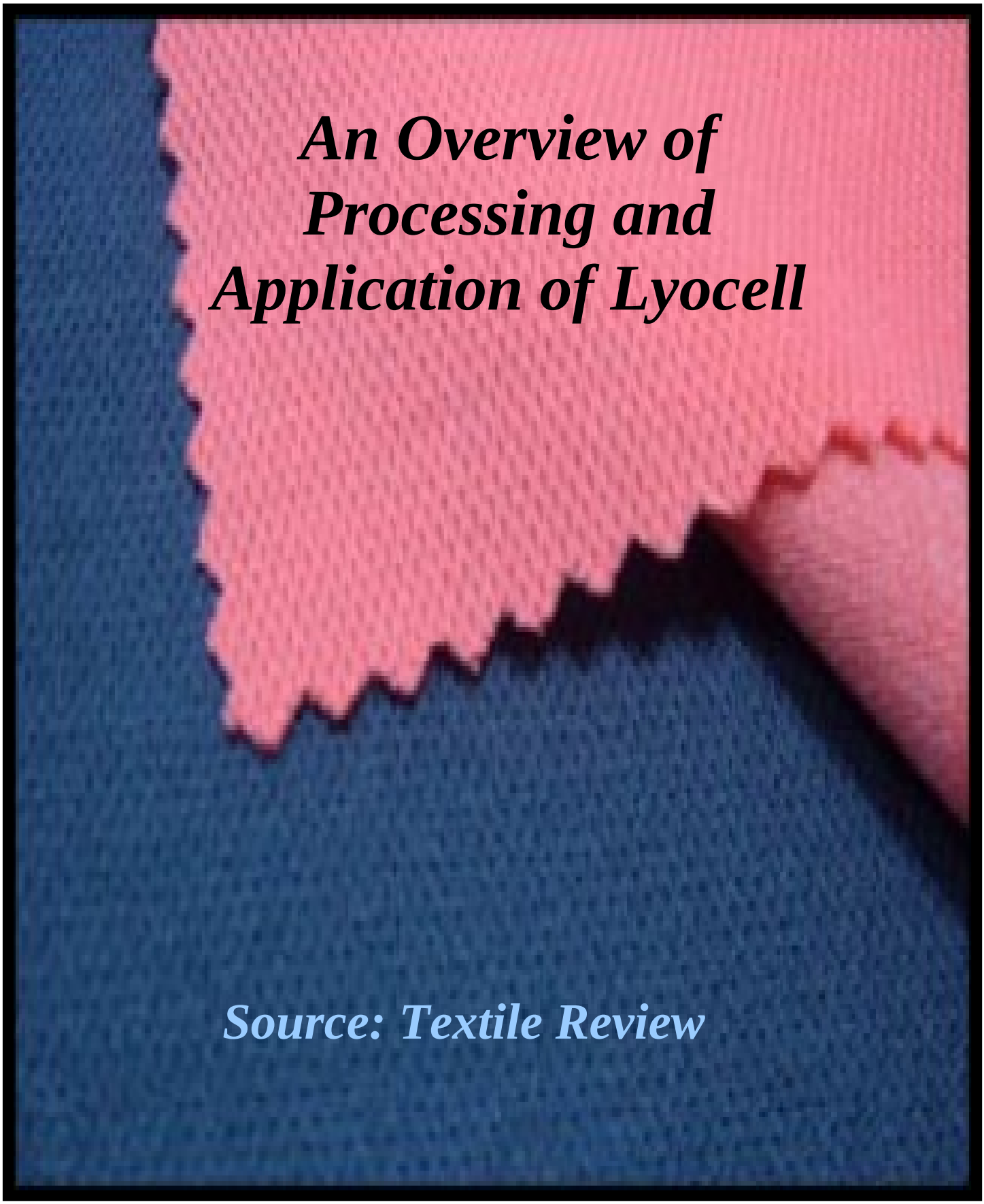

An Overview of Processing and Application of Lyocell

Source: Textile Review

An Overview of Processing and Application of Lyocell

By: Aravin Prince Periyasamy, Dr. Bhaarathi Dhurai & Dr. K.Thangamani

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Lyocell is the first in a new generation of cellulosic fibers made by a solvent spinning process. A major driving force to its development was the demand for a process that was environmentally responsible and utilized renewable resources as their raw materials. The first samples were produced in 1984and commercial production started in 1988. A wide range of attractive textile fabrics can be made from Lyocell that are comfortable to wear and have good physical performance. This physical performance combined with its absorbency also makes Lyocell ideal for nonwoven fabrics and papers. The cellulose fibers produced by direct dissolution have the generic name of Lyocell. Cellulose is one of the most abundant natural resources on earth, and there has been extensive research on the films, plastics, and fibers from this material. The history of cellulose fibers dates back to the 1860s, when the first rayon fibers were commercialized by Courtaulds. But the so-called rayon process includes toxic chemical treatments to block hydroxyl groups of cellulose to prepare a spinnable solution, mostly it causing an ecological problem. Many attempts have been made to invent new solvents to directly dissolve cellulose, and some successful results have been reported. Among these, N-methylmorpholine-N-oxide (NMMO) hydrate turned out to be the best solvent, leading to the commercial success of cellulose fibers under the trade name of Tencel by Courtaulds in 1994.

