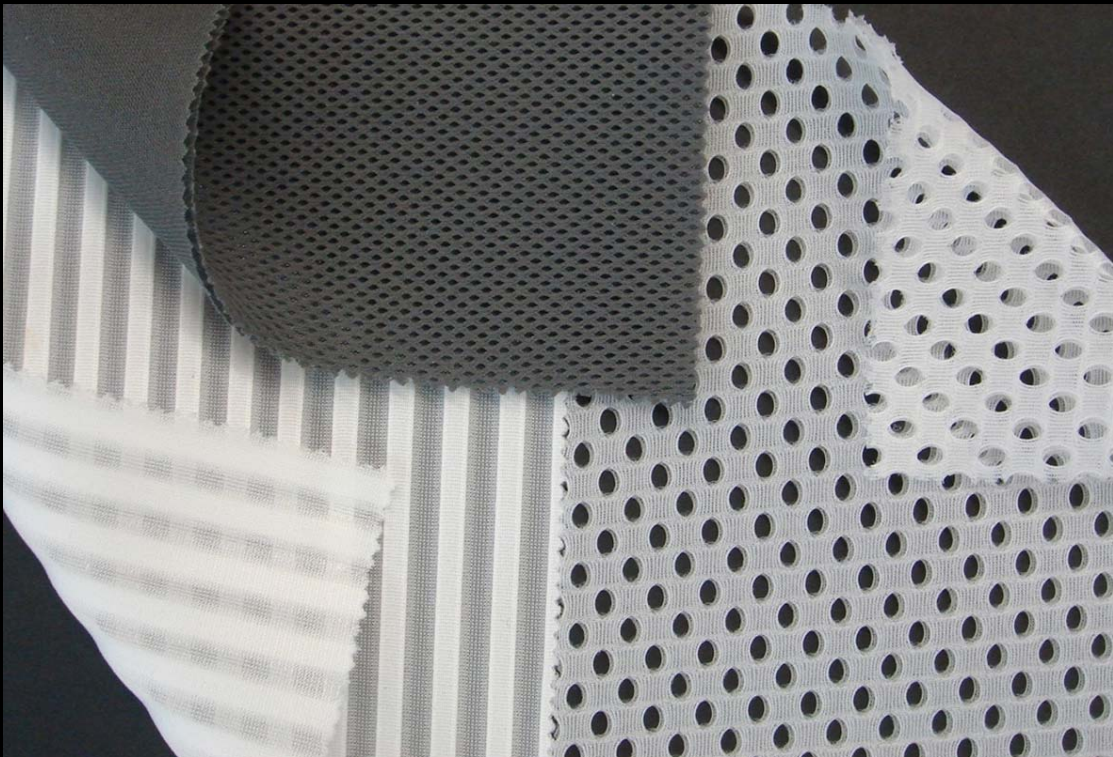


Engineered Fibres & Fabrics for Active Sportswear



By: Gaurav Agarwal

ENGINEERED FIBRES & FABRICS FOR ACTIVE SPORTSWEAR

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Abstract: The sports clothing of today have become technically oriented, using highly functional textiles for both casual and performance sportswear. The recent developments in materials for sportswear have resulted in specialized performances in different sports. In this paper an overview is given of the recent developments in fibres, yarns, fabrics for applications in active sportswear.

1. INTRODUCTION

India is increasing total wealth and per capita income. The rapid spread of satellite television is globalizing 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. Design of active sportswear is still a subject of research for many companies. As a result of this new fibre, fabrics & finishes are developed to satisfy the stringent requirements imposed by contemporary sports trends.

Constant pursuit of victories and record breaking performance by top level professional athletes, outstanding marksmanship by popular ball players and the maximum enjoyment of amateur sports activities need creative engineered sports garments. This means that the products have to be more than functional if consumers are encouraged to buy them, as they are currently demanding new looks and fabrics with a different feel to them.

