersed on Outer Surface

Waterproof Breathable Active Sports Wear Fabrics

Sanjay S. Chaudhari, Rupali S. Chitnis and Dr. Rekha Ramkrishnan
The Synthetic & Art Silk Mills Research Association, Mumbai

India is increasing total wealth and per capita income per head. The rapid spread of satellite television is globalising the vision of the healthy lifestyle and spreading knowledge of sports and leisure wears from country to country. Due to this consumers are becoming more and more conscious for the comfort of the garments that they are wearing. As a result new fibres and fabrics are emerging out for satisfying the stringent needs.
The paper reviews various works done in development of waterproof, breathable sportswear textiles. The moisture transport properties and various factors affecting it are also discussed for sportswear fabrics using different fibres. The various branded fibres and fabrics have been described along with their constitutional elements and special characteristics.

Introduction

Waterproof breathable fabrics are designed for use in garments that provide protection from the environmental factors like wind, rain and loss of body heat. Waterproof fabric completely prevents the penetration and absorption of liquid water. The term breathable implies that the fabric is actively ventilated. Breathable fabrics passively allow water vapour to diffuse through them yet prevents the penetration of liquid water. High functional fabrics support active sportswear with importance placed on high functions as well as comfort. Finally, materials with heating and/or cooling property have newly attracted the interest of the market. All these materials do not pursue a single function, but different functional properties combined on a higher level.

Fabrics that can convey water vapor from body perspiration out through the material while remaining impervious to external liquids such as rainwater are widely used in sportswear and similar applications. Water-resistant and moisture-permeable materials may be divided into three main categories - high-density fabrics, resin-coated materials and film-laminated materials - which are selected by manufacturers according to the finished garment requirements in casual, athletics, ski or outdoor apparel.

Densely woven water breathable fabrics

The densely woven waterproof breathable fabrics consist of cotton or synthetic microfilament yarns with compacted weave structure. One of the famous waterproof breathable fabrics known as VENTILE was manufactured by using long staple cotton with minimum of spaces between the fibres[1]. Usually combed yarns are weaved parallel to each other with no pores for water to penetrate. Usually oxford weave is used. When fabric surface is wetted by water the cotton fibres swell transversely reducing the size of pores in the fabric and requiring very high pressure to cause penetration. Therefore waterproof is provided without the application of any water-repellent finishing treatment. Densely woven fabrics can also be produced from micro-denier synthetic filament yarns. The individual filaments in these yarns are of less than 10 micron in diameter, so that fabrics with very small pores can be engineered.

Laminated waterproof breathable fabrics

Laminated waterproof breathable fabrics made by application of membranes into textile product. These are thin membrane made from polymeric materials. They offer high resistance to water penetration but allow water vapour at the same time. The maximum thickness of the membrane is 10 micron. They are of two types:

1) Micro porous membranes
2) Hydrophilic membranes.

The micro porous membranes have tiny holes on their surface smaller than a rain drops but larger than water vapour molecule. Some of the membranes are made from Polytetrafluoroethylene PTFE polymer , Polyvinylidene fluoride PVDF, etc[2,3].

The hydrophilic membranes are thin films of chemically modified polyester or polyurethane. These polymers are modified by the incorporation of poly. The poly (ethylene oxide)[4] constitutes the hydrophilic part of the membrane by forming amorphous region in the main polymer system. This amorphous region acts as intermolecular pores allowing water vapour molecules to pass through but preventing the penetration of liquid water due to the solid nature of the membrane.

Coated waterproof breathable fabrics

Coated fabrics with waterproof breathable fabrics consist of polymeric material applied to one surface of fabric[4,5]. Polyurethane is used as the coating material. The coatings are of two types:

1) Micro porous membranes
2) Hydrophilic membranes.

In microporous membrane the coating contains very fine interconnected channels much smaller than finest raindrop but larger than water vapour molecules. Hydrophilic coatings is same as hydrophilic membrane but the difference between the microporous and hydrophilic material is the former water vapour passes through the permanent air-permeable structure whereas the later transmits vapour through mechanism involving adsorption-diffusion and de-sorption.

The desirable attributes of functional sportswear and leisurewear are as follows[6]:

- Optimum heat and moisture regulation
- Good air and water vapour permeability
- Rapid moisture absorption and conveyance capacity
- Absence of dampness
- Rapid drying to prevent catching cold
- Low water absorption of the layer of clothing just positioned to the skin
- Dimensionally stable even when wet
- Durable
- Easy care
- Lightweight
- Soft and pleasant touch

It is not possible to achieve all of these properties in a simple structure of any single fiber or their blend[7]. The two layer structure has layer close to skin of the wicking type comprised of synthetic fibers e.g. micro-denier polyester and the outer layer

usually cotton or rayon that absorbs and evaporates. Micro denier polyester is ideal for wicking perspiration away from the skin. The use of superfine or microfibre yarn enables production of dense fabrics leading to capillary action that gives the best wicking properties[8,9].