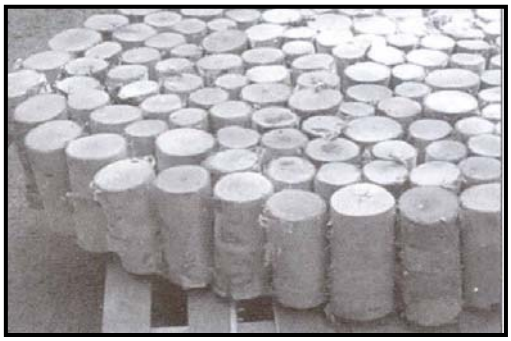


Figure 1: Raw Materials for lyocell Fiber (Oak logs)

Other Lyocell process includes Lenzing Lyocell. These processes are advantageous because they are environmentally benign, using nontoxic NMMO hydrates instead of toxic carbon disulfide, which can be almost totally recycled. The Lyocell fiber has a highly crystalline structure in which crystalline domains are continuously dispersed along the fiber axis. This offers good wet strength as well as excellent dry strength, which makes Lyocell water-washable. Further, it shrinks less when wetted by water and dried than other cellulose fibers such as cotton and viscose rayon. Recently, a new Lyocell process, which has some characteristic, features similar to the Tencel process. The new process dissolves finely powdered cellulose in molten NMMO hydrate within 5 minutes by means of a pasting stage, which causes much less decomposition of cellulose. Further, this process can use NMMO hydrates with a hydration number (n) greater than 1 because it adopts a plasticating extruder. The value of n plays a significant role in the phase behavior of cellulose solutions. It also affects the physical properties of the fibers spun from the solution; Fig.2. show the Lyocell processes consume lower

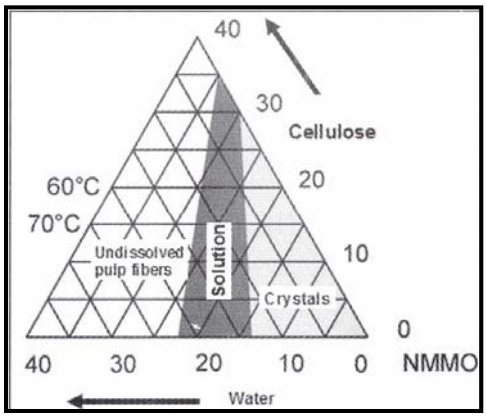


Figure 2: Ternary diagram showing the effect of temperature on the dissolution Cellulose in NMMO

amounts of water, but a similar magnitude of energy.