The sportswear and sport goods sector of the textile industry has not only resulted in market diversification for fibrous materials but has also contributed towards the elevation of textile science and technology to a level which starts to become in par with other high-tech industrial sectors. New technological developments, more fragmented niche markets and increasingly demanding customer expectations are just some of the factors relentlessly driving this industrial sector. To thrive in this environment, companies are implementing radically new product development practices.

2. DESIGN CONSIDERATIONS IN SPORTSWEAR

Design requirements of active and performance sportswear have produced designers with skills and knowledge in graphics, textiles and fashion to conceive aesthetically pleasing and ergonomically viable ranges which take advantage of the latest advances in functional and smart textiles. It is the fabrics and technology that set the trend. Incorporation of microfibres, breathable barrier fabrics, innovative stretch materials, intelligent textiles, interactive materials such as phase change materials and shape memory polymers and wearable technology as a part

of the functional design system in sportswear, will become routine in the product development process.

Advances in innovative high functional uncoated and coated textiles and coatings as well as the garment manufacturing technology have resulted in more sophisticated sportswear and footwear specifically designed to be used by different user categories of performance sports and outdoor leisure use. All this helps to speed the runner, keep the jogger dry and cool, streamlining the swimmer, protect the cricketer, hockey player and snowboarder, keep the football player and cyclist dry, and keep the user comfortable and warm in extreme weather conditions.

3. SPORTSWEAR AND COMFORT:

In active and endurance sports, the performance of a sportswear is synonymous with its comfort characteristics. In active wear for outdoor use, the clothing should be capable of protecting the wearer from external elements such as wind, sun, rain and snow. At the same time, it should be capable of maintaining the heat balance between the excess heat produced by the wearer due to increased metabolic rate on the one hand, and the capacity of the clothing to dissipate body heat and perspiration on the other.

Sportswear needs to look as a whole system. If over heating is to be avoided, thermoregulation and moisture management are key functions of clothing designed for use as sportswear or active wear. The human body, its microclimate & its clothing form a mutually interactive system. The body and its microclimate are invariables; the clothing system is the only variable.

The human body has an *operating temperature* of 37°C which it attempts to maintain under all circumstances. During physical activity such as in sport the body temperature rises. The body cools down again through the excretion of perspiration. Perspiration creates moisture vapor. If this cannot be released outward through many layers of clothing a “green-house effect” results.

To prevent the body temperature exceeding the *comfort zone*, the heat must simultaneously be dissipated outwardly. The human body has no problem excreting half a liter or even a whole liter of perspiration per hour provided that this process is not impeded by the relative humidity of its environment & clothing.

It is clear that clothing is the key to body comfort. Comfort is difficult to define since it covers both quantifiable data and subjective considerations. In general, comfort is a situation where temperature differences between body members are small with low skin humidity and the physiological effort of thermal regulation reduced to minimum.

Four types of ‘Clothing comfort’ have been defined which are essential requirements for active sportswear. They are:

1. Thermo-physiological comfort
2. Sensorial/tactile comfort

3. Mobility/Dexterity
4. Psychological comfort

- **Thermo-physiological comfort:**

This form of comfort may be said to exist when the person is in thermal balance i.e. when the rate of loss of heat from the body equals the rate at which it is being generated by the physiological processes. If the rate of loss of heat is insufficient, the person feels hot and the body temperature rises, heat stress eventually results. On the other hand if the rate of loss of heat is too high, the person first feels cold and the body temperature falls, causing discomfort to the person. Thus for getting thermo-physiological comfort the sportswear should have suitable thermal insulation properties as well as sufficient permeability to water vapor and/or sufficient level of ventilation.

- **Sensorial/tactile comfort:**

The sensorial comfort does not directly involve any temperature balance, but is related to the way that the person feels when clothing is worn next to skin. Wet feeling and wet cling can be a major source of sensorial discomfort in situations of profuse sweating. If the skin is wet with sweat and if the sweat is not released by the clothing then an unpleasant feeling with wetness will occur. Also the clothing which is next-to-skin will stick to body which will prevent the sports person to perform properly.

