Functional Finishes

- Besides the traditional function of dressing people, textiles now provide wear comfort and protection in dangerous environments.
- The most important requirements for protective wear are barrier effectiveness and thermo-physiological comfort for the wearer.
- Textile finishing chemicals are used to convert a textile material into a technical textile with functional properties.
- Novel finishes providing high value addition to textile fabrics are greatly appreciated by a more demanding consumer market.
- It is widely perceived that the end uses for technical textiles will continue to increase every year and the modification of commodity fibre and fabric properties by innovative finishes can be a cheaper route to high performance than by using a high cost fibre with inherent performance properties.
- Right type of finish should be selected depending on the fibre type of the textile substrate and the desired end use

Types of functional finishes

- ***Mechanical fi nishes-***Mechanical fi nishing involves the application of physical principles such as friction, tension, temperature, pressure, etc.
- Examples: calendaring, embossing, seuding, compacting, raising, shearing, decatising, fulling, sanforizing, etc

Chemical finishes

- The fi nishing is imparted by means of chemicals of different compositions and a textile can receive new properties otherwise impossible to obtain with mechanical means.
- A wide variety of functional properties can be created on textiles by means of chemical fi nishing and it is also possible to develop multifunctional textiles.
- The major application methods include padding, exhaustion, coating, spraying and foam application..

Nanotechnology

- With the advent of nanotechnology, a new area has developed in the realm of textile fi nishing.
- Nanotechnology is opening new avenues in chemical fi nishing, either resulting in improved processes or helping to achieve new functional properties like self cleaning effects, which were not possible with conventional fi nishes.
- Thus the application of nanotechnology to textiles creates an expanded array of functional properties enabling textiles to be used in novel materials and products.
- Unlike in conventional fi nishing, the nanometric size of the coating will not affect negatively the hand and feel of the fi nished fabric.

Sol-gel

- The low temperature sol–gel techniques, as well as the new generation of polymeric resins, are offering new possibilities in textile chemical fi nishing

Plasma

- Another important development is the plasma enhanced chemical vapour deposition (PECVD) technique.
- It is a fi nishing process which can be used to deposit thin solid polymeric fi lms from a gas state to a solid state on a textile substrate to achieve the desired properties.
- The advantage of such plasma treatments is that the modifi cation turns out to be restricted to the uppermost layers of the substrate, thus not affecting the overall bulk properties.
- In general, plasma treatments can be considered as ‘dry’ alternatives to the wet chemical treatments and so they are environmentally friendly.

LBL

- The layer by layer (LbL) assembly method is another new fi nishing technique by which ultrathin composite fi lms can be developed on solid surfaces like textiles.
- It involves a layer by layer adsorption of polycations and polyanions to build a multilayerultrathin polyelectrolyte coating on a textile substrate

Biotechnological fi nishes

- The recent trends in industrial biotechnology show that social, environmental and
- economic benefi ts go hand-in-hand with applications of this technology. Enzymes are
- the most important biological agents that are now used in the textile industry. Today,
- enzymes are used to treat and modify fi bres, particularly during textile pretreatments
- and for fi nishing the textiles afterwards.

- Enzymatic biopolishing removes the fi bre fuzz and pills from the textile surface and yields a cleaner surface and a softer hand and increases lustre.
- Cellulases are the Enzymes.For **cotton** fabrics, biofinishing is optional, but it is essential for **lyocell**
- In the case of **wool**, the use of transglutaminases has been shown to improve shrink resistance, tensile strength retention, handle, softness, wettability and consequentl dye uptake, as well as reduction of felting tendency and protection from damagecaused by the use of common detergents.

- Enzymatic hydrolysis of **polyester** fibres with different lipases or esterases can increase the hydrophilicity and absorbance properties.
- The selective enzymatic hydrolysis of **polyacrylonitrile** fibres with nitrile hydratase and amidase could be an interesting alternative to chemical finishing.
- Some of the main hurdles for the industrial implementation of enzymes are their low stability, low compatibility with other chemical agents, longer processing time, and relatively high cost.
- But on the positive side, enzymes show the advantage of lower energy consumption and avoid the use of harsh chemicals, when compared to chemical finishing.

