Innovation in fibres
(Micro fibres, Nano fibres, Hollow fibres)

Micro Fibres

- Fibres with thickness less than 0.3 dtex (denier) are termed as micro fibres.
- Micro fibres find their use in air filters, dust wipes, etc., because of their high surface area as compared to normal fibres.
- The growing demand to increase the fibre properties known to create new sophisticated application for textile materials have been the cause of the rapid growth of micro fibre technology.
- Micro fibres are half the diameter of cotton, one-third the diameter of fine wool and 100 times finer than human hair.
- In order to be classified as a micro fibre, the fibre must be less than 1 dtex in width.

- Fabrics made from micro fibres are generally light weight, resist wrinkling, have a luxurious drape and body, retain shape and resist pilling.
- They are also strong and durable in relation to other fabrics of similar weight, and they are more breathable and more comfortable to wear.
- A micro fibre is defined as a fibre (including staple fibres and filaments) of linear density approximately 1 dtex or less, and above 0.3 dtex.
- Even finer fibres are produced of 0.3 dtex or less, but these are commonly referred to as super-micro fibres.

History of micro fibres:

- Japanese fibre manufacturing companies introduced the first ‘micro-denier’ products during 1970s.
- Then followed the developments in Europe during the 1980s, and since 1990s American fibre manufacturers have been following the same.

- At present, polyester and nylon are generally used for manufacturing micro fibres.
- However, ‘micro-denier’ versions of rayon and acrylic products are on the horizon.
- Ultra-micro fibre technology has existed as well . These fibres are less than 0.3 dtex, and within the range of 0.1 dtex .
- Several different processes can be used to make ultra-micro fibres, all involving the splitting of a large fibre into many smaller ones.

Production of micro fibres:

- Micro fibres are generally considered to be fibres with a linear density of less than 1.0 dtex.
- Although the technology for micro fibre production has been available many years ago, strong demand for these fibres did not begin until the 1980s.

- The currently available micro fibres are different from ordinary fibres mainly in their dimensions, but have much lower property differences than the standard fibres.
- Toray was the first company in the world to introduce micro fibres, followed by Teijin, Hoechst, ICI, DuPont and others.
- Recently Toray has introduced an ultra-fine polyester micro fibre with a linear density of filament of about 0.05 dtex.
- This may be called the finest synthetic fibre so far produced commercially.

Manufacturing of micro fibres:

- There are various methods of producing micro fibres, including modified conventional spinning.
- All three conventional spinning methods, namely, melt spinning, wet spinning and dry spinning can be employed to manufacture micro fibres.

- For this method, carefully selected polymerization, polymer spinning and drawing conditions are required.
- Polyester, nylon and acrylic micro fibres may be manufactured by this method.

Methods of manufacturing Micro fibres :

1.Dissolved type micro fibres:

- Micro fibres of this type are manufactured from bi-component fibres.
- Comparatively thick bi-component filaments containing different types of incompatible polymers are spun, and the fabric is made using them.
- When the fabric is treated chemically with solvent, one component is dissolved and removed, and the other component remains as the micro fibre.
- Polyester and nylon micro fibres can be made by this method.
- The various combinations of soluble/insoluble polymers reported to form fibres successfully are polystyrene/polyamide and polystyrene/polyester.

2.Split type micro fibres:

- The micro fibres of this type are obtained by physically or chemically treating the bi-component filaments containing two types of polymers and splitting them into different types of filaments.
- It is easier to split the segment in filament from itself than in the fabrics.
- Suitable polymer combinations for splittable bi-component filament spinning are polyamides/polyester and polyester/polyolefines.

3.Direct spun type

- This microfibre is directly manufactured by melt spinning. For this method, highly selected polymerisation, polymer, spinning conditions, and drawing conditions are required.

4.Super-drawing technique

- In this technique, no molecular orientation is involved. Staple fibre with linear density less than 0.5 dtex can be produced with high drawing ratios.

5.Sheath-core spinning method

- In this method, two different polymers are mixed and melted, under specified conditions. The conjugate fibre comprising of a concentric circular sheath and a core is manufactured, and the sheath portion is removed to form ultra-fine fibres.

6. Some other methods

- Flash-spinning method
- Solution flash-spinning
- Emulsion-spinning method
- Jet-spinning method
- Centrifugal-spinning method
- Turbulent forming method
- Conjugate-spinning method

Properties:

- Lightweight
- Strong
- crease resistant
- Breathable
- Excellent draping
- Easy care- low temperature washing with little or no ironing
- Maintain body temperature
- Windproof and water resistant if the fabric is tightly woven

Uses of micro fibres:

- Dresses, sportswear, gloves, coats, leggings, swimwear, underwear, shirts, tights, trousers and tops.
- It is also used for soft furnishings, such as towels, table linen, mats, cushions, curtains, dusters and mops.
- It is also used for bags, nappies, tapes for computer printers, artificial blood vessels and filters.

