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INNOVATION – FOR SURVIVAL AND SUCCESS IN THE NEW ERA

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1. Introduction

Manufacturing, the transformation of materials into products, is no longer a primary source of prosperity in advanced economies. The last few years have seen intense innovation activity in all areas of textiles with convergence and close cooperation between different fields. Despite considerable amount of global exposure, technological modernization and diversification, large section of Indian textile industry continues to believe in set patterns of working. The focus more or less has been towards cost effective production of commodity products. The classical strength of the textile industry based on cheaper cost is already being challenged in many products. The trend of innovation which developed in the west essentially due to complex shifts in lifestyle and awareness encouraged constant demand for newness in textile products. Innovation in design, high tech fibres and fabrics, new products and knowledge based product differentiation and specialization are the routes the west is taking today and we will be forced to take tomorrow.

To achieve sustainable advantage, manufacturing efficiency must couple with innovative new products. Companies that go beyond manufacturing low priced commodities and offer improved customer values are the winners in the new global environment. Truly innovative companies generate a major segment of their revenue from products designed within the past three to five years. Companies increasingly need completely new and innovative products to succeed in the new and fast-moving business environment.

The new kinds of textiles possess characteristics that make them useful in numerous formerly unexpected applications. Although textiles are still mainly used for the clothes we wear and of many furnishings in our homes and offices, they are also used widely in numerous other fields. Some new textiles possess qualities that make them stain-resistant, smart etc. Innovation in textile technology continues and more unusual products will almost surely emerge. Figs, 1 and 2 shows finishing and fibre research has major attention of innovators.

