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Various Printing Techniques of Intelligent Lyocell Fabric to Enhancing its Performance Properties

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Abstract

According to marketing materials, lyocell fiber is a "green and eco-friendly fiber" with a promising future in the twenty-first century. Lyocell fiber is made using a cellulosic non-derivative solution system, which relies on N-methyl morpholine-N-oxide, which is non-toxic and recyclable. Compared to other regenerated cellulosic fibers, lyocell fiber has higher wet tenacity, a softer, silkier handle, luster, startling water absorption, and improved wearer comfort. Lyocell may be printed using dyes used for other cellulose fibres because it is a type of cellulose fiber. The lyocell substance will be identified in this study, as will the various printing methods.

Keywords: Printing Techniques Lyocell Fabric

Introduction

In recent years, the demand for regenerated cellulose, which is characterized as a sustainable material that is environmentally friendly as well as having unique advantageous features, has increased rapidly.[1]

Regenerated cellulose fiber is a sort of manufactured or man-made fiber that is made from cellulose (mostly from wood or plant fibers). Regenerated cellulose fiber was the first man-made fiber used in the textile and garment industries, and it was known as "artificial silk" in its early days, during the 1850s, as manufacturers attempted to create an artificial fiber to replace silk.[2]

A lot of research has been done on Lyocell fibers, a novel type of man-made cellulose fiber, as a result of its unique fiber qualities and ecologically benign manufacturing procedure.[3, 4]

Lyocell, sometimes known as 'Tencel' by its producers, is a natural man-made or regenerated cellulosic fiber produced by a solvent spinning technique.[5]

It is the first of a new class of cellulosic fibers. The quest for cellulosic fiber, which had a lower cost and performance profile than viscose rayon, drove its development. Another major motivator was the ongoing requirement for industrial operations to be ecologically friendly and use renewable resources as raw materials. As a consequence, lyocell satisfies both requirements. It has all of the advantages of a cellulose fibre in that it is entirely biodegradable, absorbent, and its handling may be considerably altered by the use of enzymes or chemical finishing processes.[6-8]

Compared to other regenerated cellulosic fibers, lyocells have some advantageous qualities, including increased wearer comfort, high wet tenacity, soft and silky handle, luster, and surprising water absorption. Similar dyes to those advised for other cellulosic fibers including cotton, viscose, and modal can be used to dye and print this fiber.[9-11]

Color is a textile product's most obvious design element and frequently its primary aesthetic concern. The most adaptable and important method for applying colorants to the desired portions of the textile substrate is textile printing. Analytically speaking, printing is the composition of a design idea, colourants (single or multicolored), and a textile substrate, employing a method including machines to precisely smear the colorants.[12]

When compared to the various effects of textile fabrics made from different raw materials (cotton, silk,

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lyocell, viscose, polyester, wool, etc.) and using various auxiliaries (mordants, softeners, etc.), the dye type (natural, reactive, pigment, direct, Sulphur, etc.) has a significant impact on fastness. It may be said that various dyes and auxiliaries have varying effects on colour fastness.[13-16]

Numerous research articles have been written about the printing process , techniques , the properties, and the settings for the print paste used to print lyocell fabric.[17-19]

This essay will introduce you to lyocell fabric and provide examples of various printing methods.

1. Lyocell (Tencel) fiber

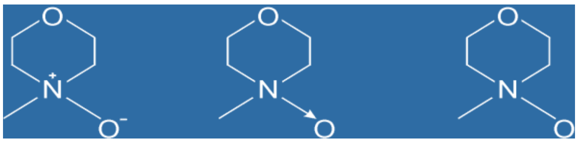
Solvent-spun fibers were given the term "lyocell" in 1989. It is from the Greek word lyein, which meaning to dissolve and from which the English words Lyo and cell are derived. It is the initial member of a new breed of cellulosic fibers. Its creation was motivated by the need for cellulosic fibre with better cost and performance characteristics than viscose rayon.[20].

Lyocell is a new generic name for a cellulosic fibre made in an ecologically friendly way by dissolving cellulose in the tertiary amine oxide N-methylmorpholine-N-oxide (NMMO). Lyocell fibre has several major advantages over other cellulosic fibres, including strong dry and wet tenacity and wet modulus.[21]

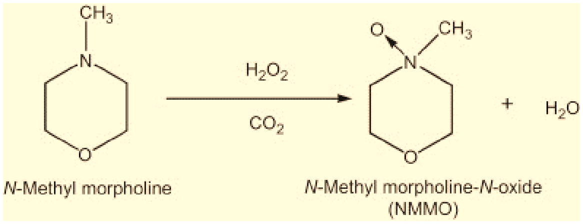
1.1. Lyocell (Tencel) fiber prepration

Although lyocell (Tencel) and rayon are essentially chemically identical, lyocell is produced using a slightly different method. The manufacturing of lyocell fabric uses a direct solvent rather than an indirect one, in contrast to the rayon process. lyocell is produced using a solvent spinning technology, therefore unlike the rayon production process, which results in major chemical changes to cellulose, the creation of lyocell does not.[22]