No single fibre or blend of different fibres can give ideal sportswear. The right type of fibre should be in the right place. Blending of fibres does not give the same effect as that of multi-layer fabric. The wicking behaviour of the fabric is mainly depending on its base fibres moisture properties.

MOISTURE TRANSPORT MECHANISM[10]

The mechanism by which moisture is transported in textiles is similar to the wicking of a liquid in capillaries. Capillary action is determined by two fundamental properties of the capillary:

- Its diameter; and
- Surface energy of its inside face.

The smaller the diameter or the greater the surface energy, the greater the tendency of a liquid to move up the capillary. In textile structures, the spaces between the fibres effectively form capillaries. Hence, the narrower the spaces between these fibres, the greater the ability of the textile to wick moisture. Fabric constructions, which effectively form narrow capillaries, pick up moisture easily. Such constructions include fabrics made from micro fibres, which are packed closely together. However, capillary action ceases when all parts of a garment are equally wet.

The surface energy in a textile structure is determined largely by the chemical structure of the exposed surface of the fibre, as follows. .

- Hydrophilic fibres have a high surface energy. Consequently, they pick up moisture more readily than hydrophobic fibres-
- Hydrophobic fibres, by contrast, have low surface energy and repel moisture.

Special finishing processes can be used to increase the difference in surface energy between the face of a fabric and the back of the fabric to enhance its ability to wick.

FACTORS AFFECTING MOISTURE TRANSPORT[10, 11]

There are several factors, which affect moisture transport in a fabric. The most important are:

- Fibre type;
- Cloth construction or weave;
- Weight or thickness of the material; and
- Presence of chemical treatments.

Synthetic fibres can have either hydrophilic (wetting) surfaces or hydrophobic (non-wetting) surfaces. They also have a range of bulk absorbencies, usually reported by suppliers and testing organisations as the percentage moisture regain[1] by weight. Synthetic fabrics are generally considered to be the best choice for garments worn as a base layer. This is because they are able to provide a good combination of moisture management, softness and insulation.

While most fabrics, both natural and synthetic, have the ability to wick moisture away from the skin, not all of these are fast-drying and air permeable-two factors, which have a direct influence on cooling and perceived comfort. High-tech synthetic fabrics are lightweight, are capable of transporting moisture efficiently, and dry relatively quickly.

It is generally agreed that fabrics with moisture wicking properties can regulate body temperature, improve muscle performance and delay exhaustion. While natural fibres such as cotton may be suitable for clothing worn for low levels of activity, synthetic fabrics made of nylon or polyester are better suited for high levels of activity. They absorb much less water than cotton, but can still wick moisture rapidly through the fabric.

The main parameters for comfort and functionality are:

- Water and wind proof, breathability and comfort.
- Moisture/Sweat management
- Warmth/temperature control
- Easy-care performance
- Smart and functional design.

Polyester

Polyester has outstanding dimensional stability and offer excellent resistance to dirt, alkalis, decay, mold and most common organic solvents. Being durable, yet lightweight, polyester has elasticity and a comfortable smooth feel or “soft hand”. These are all important qualities to consumers for a wide variety outerwear and recreational applications. Excellent heat resistance or thermal stability is also an attribute of polyester. It is the fibre used most commonly in base fabrics for active wear because of its low moisture absorption, easy care properties and low cost. Polyester is essentially hydrophobic and does not absorb moisture. However, most polyester used in base layer clothing is chemically treated so that they are able to wick moisture. This can be done by:

- Coating the polyester with a hydrophilic finish; or
- Changing its surface chemistry to improve its wetting by moisture.

Changing the surface chemistry of the polyester involves introducing free hydroxyl groups into molecules on the surface of the filament. The result is a de structuring of water, causing wetting. The combination of opposing properties-a hydrophobic core and a hydrophilic surface-creates a fabric in which the fibres encourage moisture to migrate through the fabric along the outer surface of the filament while the hydrophobic core does not absorb moisture.

The main disadvantage of chemical or molecular modification is that it is more costly for the fabric manufacturer. However, the effect on the fabric is "permanent". To be classified as permanent, it has to have the capability to withstand at least 50 home washings. Most coatings, by contrast, have an average lifespan of five home washings.

Toray[12] develops airfine Fieldsensor which is made from a polyester filament yarn which has the grooves help the fabric absorb sweat quickly and disperse it along the

surface. Company claims that the moisture absorbing and dispersing property of the new material is twice a great as its former Fieldsensor fabric.

Polyester coolmax[10] has been claimed to increase wearer comfort through rapid removal of perspiration by capillary. Also it has good wicking properties and non-absorbency. Coolmax and thermostat polyester fibers used in two fold garments claimed to wick moisture away from the skin (the former) and to maintain warmth (the later).