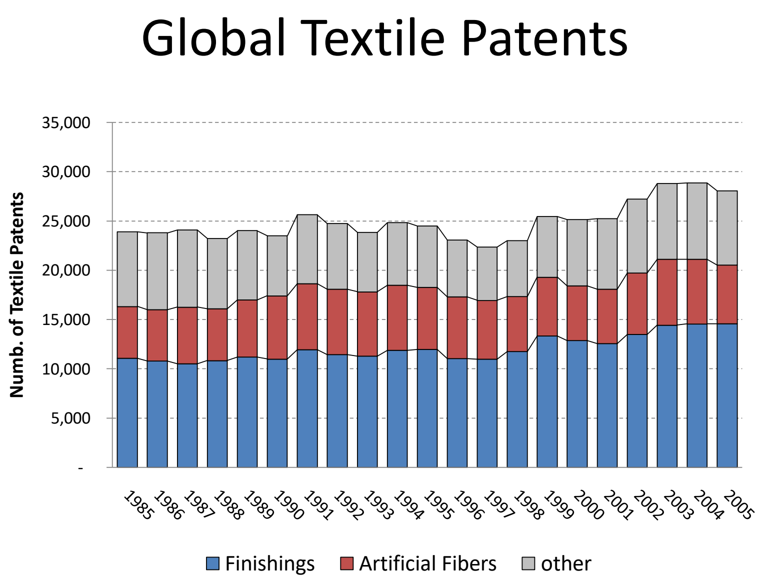

Figure 1: Areas of Textile Patents

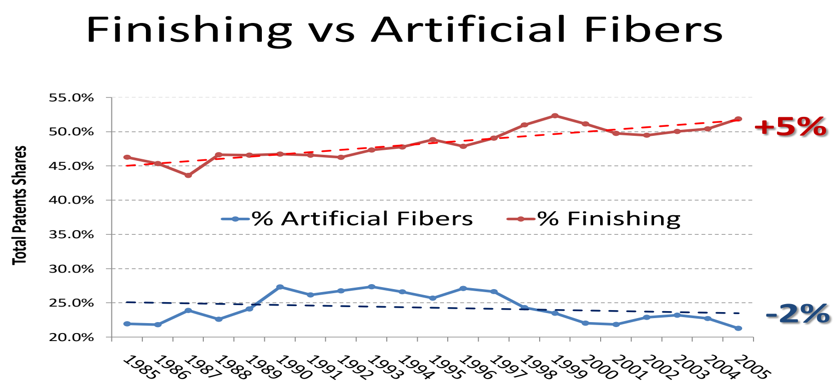

Figure 2: Patent Activity in Fibre and Finishing Areas

2. Finishing Innovations

Innovations in wet processing are being driven by consumer who has become knowledgeable and most concerned about his health, hygiene, comfort and fashion. Innovation in processing are also driven by environmental considerations, energy and water conservation requirements and development in associated technologies. In the customer driven market, specific needs of flame retardancy, antibacterial property, stain repellency, etc have further created challenges. Wet processing of textiles is the most complex stage in the manufacturing of fabric requiring immense personal attention and knowledge having potential for true value addition. It is a challenging task to attain desired appearance, feel and function right first time at competitive cost with the best of quality. The high performance standards expected in the processed fabrics by the present day consumer are to be met with right processing technology and innovations. Since the processing stage of fabric manufacture adds maximum value to the product, lot of R & D work is going on to provide specific functionalities, create unique feel and appearance in the fabric. Many new technologies such as nanotechnology, biotechnology, microencapsulation, inkjet printing, plasma processing are being used to produce innovative new products.

The technology of textile finishing encompasses very large number of finishing processes. Maximum attention is being given to produce fabrics and garments with multiple functionalities such as self-cleaning, super-hydrophobicity, antimicrobial, mosquito repellent, odour free and health promoting properties. Bio-finishing with enzymes and surface-effect mechanical finishes are considered eco-friendly finishes and being used increasingly.

The super-hydrophobic self-cleaning finishes are mostly based on the use of nanotechnology and many new methods of achieving this effect are being investigated since some of the well known processes are patented. Search is on for durable mosquito-repellent finish. Extensive studies are being carried out to find sustainable antimicrobial finishes based on chitosan, neem and Aloe Vera. Most of the deodorant finishes are based on cyclodextrin. Use of microencapsulated phase change materials and fragrances is also been made to produce value-added temperature controlled and fragrant garments. Considerable R&D is being carried out to modify surface of textiles leading to products with interesting and unique properties.

3. Fibre Innovations

The driving force for important fibre developments, especially in past two decades has been the ever increasing applications for fibrous material in non-conventional sectors such as protective clothing, medical and health care products, automotive components, building material, geotextiles, agriculture, sport and leisurewear, filter media, environmental protection etc. These applications put strong demands on good performance properties such as strength, modulus, durability and dimensional stability and on functions such as flame retardancy, hydrophilicity, hydrophobicity, biocompatibility etc.

The introduction of high performance fibres in technical textiles has allowed us to enter a new era of materials revolution. These fibres are used for special requirements demanded by certain types of technical textiles applications. Such technical requirements can be high temperature protection, high impact and dynamic energy absorption capacity, high cut-through resistance, etc. In other words, high-technology or specialty fibres are normally chosen for their particular suitability to an end-use such as protective clothing for ballistic body armour, for high-risk jobs and sports, lightweight textile-reinforced structural components for aircraft, high-performance ropes for marine applications, structural panels (reinforced with fibres) for building construction and so on. Aramids (Kevlar, Nomex, Twaron etc.), glass, carbon, polyethylene, polyphenylene sulphide, polyetheretherketone (PEEK), polytetrafluroethylene (PTFE) etc. are some of the popular high-technology fibres frequently used for technical textiles.

Tailor-made special properties are very often the features of high-technology fibres. For example, today fibres can be engineered into hollow structures that are capable of providing the varying degree of porosity and strength needed in medical applications such as synthetic blood vessels, controlled drug release etc.; in chemical/water industry applications such as purification, filtration etc.; in civil engineering and many other applications.

The long-term durability, dimensional stability, etc. of technical textiles are functions of many fibre properties. For example, thermal and thermomechanical responses of fibres describe the usefulness of the long-term utilisation of a fibre in a technical textile particularly to be used in a hostile environment such as hot gas or liquid filtration, welders' suits or even textiles used in tyres. The knowledge of various fibre properties thus allows the manufacturers of technical textiles to have a logical estimation of the suitability and subsequently the durability of the materials used in a particular environment so as to minimise the risks of unwanted failure due to the interaction of stress-deformation-temperature and degradative chemical reactions.