The Properties of Lyocell

Comparisons of Lyocell with viscose and other cellulosic in both laboratory and test markets proved that the fibers were sufficiently different to deserve separate marketing strategies. Table 1 shows various physical properties of lyocell with other fibres.

Property	Lyocell	Viscose	Cotton	Polyester (PET)
Dry Tenacity (cN/Tex)	38-42	22-26	20-24	55-60
Wet Tenacity (cN/Tex)	34-38	10-15	26-30	54-58
Dry Elongation (%)	14-16	20-25	7-9	25-30
Wet Elongation (%)	16-18	25-30	12-14	25-30

Table 1: The comparison properties of Lyocell with different cellulosic fibers

Lyocell is:

- Stronger than any other cellulosic fibres, especially when wet.
- Easy to process into yarns and fabrics alone or in blends
- Easy to blend (unique fiber presentation)
- Easy to spin to fine count yarns
- Very stable in washing and drying
- Thermally stable
- Easy to dye to deep vibrant colors
- Capable of taking the latest finishing techniques to give unique drape
- Comfortable to wear

The Courtaulds' Lyocell Process

The Courtaulds' semi-commercial production system is illustrated in Fig.3. Dissolving grade wood pulp is mixed into a paste with NMMO and passes through a high temperature dissolving unit to yield a clear viscous solution. This is filtered and spun into dilute NMMO, whereupon the cellulose fibers precipitate. These are washed and dried, and finally baled as staple or tow products as required by the market. The spin-bath and wash liquors are passed to solvent recovery systems which concentrate the NMMO to the level required for re-use in dissolution.

Lyocell Conversion

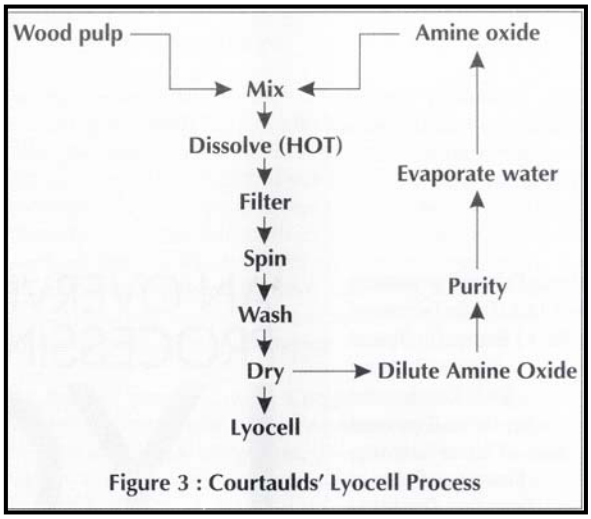


Figure 3 : Courtaulds' Lyocell Process

Lyocell is similar in strength to polyester and stronger than cotton and all other man-made staple fiber cellulosic's. It also has very high dry and wet modulus for cellulosic fiber in both the dry and wet states, the properties of Lyocell fiber is shown in bellow the table. These properties allow customers great scope for making strong yarns in blend with virtually all the other commercially available staple fibers. They also lead to excellent efficiencies in converting these yarns to woven add knitted fabrics. All man-made cellulosic's lost strength and modulus when wetted, but Lyocell reduces

by much less than others. This is important in determining how properties of the fabric are developed during dyeing and finishing.

Yarn Manufacturing

Once Lyocell fiber has been produced, either as cut staple fiber or continuous tow, it will be converted to yarns and fabrics by a range of conventional textile processes. The most common way of using Lyocell fiber is as cut staple, with 1.4 and 1.7 dtex fibers cut to 38 mm and converted into a spun yarn using machinery developed over many years for handling cotton fibers that are similar in dtex and length to Lyocell. Lenzing Lyocell is made by a wet-cut route and has different processing characteristics. The fiber can be processed on conventional machinery, usually requiring a few setting changes in order to optimize processing performance.