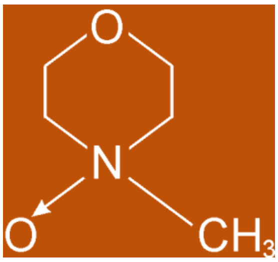
The process of making : Wood pulp originating from eucalyptus species is used as the raw material in the production process. To make lyocell, the pulp is dissolved in N-methyl morpholine-N-oxide (NMMO), which also contains a tiny quantity of water. The technique of dry-jet wet spinning creates the fibres by forcing a viscous, concentrated solution of cellulose through a spinneret and into a water bath.[23]



Possible Formulas of N-methyl morpholine-N-oxide



N-Methyl morpholine-*N*-oxide production chemical reactions



N-Methylmorpholine N-oxide is a key solvent in the lyocell Process

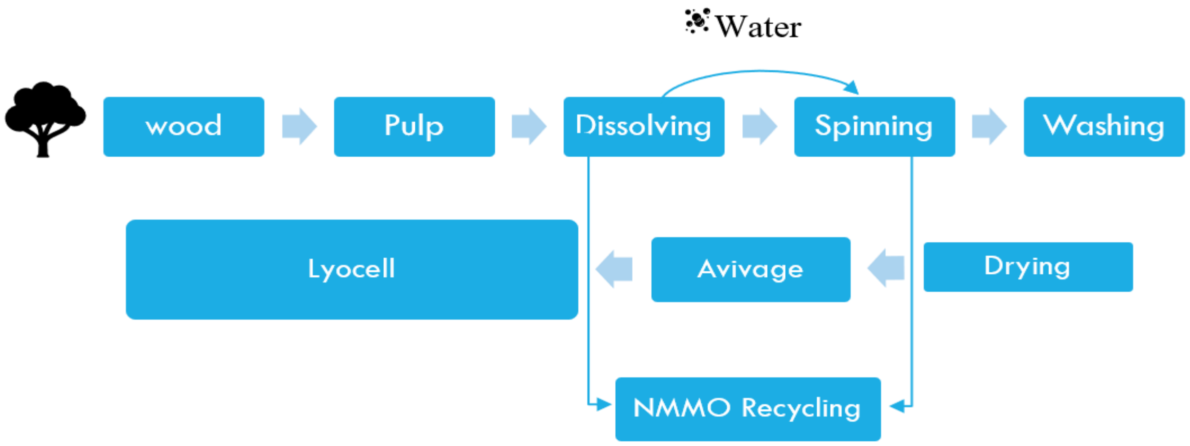
1.2. Lyocell Fibre Manufacturing Method

1.3. The Properties of Lyocell

Lyocell and viscose comparisons in test markets and laboratories shown that the two fibers were sufficiently dissimilar to warrant their own marketing plans.

Lyocell is:

- stronger than any other cellulosic fibre, particularly when wet.
- simple to work with when creating yarns and fabrics, either alone or in blends.
- It has a high absorption rate.
- It is comfortable to wear, especially in humid circumstances.
- It drapes nicely and looks good in skirts and shirts.
- simple to blend (for a distinctive fiber presentation)
- simple to spin into fine count yarns
- very stable in washing and drying; thermally stable.
- simple to dye into deep vibrant colors.
- able to accept the most recent finishing techniques to produce a distinctive drape.
- comfortable to wear.



1.4. The use of lyocell fiber in industry

Lyocell is commonly used as a cotton or silk alternative. This fabric has a smooth cotton feel to it and is used to produce everything from dress shirts to towels and knickers. While some garments are made entirely of lyocell, this fabric is more commonly mixed with other types of fabrics such as cotton or polyester. Because lyocell is so strong, it can be combined with other fabrics to create a composite fabric that is stronger than cotton or polyester on its own.

This fabric is utilised in a variety of commercial situations in addition to garments. For example, several manufacturers have substituted lyocell for cotton in the fabric components of conveyor belts; belts constructed with this fabric last longer and are more durable.

In addition, lyocell is increasingly becoming a popular fabric for medical dressings. In life and death situations, having a highly tensile fabric is critical, and lyocell has proven to be stronger than materials previously used for medical dressings. The high absorbency profile of this fabric makes it a perfect material for use in medical applications.[22]

1.5. Lyocell's advantages and disadvantages:

- **Advantage:**
  - Lyocell is a sustainable fabric since it is made of wood and hence biodegradable and compostable.
  - Lyocell has a soft, smooth feel, is breathable, and is kind to the skin. Additionally, it is elastic, effective at absorbing moisture, temperature-regulating, and antimicrobial, which makes it a good choice for eco-friendly athletic apparel.
  - While it has the appearance of a delicate fabric, it is really stronger than any other cellulosic fibres (particularly in wet strength), thermally stable, and abrasion-resistant.
  - It is possible to merge lyocell fabric with different textiles including cotton, polyester, acrylic, ethical wool, and peace silk thanks to some of its unique qualities.

- **Disadvantage**
  - Lyocell ends up costing customers more than traditional fibres like cotton.
  - While lyocell is biodegradable on its own, the new fabric won't be if it is combined with other synthetic fibres.