Specific fibre properties are required for the specific technical applications. Main properties required in many of the technical applications can be grouped as follows:

1. Mechanical properties (strength, extensibility, modulus/stiffness, elastic recovery etc.)
2. Thermal and thermo mechanical properties (melting temperature, high temperature mechanical properties etc.)
3. Chemical characteristics (resistance to various inorganic and organic chemicals etc.)
4. Electrical properties (static build-up, dielectric behaviour, insulating nature etc.)
5. Ageing behaviors (oxidative, thermal ageing etc.)
6. Surface properties (adhesion, moisture transport behaviour etc.)
7. Optical properties
8. Stretch and bulk
9. Moisture absorption
10. Biodegradability; bioactivity
11. Other special properties.

Improved fibre spinning techniques in melt spinning, wet spinning, dry spinning and new techniques such as gel spinning, bicomponent spinning, microfibre spinning, have made it possible to produce fibres with characteristics more suitable for use in technical textiles. It is now possible to produce man-made fibres with highly sophisticated non-circular cross sections, blends of filaments in a yarn having “differential shrinkage”, splitting of bicomponent filaments, surface treatments to produce required morphology and topography.

New spinning processes and slight modification of polymer systems have enabled fibre producers to go for much higher speed of production of fibres having improved mechanical properties. High tenacity polyesters, polypropylene, etc. play a very significant role in applications such as ropes, nets, fishing twines, etc. Improvement in viscose process has resulted in Lyocell fibres with greater water absorbance and higher strength. These fibres are widely being used in making medical nonwoven products and wipes.

4. Nanofibres

Nanofibres (Fig. 3) are generally taken to be fibres less than 0.5 µm (500 nm). Electrospinning is the major production method used to make nanofibres. Nanofibres formed with synthetic fibre material can be formed with a high surface area to volume ratio and very small pore sizes in fabric form. The potential uses of nano fibres are in filtration, wound dressings, tissue engineering, nanocomposites, drug delivery devices and sensors.

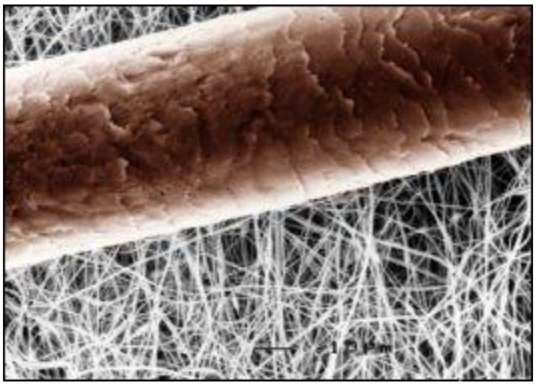

Figure 3: Nanofibres in relation to human hair

Nanocomposite fibres consist of nanofibres containing particles with one dimension in nanometer range. The particles may be spheres, fibrils, tubes or platelets and by varying the amounts, their alignment and distribution within the nanofibres improvements in mechanical, electrical, optical, or biological properties can be obtained. The incorporation of nanoparticles of various metal oxides such as TiO_2, Al_2O_3, ZnO and MgO into fibres can confer a variety of functionalities such as UV absorption capability, electric conductivity and photo-oxidising ability chemical/biological species to the products made from these fibres. The carbon nanotubes (both SWNT and MWNT) have been used for materials in high strength and high electric conductivity end uses. The incorporation of SWNTs in a polyvinyl alcohol fibre, using a cogulation spinning method, provides nanocomposite fibres with twice the strength and stiffness of steel together with twenty fold increase in toughness. Potential end uses of this fibre include safety harness, explosion proof blanket, and electromagnetic shielding.

Nanotechnologies offer great potential for producing fibres with improved properties and performance specially suited for a number of technical textile end uses.