Thus Lyocell will open very easily with little nep formation. In sliver and roving, the fibers pack together, giving high cohesion and therefore requiring high drafting forces. Lyocell yields very regular yarns with high tensile strength and few imperfections. Lyocell blends well with other fibers, including cotton, viscose, linen, wool, silk, nylon and polyester. Lyocell adds strength to the yarn as well as enhancing the performance and aesthetic properties of the final fabrics. Minimal carding power is required, as the fiber is very open. In drawing, sliver detectors may need to be reset to adjust for the low bulk of the Lyocell. In roving, the twist should be low to avoid too high a cohesion. Optimization is very important at this stage of the process.

Yarn steaming should be avoided wherever possible. Steaming cellulosic fibers, amongst other things affects fiber dye affinity, twist liveliness and splice strength. The dye affinity for cellulosic fibers reduces with increasing steam temperature and the influence on Lyocell fiber is greater than for other cellulosic, such as cotton and viscose. Therefore steaming should be avoided unless this can be extremely well controlled. Twist liveliness can be reduced in other ways, such as by storing yarn on ring tube for 16-24 hours in a high humidity environment prior to winding.

Fabric Manufacture

Weaving of Lyocell fabrics can be successfully carried out on most conventional looms and in a wide range of constructions. The construction needs to be carefully engineered with the dyeing/finishing route to develop the best performance and aesthetics. Very tight constructions can give problems in dyeing and tend to give fabrics with poorer easy-care performance.

Dyeing and Finishing of Lyocell

The dyeing and finishing of Lyocell fabrics is the key to their success. There are three characteristics of the fibers that can be manipulated to give fabrics with attractive and differentiated aesthetics- the ease of fibrillation, the high nodules and the wet swelling characteristics. Fibrillation can yield the characteristic 'peach skin' effect surface touch of fabrics made from this fiber, but un wanted and uncontrolled fibrillation can also impair the fabric quality, much of the dyeing and finishing development has been focus on this aspect.

A Lyocell is a cellulosic fiber; it can be dyed with colors normally used on cotton. Compared with unmercerized cotton, Lyocell, except with a few reactive and vat and a

number of direct dyes (pale shades), dyes to a heavier depth by exhaust techniques and therefore many shades can be attained at lower cost, particularly with reactive dyes. The dyeing mechanism for most classes of reactive dyes is similar. First the reactive dye is exhausted on to the cellulose fiber using salt. In the second stage of dyeing, alkali is added to fix the dye; dyeing behavior of Lyocell is shown in bar chart 1.