- **Mobility:**

While doing the various physical activities in the active sports, considerable movements of body parts occur. The sportswear must therefore have sufficient degree of mobility so that wearer can be able to move freely. Too much volume, too much weight or too much stiffness of fabric will tend to reduce the mobility and leads to discomfort. The clothing should have low fluid resistance and stretchability.

- **Psychological comfort**

The feeling of the wearer that he or she is dressed in a style/fashion means the psychological comfort. This is mainly related with aesthetic appeal. From top-level professional sport person to amateurs, all demand psychological comfort to some extent along with other three comforts.

4. REQUISITE FUNCTION OF ACTIVE SPORTS WEAR:

There are basically three types of sports players and their requirements of sportswear in terms of functional and other properties are different.

- (i) Top level professional primarily require functional power with aesthetic appeal as they strive for record breaking performance.
- (ii) The seriously competing amateurs involved in sports club who as potential future top-line performers need to have sportswear with at least minimum functional effectiveness and at a reasonable cost; and
- (iii) Those who enjoy sports activities for its benefits in respect of health, hobbies and social contact need the material to provide a minimum physical function but they are more conscious about comfort and sensitivity.

The requirements for an active sportswear can broadly be classified into:

(a) Functional: For top level competition active sports wear requires super light weight, low fluid resistance, super high tenacity and stretchability. For those seeking comfort and healthy pursuits, critical features include thermal retention, UV resistance, cooling capacity, sweat absorption, fast drying, vapour permeability, water proofing etc. to provide relaxation preventing fatigue.

(b) Aesthetic: From the sensitivity or aesthetic point of view, softness, surface texture, handle, lustre, colour variation, transparency and comfort in wear are important factors.

5. DEVELOPMENTS IN FIBRES AND TEXTILE MATERIALS FOR SPORTSWEAR:

The evolution of fibre developments has gone through the phases of conventional fibres, highly functional fibres and high-performance fibres. Polyester is the single most common fibre used for sports wear and active wear. Other fibres suitable for active wear are polyamide, polypropylene, acrylic and elastanes. Synthetic fibres can either be modified during manufacturing or be optimally blended with natural fibres to improve their thermo-physiological and sensory properties. Synthetic fibres with improved UV resistance and having anti-microbial properties are also commercially available for use in sportswear. New technologies for producing microfibrils have also contributed towards production of high-tech sportswear.

A. NEW POLYMERS FOR SPORTSWEAR:

1. PHASE CHANGE MATERIAL (PCM):

Phase change materials produce microcapsules full of paraffin. When, the capsules are heated, the paraffin liquidifies and heat energy is stored. When the environment cools, the paraffin crystallizes again, releasing heat. The paraffin, which is available in different recipes with various melting points, is referred to the phase-change material, or PCM. Because the paraffin can be formulated with different melting points, the microcapsules can be designed to keep the wearer either warm or cool. The

warmer paraffin is suitable for skiing and other cold weather sports; the cooler waxes are good choices for biking gear, mountaineering clothes, or footwear.

2. SHAPE MEMORY POLYMERS:

Diaplex: A special suit based on a membrane employing shape memory polymers was developed for Swedish sailor. The suit, designed employs the Diaplex smart fabric technology. Diaplex materials can be simultaneously and completely waterproof, windproof and breathable. This material can 'remember' and retain its shape, or return to a previous form. A garment made from Diaplex is able to sense changes in the surrounding environment, evaluate then intelligently, and control its responses to ensure the highest level of comfort.