Polypropylene

Polypropylene cannot wick liquid moisture. However, moisture vapour can still be forced through polypropylene fabric by body heat. Polypropylene has the advantage of providing insulation when wet But it can melt at medium heat in home dryers.

Also, polypropylene is more oleophilic (oil absorbing) than polyester Consequently, it has a greater tendency to attract and hold oily bod) odours even more. Polypropylene is claimed to be a proved performer in moisture management due to its hydrophobic nature and has very good thermal characteristics, keeping the wearer warm in cold weather and cold in warm weather[13].

Nylon

Nylon fibre characteristic include lightweight, high strength and softness with good durability. Nylon also quickly when wet. Nylon is good fabric choice when combined with PU coatings. Nylon has a much higher moisture regain than polyester and therefore has better wicking behaviour. It is most often used in tightly woven outerwear, which can trap heat because of low air permeability. It is also used in more breathable knitted fabrics, where it can perform well. However, it is much more expensive than polyester and is therefore only used in premium applications such as swimwear and cycling wear. Also, because of its higher moisture regain, it dries more slowly than equivalent fabrics made from polyester.

Teijin DuPont Nylon has developed a waterproof fabric, polus-Ex that is permeable to moisture. The material is made by laminating a multiporous film to a nylon fabric and a moisture permeability of 8000 g/m^2/24 hours, as well as 20 m head of water.

Silk

Because of its hollow structure, silk breathes well. It is soft strong and has natural wicking properties. However, it dries slowly and requires care in cleaning.

Wool[14]

Not all grades of wool are appropriate for a base layer. First, since it's next to skin, it shouldn't itch. The "itch" so commonly noticed in wool garment results from the fiber ends tickling. Consequently, short fibers will cause more itch than long fibers because there will be more fiber ends touching your skin. Second, the fiber should be very fine. This allows for a fabric of high fiber density to be made, which increases strength and abrasion resistance in addition to increasing the air movement between and adjacent to pockets of dead air space in the fabric (thus, increasing warmth). Finally, fine fibers absorb less water weight per cross-sectional area, so they are more resilient than coarse fibers. The efficiency of wicking is also greater with a fine-

fibered fabric because more fibers (and correspondingly, more cross-sectional surface area) can be packed into a given space than an equal volume of coarse fibers.

Wool has good, natural wicking properties and will provide insulation even when wet. However, it is slow to dry. However the use of fine chlorinated merino wool is employed in Sportwool as a base layer.

Wearing a Merino wool undergarment will result in the garment staying dryer for longer during periods of exertion. Wool fibers have micropores in them (a characteristic not unique to Merino wool) that readily allow for the absorption of water vapor-up to 1/3 the fiber weight. Consequently, it takes longer for a wool garment to reach the high relative humidity required for condensation to occur (synthetic fibers typically absorb less than 5% of their own weight in moisture vapor before feeling wet)[13].

A wool fabric (manufactured into long-sleeved T- shirt form) has been shown to absorb significantly more sweat than a polyester fabric (of comparable structure) during a period of exercise followed by rest. The amount of moisture desorbed from the wool fabric was significantly higher than that from the polyester fabric, and the skin temperature decreased faster and recovered more slowly after contact with the wool fabric compared with polyester fabric.

Cotton

Cotton garments provide a good combination of softness and comfort. However, cotton is not recommended for use in base layer clothing because of its tendency to absorb and retain moisture. When wet, cotton garments cling to the skin. causing discomfort. Wearing jeans on the ski slopes, for instance, will not only weigh down the skier but will also cause chilling if the jeans become wet.
The slow-to-dry and cold-when-wet characteristics of cotton make this material unsuitable in conditions in which there are high levels of moisture-either perspiration or precipitation-and where the ambient temperature is low.

During SASMIRA's trials for wicking of cotton treated with hydrophobic finishes showed good wicking properties[33].

Viscose Rayon

The viscose rayon is not preferred next to skin as it holds water (13 % moisture regain) in sportswear. The outer layer of knitted hydrophilic portion of the twin layer sportswear can be of viscose rayon, which absorbs 2-3 times more moisture than cotton. The wicking behaviour improves by incorporation of some hydrophobic finishes.

DEVELOPMENTS IN ACTIVE SPORTSWEAR

The 1980s was a period of highly fruitful innovation in sportswear garments. Some reasonably simple microfibres and coated fabrics were developed; variants of which have met the needs of many sports garments. The innovation of new materials and garments was so successful that in many sports the fundamental performance requirements have been identified and largely satisfied. Nowadays, from very simple microfibres to much more complex fabrics are effectively used in active sportswear.

The latest textile materials are much more function specific for fulfilling specific needs in different sports activities [15,16,17].