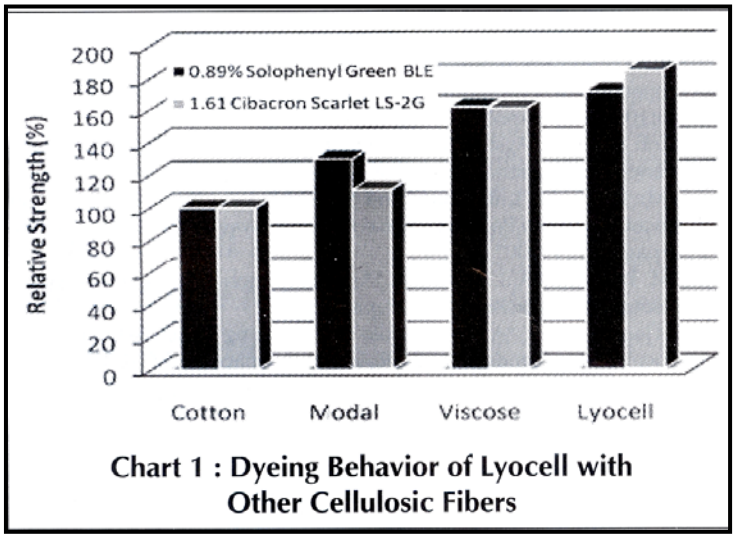


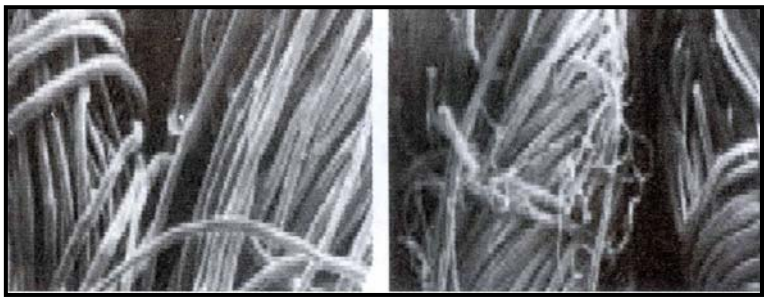
Chart 1 : Dyeing Behavior of Lyocell with Other Cellulosic Fibers

Many of modern reactive dyestuffs contain two or three reactive groups. A key discovery, made early in the development of Lyocell, was that these multifunctional dyestuffs can crosslink the fiber and there by prevent or inhibit the fibrillation of the fiber. Since manipulation of this fibrillation is critical for the development of the fabric aesthetics.

Easy-care lyocell

As with any fabric, chemical finishing is an important aspect of the process and this is especially true when considering the finishing of open-width processed Lyocell fabrics. In such processing, resin treating is the method of controlling fibrillation. If too little resin is fixed then fabrics will fibrillate on subsequent washing, too much and physical performance deteriorates. It is also important to include appropriate softeners and auxiliary products into the chemical finish so that performance and handle are appropriate to the customer's requirements. The application of ~2-3% omf (on mass of fiber) fixed resin appears to be optimal for easy-care properties, dependant on the fabric construction and weight. Application levels of 2% omf are needed to stop fibrillation on domestic washing. In addition to the resin, the choice of softener can have a large effect on the easy-care performance of fabrics, and it is important to consider the whole formulation and build it up to give the required performance. Silicone micro-emulsions penetrate yarns more than the macro-emulsions. Polyethylene dispersions aid sewing and build the handle of the fabric, whilst some soft acrylic-based chemicals can increase the abrasion resistance. It is also worth remembering that caustic soda or liquid ammonia treatment in preparation will help to increase the easy-care rating of Lyocell fabrics.

Fibrillation



(a) (b)

Figure 4: An example of a non-fibrillated (a) and a fibrillated (b) Lyocell fabric.

This can be defined as the longitudinal splitting of a single fiber filament into micro fibers. The splitting occurs as a result of wet abrasion, particularly against metal. The fibrils formed can be so fine that they become virtually transparent and give a frosty appearance to the finished fabric. The samples fig 4 shows an example of a non-fibrillated (a) and a fibrillated (b) lyocell fabric. The fibrillated fabric gives frosty

appearances. In case of extreme fibrillation, the loose fibers on the surface of the fabric fibrillate and then tangle together to form very light colored pills. The appearance of the fabric becomes totally unacceptable.

Applications

Lyocell feels like silk, and drapes luxuriously. Compared to cotton, Lyocell wrinkles less, is softer, more absorbent, and much more resistant to ripping. In material physical properties, Lyocell is more like cotton than rayon. Like other cellulosic fibers, it is breathable, absorbent, and very comfortable to wear. In fact, Lyocell is more absorbent than cotton or silk, but slightly less absorbent than wool, linen, or rayon.

Lyocell has good resiliency: it does not wrinkle as badly as rayon, cotton, or linen, and some wrinkles will fallout if the garment is hung in a warm moist area, such as a bathroom after a hot shower. A light pressing will renew the appearance, if needed. Also, slight shrinkage is typical in Lyocell garments. Lyocell is a stable a fiber better than cotton or linen. Lyocell is more expensive to produce than cotton or rayon, but is included in many everyday items. Staple fiber is used in apparel items such as denim, chino, underwear, other casual wear clothing & towels. Filament fibers are used in items that have a silkier appearance such as women's clothing and men's dress shirts. Lyocell can be blended with a variety of other fibers such as silk, cotton, rayon, polyester, linen, nylon, and wool.