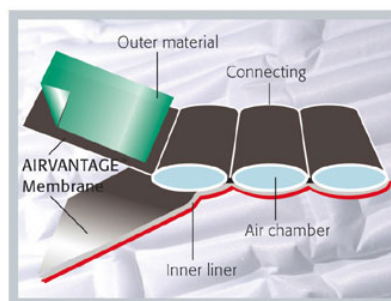
Its intelligence lies in the unique way in which it takes advantage of micro-Brownian motion (thermal vibration). Micro-Brownian motion occurs within the Diaplex membrane when the temperature rises above a predetermined activation point. As a result of this motion, micro-pores are created in the polymer membrane which allows water vapour and body heat to escape. Because permeability increases as the temperature rises, the membrane is able to respond intelligently to changes in the wearer's environment and body temperature.

Diaplex is also unique in that the temperature at which micro-Brownian motion begins can be freely specified. This means that the activation point can be set to match, the environmental conditions in which a garment is likely to be worn.

3. MEMBRANE TECHNOLOGY:

Airvantage: Airvantage system by W.L. Gore is the first personal thermal climate management system for clothing in the world. It enables wearers to react as though they had their own personal air conditioning system.

The secret of the system is based on an age-old piece of wisdom - air is a poor conductor of heat and therefore the best natural insulator. On the one hand trapped air protect, against the cold, on the other it keeps in existing body heat.



Airvantage membrane system, specially developed for the construction of permanently airtight and breathable chambers, is based on the same PTFE technology as Gore Tex.

Two laminates are bonded together to be airtight and breathable. The special air chambers of this garment component are adjusted using a valve. When the outside

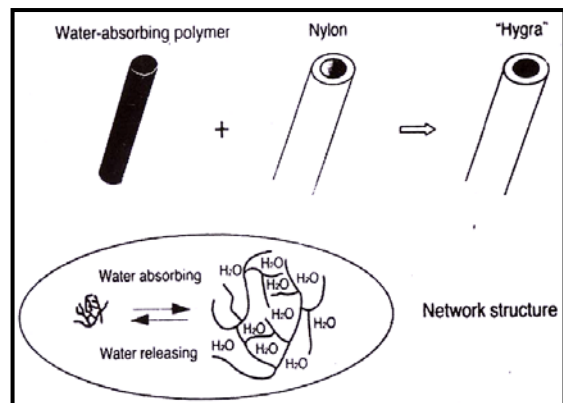
temperature changes, or when wearer becomes more or less active, the insulation layer can be regulated as required, simply by blowing air into the chambers or by allowing it to escape. In the first case, blowing air into the chambers significantly improves heat retention (thermal insulation) so that the wearer feels warmer. In the second, reducing the amount of air trapped in the chambers means that excess body heat can be released.

Sympatex: Sympatex differs from its main competitor Gore-Tex in being extremely thin-layered (70-100 microns) solid polyester membrane with no micropores. It is effective in transporting perspiration moisture away from the wearer's body but at the same time a good barrier to water and wind.

B. FIBRES & YARNS FOR ACTIVE SPORTSWEAR:

Developments in synthetic fibres which are tailor-made have opened up enormous avenues for their use in sportswear to meet specific requirements. In active sportswear single fibre is seldom used. Mostly, specialty fibres are used in conjunction with normal fibres. Examples of such fibres are given below:

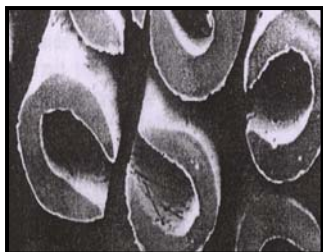
Hygra: Unitika Limited has launched Hygra, which is a sheath-core type filament yarn composed of fibre made from water absorbing polymer and nylon. The water-absorbing polymer has a special, network structure that absorbs 35 times its own weight of water and offers quick releasing properties that the 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 athletic wear, skiwear, golf wear etc.



Lumiace: 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.