5. High Performance Fibres

A relatively small (albeit important and growing) proportion of technical textiles, perhaps 2-3% by volume, uses the so-called high-tech fibres; aramids such as Kevlar, Twaron, Nomex, carbon fibre and high molecular weight polyethylene (Dyneema, Spectra). Both the highly temperature resistant *meta-aramids* (widely used in protective clothing and similar applications) and the high strength and modulus *para-aramids* (used in a host of applications ranging from bullet proof vests to reinforcement of tyres, hoses, friction materials, ropes and advanced composites) are now widely used. The aramid fibres, while not huge in overall terms (representing less than 0.5% of total world technical fibre and yam usage in volume terms but closer to 3-4% in value), the aramids represent a particularly important milestone in the development of the technical textiles industry.

Carbon fibres are used not only in aerospace markets but also of high technology sporting goods and industrial applications such as wind generator turbine blades and reinforced fuel tanks. As new manufacturing methods and greater economies of scale start to bring prices down, the feasibility of even larger scale applications such as the reinforcement of buildings and structures in earthquake zones becomes more attractive.

The introduction of other high performance fibres proliferated, particularly during the late 1980s, and in the wake of the aramids. These included a range of heat and flameproof materials suitable for protective clothing and similar applications (such as phenolic fibres and PBI, polybenzimidazole), ultra-strong high modulus polyethylene (HMPE) for ballistic protection and rope manufacture, and chemically stable polymers such as polytetrafluoroethylene (PTFE), polyphenylene sulphide (PPS) and polyethyletherketone (PEEK) for use in filtration and other chemically aggressive environments.

Specialty fibres are being developed for specific technical applications such as in medical textiles, protective clothing, etc. Alginate fibres, chitosan fibres, chlorofibre, electro-conductive polymeric fibre, artificial spider silk fibres are some of these.

Individually, none of these other fibres has yet achieved volume sales anywhere near those of the aramids (or even carbon fibres). Indeed, the output of some specialty fibres can still be measured in tens of tonnes per year rather than hundreds or thousands.

6. Inorganic Fibres for Technical Textiles

Glass has, for many years, been one of the most underrated technical fibre. Used for many years as a cheap insulating material as well as reinforcement for relatively low performance plastics (fibre glass) and roofing materials, glass is increasingly being recognized as a sophisticated engineering material with excellent fire and heat-resistant properties. It is now widely used in a variety of higher performance composite applications, including sealing materials and rubber reinforcement, as well as filtration, protective clothing and packaging; The potential adoption, of high volume glass-reinforced composite manufacturing techniques by the automotive industry as a replacement for metal body parts and components, as well as by manufacturing industry in general for all sorts of industrial and domestic equipment, promises major new markets.

Various higher performance ceramic fibres have been developed but are restricted to relatively specialized applications by their high cost and limited mechanical properties.

7. Product Innovations

A partial list some of the textile related innovations of the last century is given below

- **QTCs** - Peratech
- **Aerogel flexible blanket** - Aspen Aerogel
- **Digital screen garments** - France Telecom
- **NanoPel, NanoDry and NanoTouch** - NanoTex
- **G-Lam** - US Global Nanotech
- **GLARE** - Stork Aerospace
- **LifeShirt System** - Vivometrics
- **Invisibility coat** - Tokyo University
- **The "1" running shoe** - Adidas
- **Fastskin FSII swimsuit** - Speedo
- **Intelligent surgical sutures** - mnemoscience
- **Elektex fabric sensors** - Eleksen
- **Self-ironing shirt** - D'Appolonia/European Space Agency
- **Mater-Bi** - Novamont
- **Embedded floorcoverings** - Infineon Technologies and Vorwerk
- **DNA markers** - Applied DNA Sciences
- **Gription Tex** - Vibram
- **Nanofibre webs** - Donaldson Company
- **Softswitch** - Canesis
- **Ingeo Fibre** - Cargill-Dow
- **Biosteel** - Nexia
- **Texcote** - U-Right
- **Embroidered surgical implants** - Ellis Developments
- **Nanogel** - Cabot Corporation
- **Flexible, large area polymer displays** - Philips
- **Nanosphere** - Schoeller
- **Solar-powered jackets** - Technology Enabled Clothing (TEC) and ICP Solar Technologies
- **Electronic textile antennas** - Applied Radar
- **Wonder Slim** - Fuji Spinning
- **Under floor heating system** - Advanced Heating Technologies (AHT)
- **Machine-washable suede and leather garments** - Bernardo
- **Coretex** - Owens Corning
- **Luminex** - Caen and Stabio Textile
- **Hydrospace** - Nonwoven Research Group, University of Leeds
- **Seamguard** - WL Gore
- **Spacer fabrics** - Karl Mayer
- **Single layer stretch nonwovens** - Advanced Design Concepts (ADC)
- **Curv** - BP
- **EMC shielding spacer fabric** - Tissavel
- **Sphere** - Nike