Nano-Fibres

- Nano –fibres are defined as fibres with diameters less than 100 nm.
- In textile industry, this definition is often extended to include fibres as large as 1000 nm in diameter.
- Nano-fibres are extremely small; they vary in size from 1 micron to approximately 0.5 nm.
- Nano-fibres range in diameter of 2-600 nm and are very difficult to see with the naked eye.
- These fibres are used in aerospace industry.
- Non-woven sheets can be produced by electro spinning process.
- Tiny fibres are collected as non-woven sheets that can cover well, and they are combined with lightweight materials.
- Nano-fibres can be incorporated onto the surface of fabrics or added to yarns.

Techniques of making nanofibres:

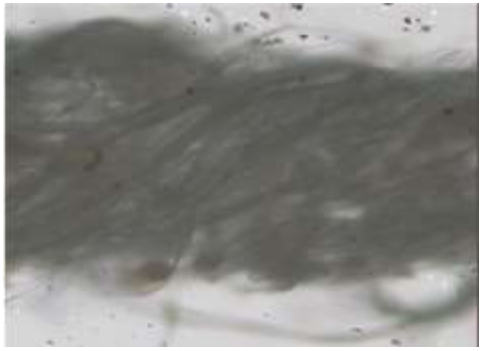
Nanofibres can be prepared by one of the following techniques :

- Drawing
- Template synthesis
- Self assembly
- Phase separation
- Electrospinning

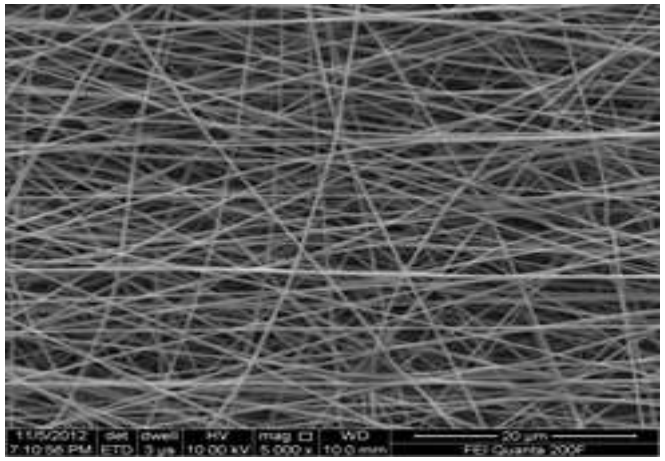
- Among all these, ***'Electrospinning'*** is recognized as the most efficient production technique. Mostly polymer solution and sometimes polymer melts are used in this technique to produce nanofibres.
- Electrospinning is a fibre forming process which makes use of a high voltage electric field to produce an electrically charged jet of polymer fluid, which on solidifying produces a nanofibre web typically with fibre diameter from a few nanometres to few microns.
- Carbon nano-fibres are produced by catalytic synthesis.

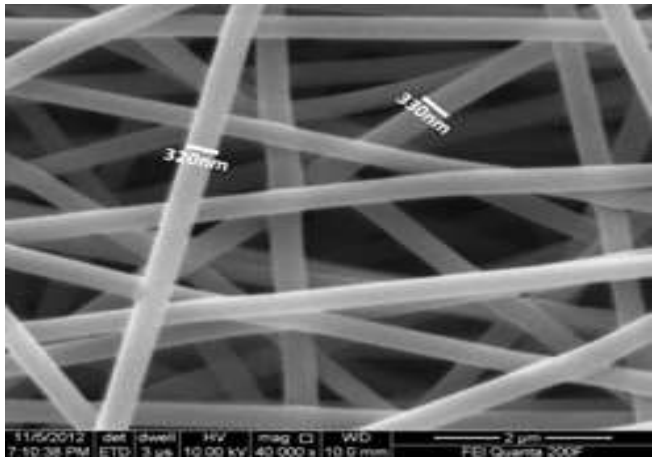
Properties:

- Extremely lightweight and strong
- Fine, smooth and delicate
- Versatile- can incorporate different fibres and be engineered to suit various end uses
- Good covering power
- Large areas of fabric reduced to a small size



Twisted nanofibre yarn





SEM micrographs of electrospun web a) at lower magnification
b) at higher magnification

Uses of nano-fibres:

- Seamless spray products, breathable membranes for clothing (e.g. Sportswear), filters for industrial purposes, space mission fabrics.
- Nanotechnology fibres have endless uses in our fast-growing technological world; they are developed specially for performance and function.
- These fibres are also used in life sciences (drug delivery carrier, wound dressing); as filtration media (liquid filtration, gas filtration, molecular filtration); as cosmetics skin masks (skin cleansing, skin therapy, skin healing).
- Also in military protection clothing, industries and as nanosensors.