Finishes for improving comfort and performance

Thermal regulation fi nishes

- Microencapsules containing the phase change materials (PCM) use chemicals such as nonadecane and other medium chain length alkanes in their core.
- When the ambient temperature increases above their melting point, the microencapsulated chemical melts and latent heat is absorbed thereby interrupting the increase in temperature of a garment.
- Once the ambient temperature falls the PCMs solidify and the latent heat is released, providing a heating effect.
- PCMs, such as paraffin waxes, hydrated salts, polyethylene glycols, fatty acid derivatives, bio-based materials, etc

Self cleaning finishes

- In recent years, there is a general tendency to imitate nature by using nanomaterials and other approaches for developing new functional materials.
- The self cleaning action of the surface of the lotus leaf has given rise to the so-called 'lotus effect' which is being utilized to produce superhydrophobic finishes.
- Another interesting approach in self cleaning is the nanocoating of textiles with nanoparticles of anatase titanium dioxide, which can effectively decolorize stains in the presence of water, oxygen and solar radiations.
- Starting from the concept of superhydrophobicity, the scope of self cleaning surfaces has now been further extended to photocatalytic as well as superhydrophilic effects.
- Apart from titanium dioxide, bismuth vanadate and benzophenone are now being tested for their self cleaning effect.
- There is still a need to develop methods based on a simple one step preparation and coating process that can be carried out at low temperatures.
- A major challenge is posed by the low surface energy of textile surfaces which makes it difficult to achieve sufficient interfacial adhesion for the coating to adhere to the substrate.
- In this respect, the low temperature sol–gel techniques and the new generation of polymeric binders are promising

Superabsorbent finishes

- A superabsorbent is a material that acts like a super sponge and can absorb aqueous fluids many times its own weight, forming a gel.
- Super absorbents can absorb water up to 300 times their weight and, once absorbed, do not subsequently release it.
- They are therefore an ideal material for use in products which are designed to contain fluids such as nappies, incontinence products, etc.
- Liquid absorption rate and retention are the two most important super absorbency parameters.
- for applications in areas such as agriculture, biomedicine, sanitation, geotextiles and protective clothing.
- The main types of finishes include hydrogels, inorganic nanocomposites and colloidal solutions, and they can be applied on textiles by different techniques like padding, spraying, electrospinning, plasma treatment, etc.

Medical, cosmetic and odour resistant fi nishes

- Textiles can act as delivery systems of bioactive compounds as they are in contact with the skin.
- Hence, they are now widely used for medical, hygienic, health and cosmetic purposes.
- They can provide a controlled slow release of the active medical ingredients to be absorbed through the skin.
- Cosmetotextiles are textiles which are embedded with cosmetic ingredients that have to be transferred to the wearer ’ s skin. The amounts transferred have to be sufficient to ensure that cosmetic benefits are possible. There are opportunities for health and wellbeing by using cosmetotextiles in which substances that enhance skin appearance or vitamins can be absorbed by the skin.
- In the meantime, odour resistant textiles have the function of containing unpleasant odours. Among other possibilities, cyclodextrins incorporated into textiles can absorb or remove odour. The odour molecules, being hydrophobic, become trapped in the cavities of the cyclodextrins and are removed during laundering

Finishes for protecting wearers and textiles

Antimicrobial fi nishes

- Most synthetic fibres are more resistant to microbes than are natural fibres, due to their high hydrophobicity.
- The structure and chemical nature of natural fibres can induce microbial growth, but it is the humid and warm environment that aggravates the problem further.
- Antimicrobial finishes should be applied to textiles to prevent the growth of microbes and also to protect the textiles from strength and colour loss, unpleasant odour and quality deterioration.
- Not even a single antimicrobial finish, as yet, fulfils all the necessary criteria for the end uses, but some very effective and durable antimicrobial finishes have already been developed.
- The antimicrobial agents can be applied to the textile substrates by padding, exhaustion, coating, spray and foam techniques.
- Special care should be taken so that the application of antimicrobial finishes will not alter the physical and performance properties of the fabrics such as handle, stiffness, air permeability and strength.

Hydrophobic and oleophobic fi nishes

- Water repellent and oil repellent textile finishes are based on fluorinated compounds.
- The textile fabrics that do not allow absorption or penetration of water or oil for a fixed period of time are considered as hydrophobic or oleophobic textiles, respectively.
- A variety of new generation chemicals and processes, including nanomaterials and plasma techniques, are now available for developing hydrophobic and oleophobic textile surfaces.
- A superhydrophobic surface developed on textiles can exhibit a 'lotus effect', as the textile surface behaves like a lotus leaf.
- There is great thrust in research to develop new hydrophobic and oleophobic textile finishes, and new materials like carbon nanotubes, dendrimers and hydrophobins are now being tried with an aim of replacing conventional fluorinated compounds

Flame retardant fi nishes

- Flame retardant treatments are usually applied to combustible fabrics used in children ' s sleepwear, carpets and curtains for preventing these highly flammable textiles from bursting into flame.
- Ideally, the best flame retardant system for textiles should char the fibre, releasing no toxic smoke or gases, and prevent afterglow.
- The future of flame retardancy is hindered greatly by environmental and eco-toxicological considerations, both of the flame retardant chemicals and of the toxic nature of the byproducts released upon combustion of textile fabrics.
- The new environmental, health and fi re regulations are now forcing halogenated flame retardants to be phased out. The new flame retardant chemistry is based on phosphorus, silicone and nitrogen compounds.
- Research is also focusing on 'green' solutions like enzymes and intumescent flame retardants such as expandable graphite.
- Synergistic combinations of conventional flame retardants and inorganic compounds would also be a major focus.
- The latest techniques of flame retardation of textiles include sol–gel, layer by layer and plasma. Even though a wide variety of new halogen free flame retardant chemicals and techniques have been developed in recent years, there remain some hurdles for their commercial exploitation.