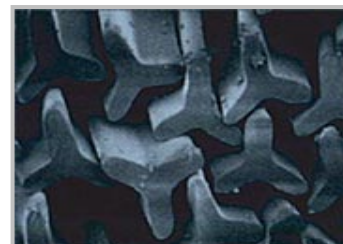
Dryarn: Dryarn is the new fibre from Aquafil. It is a completely recyclable polypropylene microfibre. Fabric from Dryarn is very lightweight and comfortable and used in different sports. In addition, it has a soft handle and a high thermoregulatory capacity and also dries quickly. Bacteria cannot settle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

Killat N: 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 bi-component 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 bi-component filament will dissolve and a large hollow portion (exceeding 30 per cent of the cross section) will be created.

Triactor: Toyobo Co Ltd has developed Triactor, which is a perspiration absorbing/quick drying polyester filament. Polyester is hydrophobic and does not absorb moisture but by changing the filaments to Y shaped cross section Toyobo has realized quick perspiration absorbency by capillary action. The hydrophobic nature and large filament surface of polyester filaments realize quick drying and refreshing properties at the same time.



CoolMAX: It is a tetra-channel polyester fibre with a cross section like a double scallop. This fibre was produced specifically for the sportswear market. It has improved wicking capability and moisture vapor permeability.

Dri-release: Dri-release 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 fibres such as polyester and 10-15% hydrophilic wicking staple such as cotton. Dri-release is incorporated in athletic wear, socks and underwear. Dri-release combines the wicking and soft touch properties of cotton with the non-absorbing nature of polyester. Dri-release also incorporates a Freshguard finish. This neutralizes odors retained in the fabric for the life of the garment.

NEW Elite: Elite is the trademark for a PBT (polybutyleneterephthalate) textured yarn manufactured by Nylstar and marketed by Rhotex, Italy. After thermal treatment at the dyeing or finishing stage Elite yarn can achieve permanent elasticity with comfortable stretch properties for sportswear. The easy dyeability of Elite yarn with disperse dye at 98°C, makes it suitable for blending with natural and synthetic fibres.

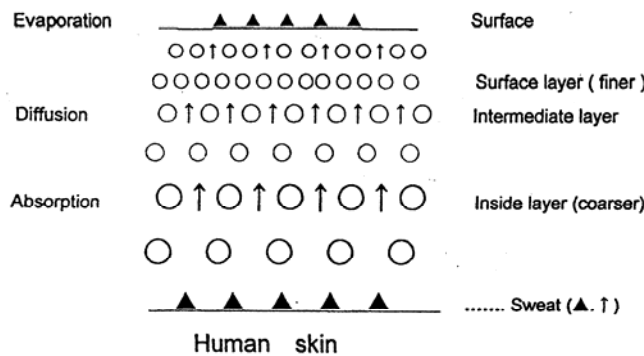
C. FABRIC DEVELOPMENTS FOR ACTIVE SPORTSWEAR:

There has been a strong growth in development and use of high functional materials used in sportswear and outdoor leisure clothing. The performance requirements of many such products demand the balance of widely different properties of drape, thermal insulation, barrier to liquids, antistatic, stretch, physiological comfort etc. The research in this field over the past decade has led to the commercial development of a variety of new products for high functional end-uses. By designing new processes for fabric preparation and finishing, and as a result of advances in technologies for production and application of suitable polymeric membranes and surface finishes, it is now possible to successfully combine the consumer requirements of aesthetics, design and function in sportswear for different end-use applications. The fabrics for

active wear and sportswear are also specially constructed in terms of the geometry, packing density and structure of the constituent fibres in yarns as well as the construction of the fabric in order to achieve the necessary dissipation of heat and moisture at high metabolic rates. Many smart double-knitted or double-woven fabrics have been developed for sportswear in such a way that their face closer to human skin has optimal moisture wicking and sensory properties whereas the outer face of the fabric has optimal moisture dissipation behavior.