Sweat absorption and fast drying property

Moisture handling properties of textiles during intense physical activities have been regarded as major factor in the comfort performance. Actually the comfort perceptions of clothing are influenced by the wetness or dryness of the fabric and thermal feelings resulting from the interactions of fabric moisture and heat transfer related properties. For the garment that is worn next to skin should have[18,19]:

a) good sweat absorption and sweat releasing property to the atmosphere, and
b) fast drying property for getting more tactile comfort.

It has been found that frictional force required for fabric to move against sweating skin (resulting from physical activities, high temperature and humidity of surroundings) is much higher than that for movement against dry skin. Which means, the wet fabric, due to its clinging tendency, will give an additional stress to the wearer.

In removing the liquid sweat from the skin, some textile manufacturers claim that moisture absorbency of the fibre is important and hence cotton or viscose is a necessary compone-nt for the sportswear, which is next to skin. While others say that fibres in these garments should not absorb moisture, so that moisture or perspiration is wicked away from the skin to outer layers of clothing from whence it can evaporate into atmosphere. However, a lot will depend on the degree of activity contemplated. In fact, so far as cotton is concerned, the synthetics should be preferred in clothing of active sports as they do not retain moisture and this has the advantage of keeping garments lighter than the cotton when it is wet. Also synthetic fibres have some added advantage of quick dry and good shape retention property. Most of the modern textile materials use the basic idea of capillary action for sweat absorption and fast drying.

SPECIAL FIBRES USED

Hygra[20] : Unitika Limited has launched Hygra, (fig. 1) which is a sheathcore type filament yarn composed of fibre made from waterabsorbing polymer and nylon. The water-absorbing polymer has a special network structure that absorbs 35 times its own weight of water and offers quick releasing properties that the conventional water-absorbing polymer cannot do. On the other hand, nylon in the core gives tensile strength and dimensional stability. Hygra also has superior antistatic properties even under low wet conditions. The main apparel applications include sportswear like

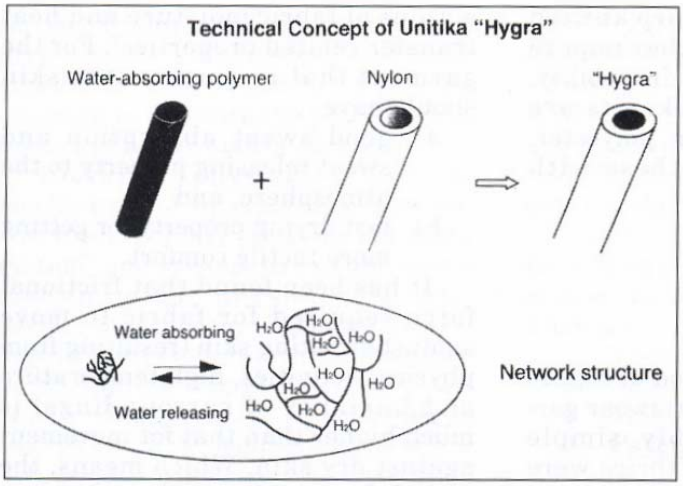


Fig 1 : Hygra sheath-core type fibres

athletic wear, skiwear, golf wear etc.

Lumiac[21] : Lumiace is also a product from Unitika. It is a collection of polyester filaments having different fineness (0.5 - 2.0 denier per filament) and irregular cross sections. Hygra - Lumiace combination in knitted fabric is very popular in top Japanese athletes.

Dryarn[22] : Dryarn is the new fibre from Aquafil. It is a completely recyclable polypropylene microfibre. Fabric from Dryarn is very lightweight and comfortable and used in different sports. In addition it has a soft handle and a high thermo-regulatory capacity and also dries quickly. Bacteria cannot settle on smooth surface of the fibre which avoids unpleasant odour associated with decomposition of bacteria.

Killat N[23] : Killat N from Kanebo Ltd is a nylon hollow filament. The hollow portion is about 33 per cent of the cross section of each filament due to which it gives good water absorbency and warmth retentive property. The manufacturing technology of Killat N is very interesting. The yarn is spun as bicomponent filament yarn with soluble polyester copolymer as the core portion and nylon as the skin portion. Then by giving alkali weight loss treatment the soluble polyester copolymer of the bicomponent filament will dissolve and a large hollow portion (exceeding 30 per cent of the cross section) will be created. Which is shown is figure. 2.