Lyocell - a versatile, high performance fiber for nonwovens

The early stages of the commercialization of Lyocell were focused towards the fashion textile apparel sector. However, this has changed during the first years of the twenty-first century so that Lyocell is now targeted equally into the industrial sector, with particular emphasis on the key nonwovens markets of wipes, filters and feminine hygiene products. The key difference between traditional textile production and nonwovens production is the omission of the yarn stage from the production process. In nonwovens manufacture, the fibers are formed into a web and a fiber bonding or entangling process is used to impart integrity and control the function, hand and appearance of the resulting nonwovens' substrate. Staple fiber grades are produced to suit carded dry laid, air laid and wet laid processes. Lyocell is also used in

- Conveyer Belt
- Specialty Paper
- Medical Dressing
- Surgical swabs, drapes, gowns
- Floppy disc liners, filtration cloth
- Lining materials

Conclusion

Cellulose is one of the most abundant natural resources on earth, and there has been extensive research on the films, plastics, and fibers from this material. This century modified cellulose were investigated with eco friendly route, Lyocell is one among these. Lyocell is not only environmental friendly fiber; it offers more desirable properties like highly crystalline structure in which crystalline domains are continuously dispersed along the fiber axis, good wet strength as well as excellent dry strength, which makes Lyocell water-washable. Further, it dye uptake more, shrinks less when wetted by water and dried than other cellulose fibers such as cotton and viscose rayon.

Reference

1. Bates I, Mauchru E, Phillips DAS, Renfrew AHM, Su Y, Xu J (2004) Crosslinking agents for the protection of Lyocell against fibrillation: synthesis, application and technical assessment of 2,4diacrylamidobenzenesulphonic acid. Color Technology 120:293-300. doi:l0.1111/j.1478-4408.2004.tb00233.x
2. Chae OW, Chae HG, Kim BC, Oh YS, Jo SM, Lee WS (2002) Physical properties of Lyocell fibers spun from isotropic cellulose dope in NMMO monohydrate. Text Res J 72:335-340. doi:l 0.1177/004051750207200410
3. Chavan RB, Patra AK (2004) Development and processing of Lyocell. Indian J Fiber Text Res 29:483-492
4. Colom X, Carrillo F (2002) Crystallinity changes in Lyocell and viscosetype fibers by caustic treatment. Europe Polymer journal 38:2225-2230. doi:l 0.1 016/S0014-3057(02)00132-5
5. Goswami P. Blackburn RS, Taylor j, Westland S, White P (2007) Dyeing behavior of Lyocell fabric effect fibrillation. Color Technology 123:387-393
6. Goswami P, Blackburn RS, EI-Dessouky HM, Taylor J. White P (2009) Effects of sodium hydroxide pre-treatment on the optical and structural properties of Lyocell. Europe Polymere Journal 45:455-465. doi:l 0.1 016/j.eurpolymj.2008.1 0.030
7. Jakob B. and E. Agster, "Pretreatment and Finishing of Lyocell Woven Fabrics", International Textile Bulletin, No.3, page 18-26 (1998).
8. J. M. Taylor, M. j. Bradbury and S. Moorhouse, "Dyeing Tencel and Tencel A 100 with Poly-Functional Reactive Dyes", AATCC Review, No. 10 page 21-24 (2001).
9. J. M. Taylor and A. L. Harnden, "An Introduction to Tencel Processing", International Dyer, August 1997, page 14.
10. K. Gandhi et. al., "A Novel Route for Obtaining 'Peach Skin Effect' on Lyocell and its Blends", AATCC Review, No.4 page48-52 (2002)
11. http://www.tencel.com
12. http://www.lenzing.com
13. http://www.everything2.com
14. http://www.madehow.com
15. http://en.wikipedia.org/wiki/Lyocell
16. http://www.fibersource.com

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