- **Optical woven fabrics** - Dubar Warneton/Rubens Gallant
- **Biomesh A2A** - Cousin Biotech
- **EL films** - Bayer MaterialScience
- **M5** - Magellan Systems
- **XLA** - Dow Chemical
- **Radio wave absorbing material** - Toray
- **Three-layer nonwoven composites** - Fleissner/Georgia Pacific
- **Epic fabric** - Nextec
- **A380 composite spoiler** - Cytec/Fischer
- **ZPREG** - Advanced Composites Group (ACG)
- **Nanocomposite coatings** - InMat Inc.
- **Metafloor** - Lees Carpet
- **Sensatex** - Smart Shirt
- **Ravlex PPC** - Ravensworth
- **Alginsulate** - Graz University/Verpackungzentrum Graz
- **Demron fabric** - Radiation Shield Technologies
- **Corterra fibre** - Shell
- **Pneumatic aircraft seat cushion** - Lantal/Recaro
- **Low temperature plasma coating** - P2i
- **Vent-X ART** - Diffusion Textiles
- **2H filter media** - Emergency Filtration Products.
- **Diaplex** - Mitsubishi Heavy Industries
- **Spacetec** - John Heathcoat
- **Soric** - Lantor
- **ThermalShield TK** - Powell Corporation
- **d2w** - Symphony Environmental
- **3DL** - North Sails
- **Inflatable loading bay system (LBIS)** - Lindstrand
- **Dyneema Purity** - DSM
- **Absolute Zero** - Corpo Nove/ESA
- **D3 spacer fabrics** - Gehring
- **Lextra Film IMD** - Fiberlok
- **SPT** - Woolmark
- **Electric Plaid** - International Fashion Machines
- **B9** - Consolidated Ecoprogress Technology (CET)
- **Holofiber** - Hologenix/Wellman
- **Space tether fabrics** - Culzean
- **Auxetic fabrics** - Heriot Watt University
- **Combat Casualty Care textiles** - Polartec
- **eVent** - BHA Technologies
- **Thiolon LSR** - Royal Ten Cate
- **Suevo** - Eybl International
- **Techx** - Amann
- **Cooley-Brite Back-In-Black** - Cooley
- **Resolution print media** - BBA Fiberweb

Detailed description of these innovative products can be found at the websites of the respective companies. Most of these companies have been successful and grown because of their emphasis on bring out innovative new products. Summary of these products was published by us in Asian Textile Journal in a 9 Part Series of Papers from July 2007 to March 2008. A few examples are shown below.

Figure 4: Summary of the products which was published in Asian Textile Journal in a 9 Part Series of Papers from July 2007 to March 2008