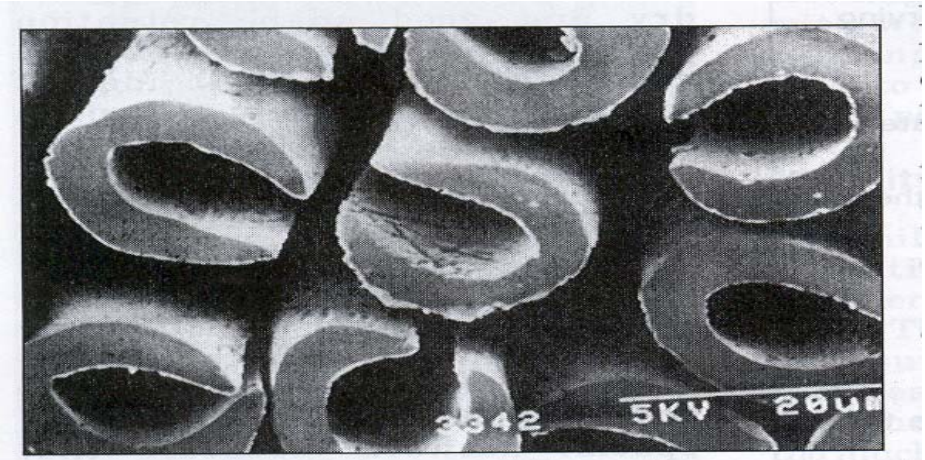


Fig 2 : Killat N hollow nylon fibre

Triactor [24]: Toyoba Co Ltd has developed Triactor, which is a perspiration absorbing/quick drying polyester filament as shown in fig.3. Polyester is hydrophobic and does not absorb moisture but by changing the filaments to Y shaped cross section Toyobo has realised quick perspiration absorbency by capillary action. The hydrophobic nature and large filament surface of polyester filaments realise quick drying and refreshing properties at the same time.

There are many other fibres, which have good sweat absorption and fast drying property. Most of them are either nylon or polyester.

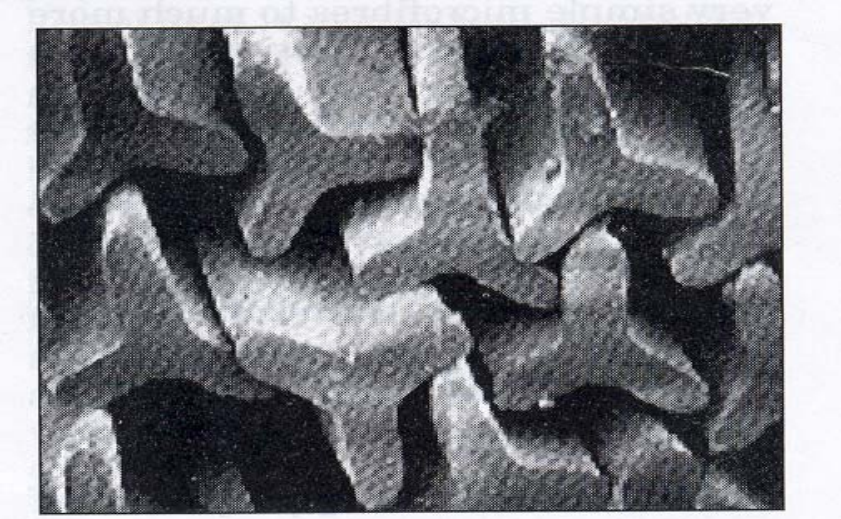


Fig 3 : Structural model of Triactor

Lycra[25]*:* Lycra, a truly synthetic fibre oflong chain polymer composed of at least 85% segmented polyurethane, finds wide range of end uses such as swimwear, active sportswear, floor gymnastics because of its comfort and fit2O. Adding Lycra to a fabric gives it stretch and recovery, particularly in gymnastics and swimwear where body skin flexing and stretching are inevitable. Lycra T-9026 requires still effort for the same extensibility.

Roica and Leofeel[26] : Roica is a polyether type spandex made by dry spinning method and Leofeel is a soft nylon-66 yarn developed by Asahi Chemical. The combination of Roica and Leofeel in mixed knitted tricot fabric gives a soft touch and excellent stretch. It is mainly used in swimwear.

Various other fibres like Elite from Nylstar Co, Linel Ac from Fillattice Co, Elastil and Sens from Miroglio etc also have good stretchability and are effectively used in swimwear.

Branded synthetic fibres for sportswear[11]

Brand	Fibre	Property Claimed
Sillook Royal S	Polyester	Three petal cross-section, silk-like fabric, including traditional 'rustle'
Malor	not given	Continuous filament, textured, random crimp along filament
UTS	not given	Smooth touch, textured fibre, 2 μm microfiber
Reebarg P	not given	Rustling sound
Sillok Chatelaine	not given	Dry touch of fabric; microgrooved cross-section allowing water absorption
Cheddy	not given	Dry touch of fabric; microcaters on surface of fiber, which when rubbed together give silky-dry handle
CEOx	not given	Water-absorbency based on capillary tubes of up to 10 μm between single filament yarns in a multifilament arrangement, ultra fine and ultra thick fibres interspersed
Rirancha	not given	Slab-shaped yarns
Sillook Airly	not given	Crinkling, dry touch, air-hole, highly modified cross-section (hollow?)
Sillook Sildew	not given	
Belima-X	Polyester /polyamide core	Consisting of polyester and polyamide 6, splittable

MULTI-LAYERING OF FIBERS

Blends in form of layering of fibres are capable of offering the best properties of each. Bicomponent knits such as polyester/wool or polypropylene/wool blends provide wicking and insulation properties in a single layer[10,27,28].