Ultraviolet protection fi nishes

- Textile structures render unique characteristics required for sun screening apparel such as pliability, good mechanical strength, softness, aesthetics and other engineered properties.
- But textiles as such may not be able to provide effective protection and should be treated with UV blocking agents to ensure that the fabrics deflect the harmful UV rays.
- The extent of skin protection required by different types of human skin depends on UV radiation intensity and distribution with reference to geographical location, time of day and season
- Several UV blocking agents are being developed to add to or improve the UV protection function of textiles.
- There are both organic and inorganic UV blockers.
- The organic blockers are also known as UV absorbers as they absorb the UV rays, whereas the inorganic blockers efficiently scatter both UVA and UVB rays, the main cause of skin cancer.
- Compared with organic UV absorbers, inorganic blockers ar now preferred due to their properties such as non-toxicity, chemical stability under UV radiation, etc.
- The UV blocking agents can be combined with other protective finishing chemicals and it should be possible to develop multifunctional textiles

Radiation protection fi nishes

- Exposure to both ionizing and non-ionizing radiations can be dangerous to human beings, so there is an increasing demand to develop new shielding materials that can be customized according to specific application or radiation type.
- An effective radiation shield should cause a large energy loss in a small penetration distance without emission of more hazardous radiation.
- Furthermore, the good shielding material should have high absorption cross section for radiation and at the same time irradiation effects on its mechanical and optical properties should be negligible.
- In a market that is receptive to new products and technologies, this kind of protective clothing may be attractive to companies wishing to diversify.
- It has been demonstrated that by combining various nanoparticles with other organic and inorganic substances, textile fabrics can be modified to achieve considerably greater electromagnetic protection along with other protection properties.
- Modification of fibres based on conductive polymers seems to be another interesting approach for enabling these new functionalities.
- Although conducting polymers can be converted into fibres, many of them are brittle. Water soluble conductive polymers are also under development

Biological and chemical protection finishes

- Unlike in earlier times, there is now an increasing need to develop protective wear against chemical, biological, radiological and nuclear (CBRN) threats.
- Nuclear disasters, the global upsurge in terrorist activities and the needs of the military to protect their personnel against biological and chemical attacks have stimulated this.
- There is also great interest in developing highly efficient means of protection against chemicals, either from the hazards created by accidents and spillages, or from deliberate attacks.
- The protective clothing should offer multiple functionalities not only to give the necessary protection, but also to facilitate soldiers and first responders to carry out their activities in an effective way.
- As this field is very complex, it is necessary to combine the technological potential of several disciplines of research for developing a multifunctional protective system that is really effective

Ballistic and stab protection fi nishes

- At present, the most promising technology is based on the use of shear thickening fl uids, which consist mainly of highly concentrated nanoparticles dispersed in liquids.
- A shear thickening fluid can harden in a few milliseconds when it encounters mechanical stress or shear and will start behaving like a solid.
- The viscosity and surface tension of such fluids can be regulated in order to adapt the chemical formulation to conventional finishing technologies available in the textile industry.
- Some other very interesting alternatives to shear thickening fluids include ceramic or metallic spray coatings and silicon based dilatant powders. However, these technologies are still in their infancy, particularly for the textile sector.
- Other functional finishes can also be applied in combination with ballistic and stab resistant finishes to confer extra properties onto them.
- But combining ballistic protection with stab resistance for developing dual protection body armour is really a challenging task.
- The main applications of such textiles include protective wear for defence and security personnel, law enforcement agencies and first responders

Future trends and challenges

- A careful balance between the compatibility of different fi nishingchemicals and treatments is needed.
- Concerns that nanotechnology may have toxic effects are growing, particularly about it causing damage to the lungs.
- The cosmetic ingredients of cosmetotextiles usually are of a very complex nature and therefore there are some toxicological concerns
- Legislations are being imposed by different governments, including regulations from the European Commission such as REACH
- Due to the increased consumer awareness, several ecological labels like Oeko-Tex, assuring the safety of end users, are now gaining importance
- It seems that new fi nishing possibilities such as nanofi nishes, biotechnological fi nishes based on enzymes, dry fi nishing techniques such as plasma or laser, and layer by layer assembly techniques will play a key role in the future.