Hollow Fibres

- Hollow fiber is described as a filament with a hollow core.
- They can be of different types including hollofil 1 which is a polyester lagging with a single hollow space through the core of each fiber.
- Hollofil 2 has four hollow spaces inside it, thus, it is better with the insulative characteristics than the hollofil 1.
- Another type of hollow fiber is hollow filament which is a synthetic continuous fiber with a single continuous core.
- The hollow fiber shows unusual liquid retention properties. The reason for such a property may be attributed to the microspores that are formed during the forming process and especially at the final stage by dissolution of a hydrophilic chemical.
- This makes the fiber very absorbent of sweat without changing in diameter or mass and weight.
- The hollow fiber garments also dry fast because they store liquid intramolecularly and not between the molecules as in the case of solid fibers and especially natural fibers.
- The total voids to mass ratio content makes the fiber have good heat retentive properties when dry.

How to Make a Hollow Fiber:

- Hollow fiber spinning processes can be categorized into extrudate and quench type.
- When the polymers are insolvent the polymer extrudate process is used and is known as melt spinning.
- On the other hand, use of a solvent in the polymer to form a polymeric solution is known as the quench type. The quench type may be either dry or wet. This depends on the fact that the quench may be in liquid or in gaseous form.
- The form of solution spinning known as wet spinning indicates that the polymeric solution passes through an aqueous solution/liquid after coming from the spinneret.
- In dry process, the polymer is passed through a gas quench bath.

The manufacturing processes in production of hollow fibres variance:

- Synthetic polyesters which have more than one polymer content are produced by melting usually in the ratio of 1:1 and then spinning them at a high rate in a ring spinneret, heating them at 120 degrees Celsius and cutting them and giving them hollowness to solid ratio of 5 to 30 percent.
- Acrylic fibres can also be produced as hollow fibres by the process of wet or dry spinning or as multi components having a soluble core which is dissolved to yield the hollow structure in form of an inner linear continuous channel.

- Hollow acrylic fibers are used in making insulative garments. They are used as antecedents to carbon fibers because they disperse heat more effectively and normally than if they were not hollow.
- In all the above processes, the polymer solution or melt passes through an annular region with a fluid known as the bore liquid which can be in liquid or gaseous form. The bore liquid helps in making the fiber to remain open.
- At the raised room temperature, the dilute polymer is extruded together with a gas such as nitrogen. As the emerging film moves through the air, it cools and looses the liquid solvent due to the evaporation before entering the liquid bath that cannot dissolve it. The fiber solidifies quickly the polymeric fibers are formed showing the microstructure properties that defines it as hollow fiber.

General Uses and Properties of Hollow Fiber:

- One of the uses of hollow fiber is in the automotive industry where the fiber is used to make fabric that is used for deafening sound. The hollow fiber fabrics can absorb sound at a higher rate than the normal solid fibers.
- They are also easy to clean and can be used for car interiors. Due to their thermal insulative properties and a lustrous finish, the hollow fibers are used to decorate the inside of the car as they serve two purposes simultaneously, decorative and thermal insulation.
- The hollow fibers have also been used to make tents and sleeping bags. This is because they have a low adherent to dirt and water.

- They have also exhibited properties of resistance to wetting because the residual solvent that is used during spinning evaporates at a high temperature, thus, forming a coat with wax properties on the surface of the fibers. This gives the fibers its resilience to wetting property.
- In very cold months the fiber has been used to make house insulation, bed stuffing material and generally used in making fabrics for keeping oneself warm. Their insulative property comes from the fact that there is a hollow gap in the middle of the fiber which basically is filled with air or liquid. This means that warm air cannot be conducted through the void once it is generated by the body or in the house or car.
- Special spinning of hollow fiber has been done in the medical field to aid in dialysis of the kidney. The dialyzer is made from hollow fiber which allows the blood to pass through as it gets cleaned. The fibers, however, are especially spun to give them the desired quality that can be used in dialysis.

- Hollow fiber is used in making fabrics for use in areas where they are not supposed to withstand the pressure but should regain their shape when the pressure applied is removed. They are, therefore, very suitable for use in stuffing of pillows and making the inside fabric of shoes especially those designed for the cold seasons.
- Hollow fibers are used in drinking water treatment.
- This is another use where a bundle of hollow fibers is used to form a membrane for separation of gases in the industrial gas separation processes.
- The hollow fiber textiles have been used in computing industry in the manufacture of optic fibers.
- Hollow synthetic fibers are particularly used in making underwear and sportswear because they dry fast. The pore to the surface area ratio is very small and, thus, the fabric is able to dry very fast.

- The use of synthetic polyester for use in sportswear is not only limited to the clothes only but also to the footwear. This is because they are very light and especially very perfect in games that need the players to move at high speed. This is because the hollow polymers bend under pressure but retain their natural shape when the pressure is removed. This is perfect for footwear in the sports industry.
- The ability of hollow fiber to stretch is another desirable character for using it in making sports wear.