Push-pull fabrics are bicomponent materials composed of a non-absorbent hydrophobic material on the inside-worn next to the skin-and an absorbent hydrophilic material on the outside. Usually, the hydrophobic material is polyester, and the absorbent hydrophilic material nylon.

Sportswool[29], a trade mark of The Woolmark Company, is an example of a fabric which has been engineered to manage moisture. Developed by scientists in 1994, it is a hybrid material composed of a fine Merino wool sub-layer for Insulation and a polyester exterior which draws moisture away from the wool layer to the surface.

The wool fibre next to the skin attracts perspiration vapour molecules, before they have the chance to condense into liquid, and disperses them into the atmosphere. The fabric has attracted the attention of top Australian athletes and the Manchester United soccer team. Its major drawback, however, is that it takes longer to dry because of its wool content.

Dri-release[10] is a wicking performance yarn developed by US-based Optimer, a company founded by a group of former DuPont scientists. This patented product is an intimate blend of 85-90% hydrophobic low moisture-absorbing staple fibre-such as polyester-and 10-15% hydrophilic wicking staple such as cotton.

Dri-release is incorporated in athletic wear, socks and underwear. It is used by a number of major brand names in apparel-including Adidas, Fila and The North Face.

The main Dri-release product is made from 85% copolymer polyester and 15% long staple cotton. Dri-release combines the wicking and soft touch properties of cotton with the non-absorbing nature of polyester.

When combined in small quantities with polyester, chemicals can be added during the manufacturing process to inhibit the formation of body odour-for which polyester is notorious-in the final fabric.

The incorporation of cotton during spinning results in an intimate blend, which locks the wicking phase into the structure. Consequently, its effects are permanent.

Over time, the soft ends of the cotton become more exposed on the fabric surface. This improves the wiping action and gives the fabric a softer touch.

The incorporation of cotton in Dri-release contrasts with the approach used in the case of other treated polymers, where fabrics are made wettable by applying topical polymeric finishes. However, fabrics treated in this way can lose their ability to wick moisture after only
five washings.

Tests by Optimer and its customers show that its 85/15 copolyester/cotton blend wicks and releases moisture better than a fabric made from 100% polyester fibre whose entire surface has been converted to hydrophilic hydroxyls.

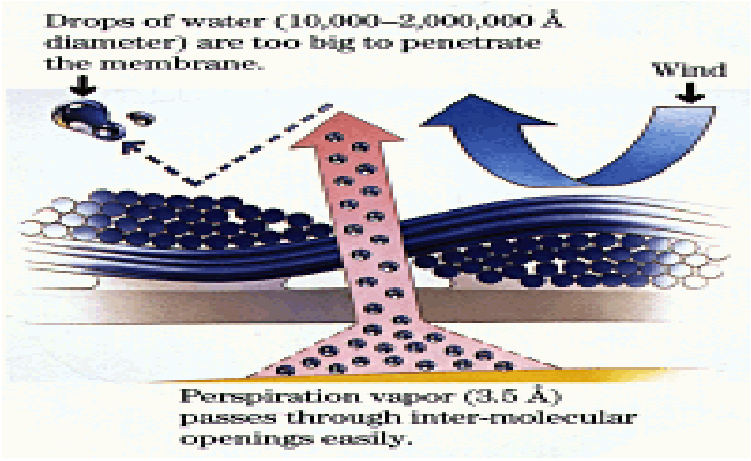
In tests, Dri-release was shown to dry four times faster than cotton and as fast as, or faster than, other performance polyesters-particularly after several washes.

Dri-release also incorporates a Freshguard finish. This neutralises odours retained in the fabric for the life of the garment.