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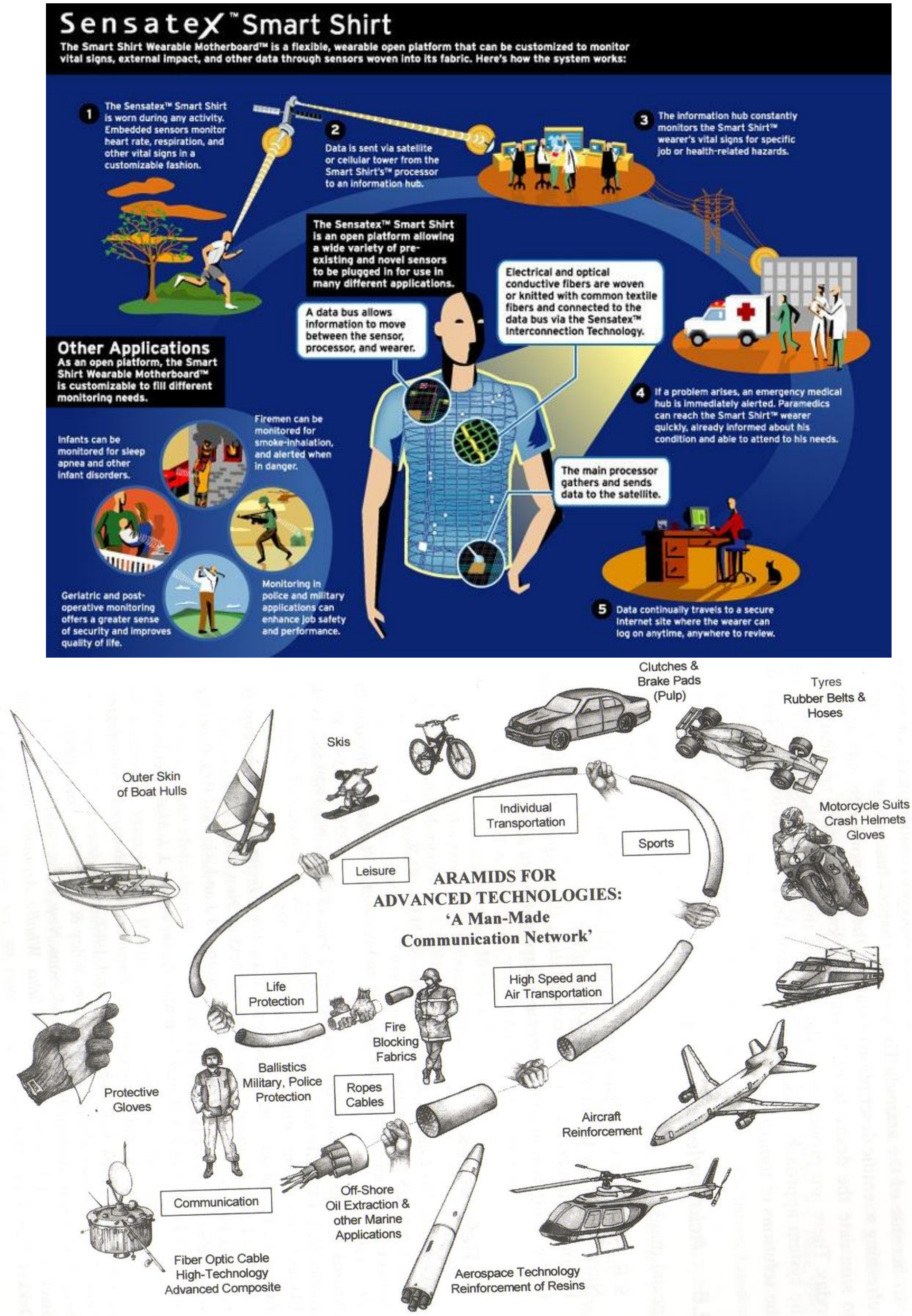

Figure 5: Smart Textiles

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8. Concluding Remarks

A number of developments are taking place in textile chemical processing to meet the new customer expectations, health and hygiene consciousness, energy crisis or environmental consideration.

The diverse applications of textile materials for technical purposes have opened up a new era of development in fibre science and technology. Existing fibres are being modified and new fibres are being developed to meet specific and stringent requirements of the technical textile applications. The critical role played by the technical textile products in most of the cases, and the undoubted advantage of their use has enabled a market of high value products. This allows the manufacturers to go for high value raw materials. In an industry where innovation has become the only means of survival, almost all the major players are engaged in research and development regarding raw materials and their applications.

New and demanding applications of textiles in diverse technical uses will fuel new product developments in future. Development of other disciplines such as electronics, biotechnology, nanotechnology, etc. gives further boost and new possibilities for the development of new textiles. Innovation will be the key to success and growth of textile companies. If Indian Textile Companies want sustainable future, they must invest in developing competencies for innovation.

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