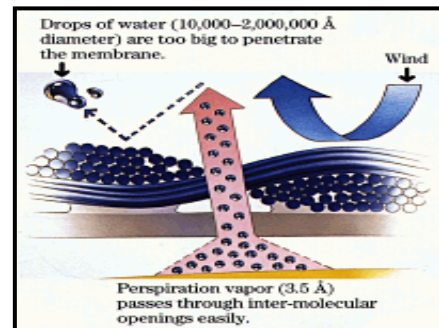
Naiva: Unitika has developed Naiva fabric by combining the Naiva yarn with a nylon microfibre. Naiva is an Eval/nylon bi-component filament yarn. Eval is basically a copolymer resin of ethylene vinyl-alcohol. Naiva yarn composed of 55% Eval and 45% nylon. In the Naiva fabrics there are many nylon micro-loops 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.

Field Sensor: Field Sensor is a very popular high performance fabric from Toray, which employs a multilayer structure that not only absorbs perspiration quickly but also transports 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. The model of absorption and fast drying mechanism of field sensor is shown in fig. below

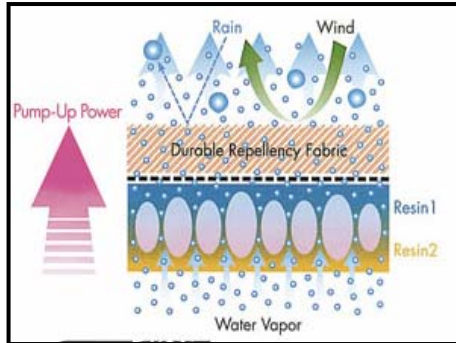


Water magic: Water magic from Kuraray also utilises the same principle for sweat absorption and quick drying as that of Naiva. Water magic is a 3-layered knitted fabric of Wrap (67% polyester / 33% nylon ultra fine microfibre). Water magic has innumerable random and minute pores. These micropores speedily transport perspiration from the skin side to outer air.

Gore-Tex: The first and probably the best known waterproof breathable fabric is Gore-Tex. This is a thin microporous membrane of polytetrafluoroethylene (PTFE) sandwiched between two fabric layers. The polymer claimed to contain 1.4 billion tiny holes per cm. These holes are much smaller than the smallest rain drops (2-3



gm compared with 100 pro), yet very much larger than a water vapour molecule ($40 \times 10^{-6} \mu\text{m}$).



Entrant G II: Toray has developed a high performance waterproof breathable fabric Entrant G II. It is a microporous coating of polyurethane developed with importance given to high water pressure resistance and high moisture permeability.

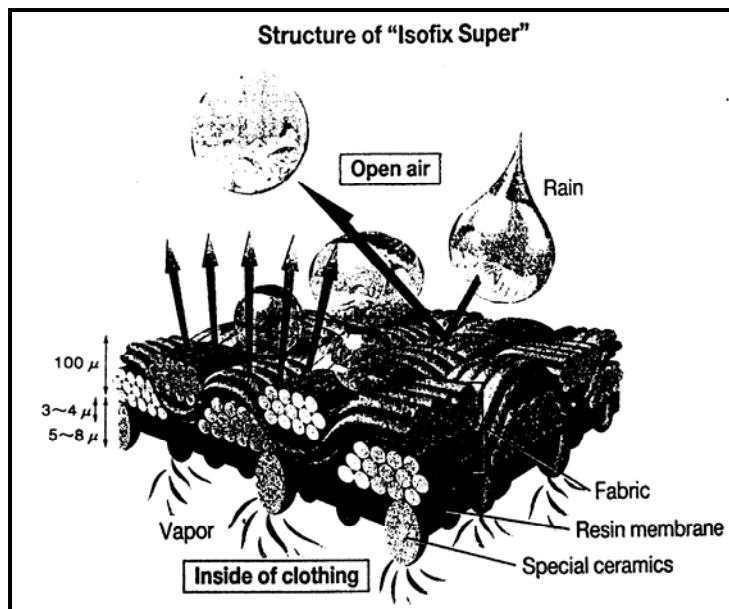
The secret of high performance of Entrant G II is in the three-layered polyurethane coating membranes including two different micro porous layers. If the layers from the top fabric side are called layer 1, layer 2 and layer 3, each layer has the following properties:

layers from the top fabric side are called layer 1, layer 2 and layer 3, each layer has the following properties:

- Layer 1:** Foam layer with miniscule micro porous improves water proofing and durability;
- Layer 2:** Regularly configured micro porous increases moisture permeability;
- Layer 3:** Pores in the resin surface enhance waterproofing. Strengthening coating surface and inhibit dew condensation.

Isofix Super: "Isofix Super", developed by Kanebo, is the name applied to a coating which incorporates new processing and structural technologies by fusing anti-sublimation / anti migration coating techniques to special ceramics with countless number of pores. The major features of "Isofix Super" other than water proof / moisture permeable property are as follows:

- Anticondensation property: Once the special ceramics, which are composed of hydrophilic crystals with counters numbers of microporous, reach the supersaturated condition, they demonstrate their water absorbing power to the hilt by presenting condensation inside the garment. This water absorbing power is as high as one hundred to two hundreds times the weight of the special ceramics themselves in the coating.
- Dry feel: As the ceramic particles protrude from the surface of the coated resin, none of the resin ever touches the body and thus provides wear comfort without any sticky feeling.
- Soft touch: "Isofix Super"



adopts a resin which is softer than the polyurethane which is normally used in waterproof / moisture permeable coatings.

Sportwool™: It is a trade mark of The Woolmark Company. In 1994 research into the physiological benefits of wool led to the breakthrough development of Sportwool. 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 vapor molecules, before they have the chance to condense into liquid, and disperses them into the atmosphere.



The removal of the vapor from the micro-climate between the skin and fabric reduces the formation of liquid sweat leaving you drier and more comfortable. Sportwool's unique natural thermal regulation and vapor management properties cool down when it's hot and keep warm in extreme cold. So whether wearer is skiing on a cold winter morning or cycling in the heat of summer, Sportwool is the natural choice when wearer wants to perform to the maximum.

6. CONCLUSION:

Sporting culture in the world has changed dramatically in recent years following the emergence of a new generation of consumers. With the ageing population and consequent increase in leisure time and travel, there will be more emphasis on team sports, leisure & individual sports. Performance apparel represents one of the fastest growing sectors of the international textile and clothing industry. Market growth is being fuelled by the emergence of new fibres, new fabrics and innovative process technologies.

The market is also being boosted by changes in consumer lifestyles. People are spending more time on leisure activities. New high-tech fabrics are being developed for a wide range of active sports such as aerobics, athletics, running, cycling, hiking, mountaineering, swimming, sailing, windsurfing, ballooning, parachuting, snowboarding, etc. More developed technologies, improved functional properties of sportswear, new fibres and fabrics are expected to come out in the near future to meet stringent expectations.

7. REFERENCES

1. Textiles in Sports, Ed. By R. Shishoo, Woodhead Publishing Ltd
2. V. K. Kothari, 'Fibres and Fabrics for Active Sportswear', Asian Textile Journal, March 2003
3. Akira Yonenaga 'Engineered fabrics for active sportswear', Intl Textile Bulletin, No. 4, 1998
4. Jurg Rupp, "Functional Sportswear", Intl Textile Bulletin, No. 4, 1998
5. S C Anand & L Higgins, 'Textile Materials & Products for Activewear & Sportswear', Proceedings – 2nd International Conference of NISTI, 2-3 December 2004, Delhi

6. R. Shishoo, 'An overview of the Recent Developments in Materials for Sportswear', Journal of Fibre Bioengineering & Informatics Society, 2008
7. www.sportwool.com
8. www.gorefabrics.com
9. www.torayentrant.com

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