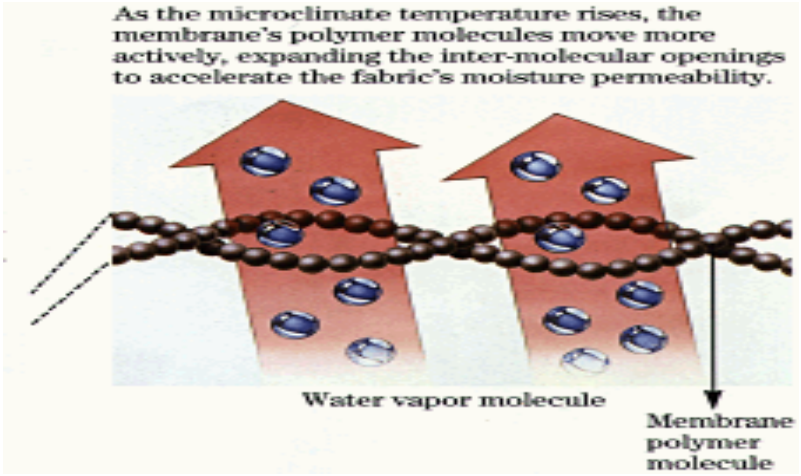
Optimer is carrying out research into the possibility of combining other hydrophilic fibres with polyester in order to create moisture controlling fabrics. One such fibre is wool.

Toray industries Inc.[12] is marketing successively a series of waterproof/breathable fabrics ‘entrant”. There are three main versions of “Entrant” and they are as follows:

"Entrant Dermizax EV " is a lightweight fabric having a feather smooth texture with excellent waterproof/moisture permeability and durable water repellency such as 20,000mm of water pressure resistance and moisture permeability of 30,000 g/m^2/24 hrs. It is an excellent and original active sportswear fabric with globally top class water proof/moisture permeability, as well as excellently durable water repellency. Its action of Waterproofing & moisture permeability is shown in Fig.4.



Waterproof, moisture permeable mechanism



Water vapor permeating mechanism

Fig 4 Entrant Dermizax EV

"Entrant HB" is a new generation fabric with hybrid structure that synergistically integrates the advantages offered by a coating (well-balanced moisture permeability) and lamination (high waterproofness). It has high resistance to water pressure and high durability against repeated washings (80 points or higher after 20 wash cycles). Its main application is outdoor wear.

"Entrant DT" is a microporous coated fabric offering a smoother and refreshing dry touch as well as attractive appearance through an innovative inner surface treatment technology. It has patterns printed on a coated membrane and a dry touch obtained by

improving the coated membrane as shown in fig.5. It features lightweight configuration, easy packing and high breathability/waterproofness.

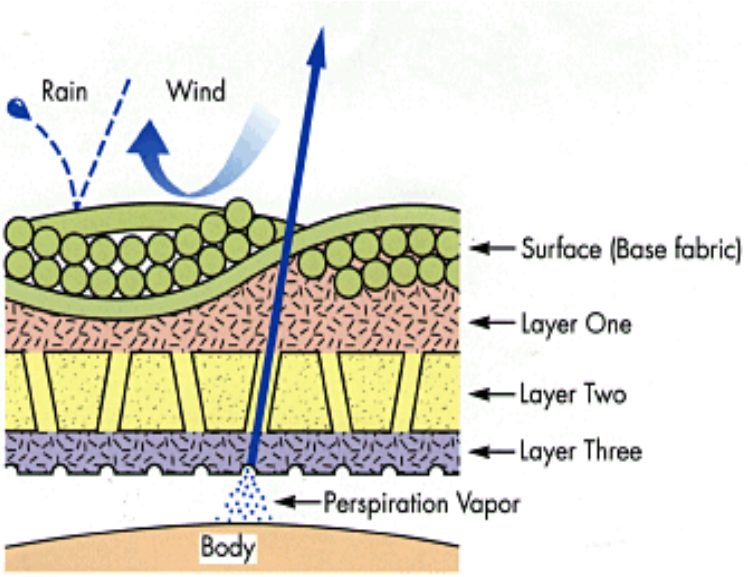


Fig 5 ENTRANT DT

In addition, Toray has developed "H_2OFF" made up of polyester microfiber fabric with a unique high-density weave structure comprising millions of microcrimped fiber loops (fig.6). It also feature superb and durable water repellency, superior breathability and wind-chill resistance and attractiveness with soft hand.

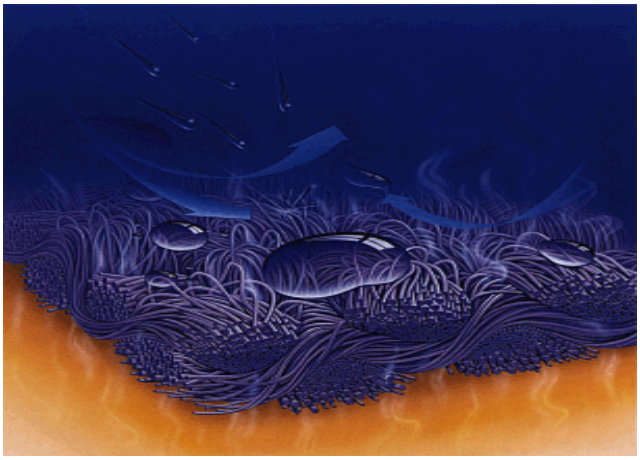


Fig 6 H_2OFF

Toray's "Fieldsensor" is a polyester filament multilayered knitted fabric that offers perspiration absorbing/quick drying properties. The inner layer absorbs perspiration from the wearer quickly, where it evaporates in the air. This mechanism makes use of capillary action. Their uses mainly include knitwear for athletic sports or lining for skiwear.

Naiva[30] : Unitika has developed N aiva fabric by combining the Naiva yarn with a

nylon microfibre14. Naiva is an Eval/nylon bicomponent filament yarn and Eval is nothing but a copolymer resin of ethylenevinylalcohol. Naiva yarn composition is 55% Eval (23% ethylene + 32% vinyl alcohol) and 45% nylon. In the Naiva fabrics there are many nylon microloops *(Fig* 7) on the surface, which are formed by making use of high thermal shrinkage property of Naiva yarn. Naiva fabric not only has good moisture permeability but also has some other positive features like lightweight, softness and has capability of secondary finishing. The fabric is very successfully used in mountaineering wear and other active sportswear.

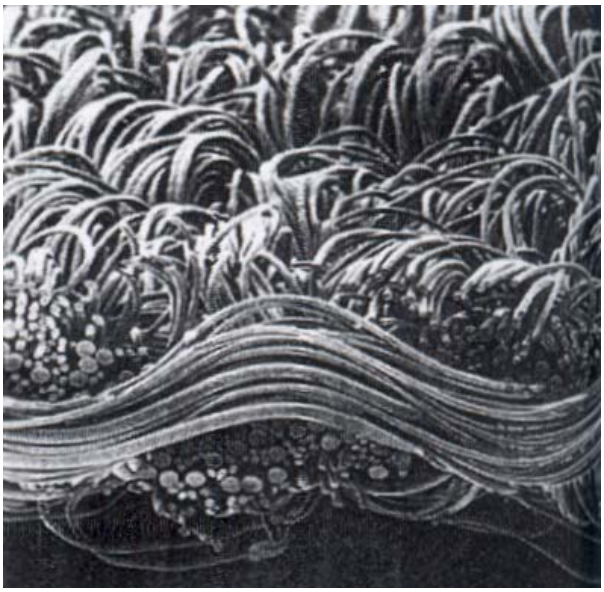


Fig 7: Naviva fabrics with microloops on the surface

Field Sensor[21]*:* Field Sensor is a very popular high performance fabric from Toray, which employs a multi. layer structure that not only absorbs perspiration quickly but also trans. ports it up to the outer layer of fabric very rapidly using principle of capillary action. It is composed of coarser denier yarn on the inside surface (in direct contact with skin), and fine denier hydrophobic polyester yarn in a mesh construction on the outer surface to accelerate quick evaporation of sweat (fig.8).

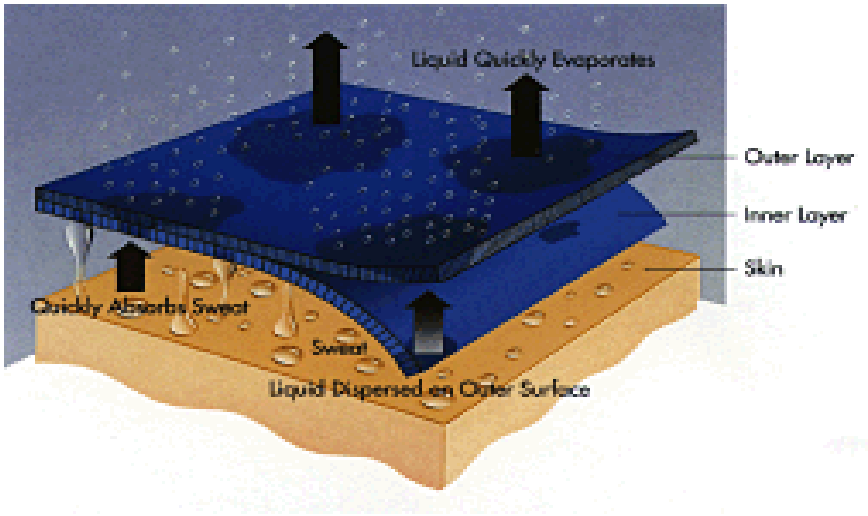


Fig 8: FIELDSENSOR

A variation of same concept is used for Cubesensor and Coolmagic woven fabrics and in Aerosensor, which is a two-way warp knitted fabric.

Reospec[31] : Toray has developed Reospec, which is a same base product as Aquapion but provided with stripe coating of water-repellent chemicals. Reospec has water friction resistance even lower than Acquaspec.

Dimplex[32] : Descente Ltd has developed Dimplex, which takes the dimple convex on the surface jump suits based on fluid mechanics and can substantially reduce air resistance during the run up and flight. It is generally used in skiwear.

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