2. Printing textile

The process of printing involves applying pigments, dyes, or other materials in the shape of patterns and designs to textile textiles. Textile printing has advanced significantly over the years and now requires the talents of several designers and artisans. [24-27]

Printing on textiles primarily uses block, roller, screen, and heat transfer techniques. In each of these procedures, the colour is first applied(typically as a thicker paste) then fixed (typically by steaming or heating) and then removed by washing any surplus color. Direct, discharge, and resist printing are the three types of printing. [28-34]

Direct printing involves printing colored pastes directly on the fabric. The fabric is first dyed with a background color for discharge printing, which is then removed by reagents, or reducing agents, conveyed in a print paste. Although print pastes may contain coloring materials that are not destroyed by the discharging agent, generating a colorful design, this procedure may leave the discharged design white on a colored backdrop. In the resist method, a chemical known as a resist is initially printed on the fabric to prevent the printed regions from taking on color. Only the areas of the fabric that were not printed with the resist are colored or pigment padded. [35-44]

Printing lyocell fiber

Lyocell fabrics are a form of rayon viscose fabric in which cellulose is the primary constituent. This fiber can be colored and printed using colors similar to those used on other cellulosic fibers like as cotton, viscose, and modal. [45, 46]

2.1. Some lyocell printing techniques

- **Screen printing technique with a Blend of Thickeners**

Lyocell is a cellulosic fiber may be colored and printed with colors similar to those used on cotton, viscose, and modal .Most of the cellulosic fibers are printed with pigments or reactive dyes.[21]

Reactive dyes come in a variety of colors, and during printing, dye molecules diffuse into the fibers and form chemical connections with them. Thickening agent, alkali, humectant, and other ingredients are included in reactive dye print paste. The most often used thickener in reactive dye printing is sodium alginate, a seaweed derivative..[47]

Some advantages of sodium alginate thickener include clear printing figure, consistent color, high plasticity, and good air permeability but its unpredictable price and scarcity have led to the discovery and usage of substitutes including guar gum, carboxymethyl cellulose (CMC), and synthetic thickeners.[48]

The need for printing reactive dyes in high-quality, cost-effective fashion nowadays has prompted printers to introduce the mixed thickener idea. However, starch, cellulose ethers, various gums, and artificial thickeners can all be used with sodium alginate. Therefore, the goal of this investigation was to ascertain how printing over lyocell knitted fabric was affected by a combination of thickeners.[19, 49]

Methods: Preparation of thickening stock paste and printing paste with binary thickener mixes. The stock paste for each thickener was created as described in (Table 1), and then the print paste, reactive dye, and auxiliaries were added to each thickening combination (the formula for the common printing paste is presented in Table 2). A total of 11 varieties of print pastes were made for each colourant, comprising three separate pure thickeners and two types of binary combinations of thickeners prepared in six different ratios (Table 3).

Table (1) Stock paste recipes

Ingredients	A	B	C
Al (g)	140	-	-
GG(g)	-	60	-
SGG(g)	-	-	80
Water	860	940	920
Total(g)	1000	1000	1000

Table(2) Common print paste recipes

Ingredients	Amount (g)
Thickener (single/binary mixture of thickener)	750
Dye (Turquoise Blue P-GR/Red P-4B-GR)	30
Sodium bicarbonate	30
Resist salt	10
Urea	150
Water	30
Total	1000

In the laboratory, the printing pastes were applied to light-weight lyocell knitted fabric using a flat printing screen. The printed materials were dried, fixated with saturated steam, washed in cold water and previously twice in hot water (soaping was done at the boil), rinsed, and dried.

Each pair consists of a motif printing and a motif-free printing (also known as blotch printing). The sample featuring the theme was used to evaluate the print's sharpness. Other printing parameters, such as paste add-on%, penetration%, K/S value, stiffness, and colour fastness, were measured using blotch printed samples.

Results and discussion: Modified guar gum (SGG) can be employed as a thickening agent for reactive printing based on the results of several experimental tests on the printed paste and printed samples. SGG thickening print paste has a reduced viscosity, paste add-on percentage, and penetration percentage when compared to alginate. SGG printed fabric, on the other hand, has almost same K/S value, sharpness, and fabric handling.

Table(3) Combination of thickeners used in the print paste

Mixture of thickener	Ratio of the thickener	Abbreviation
Pure Na alginate	100%	Al
Na Alginate: Guar gum	80:20	Al: GG (8:2)
Na Alginate: Guar gum	60:40	Al: GG (6:4)
Na Alginate: Guar gum	40:60	Al: GG (4:6)
Na Alginate: Guar gum	20:80	Al: GG (2:8)
Pure guar gum	100%	GG
Na Alginate: Substituted guar gum	80:20	Al: SGG (8:2)
Na Alginate: Substituted guar gum	60:40	Al: SGG (6:4)
Na Alginate: Substituted guar gum	40:60	Al: SGG (4:6)
Na Alginate: Substituted guar gum	20:80	Al: SGG (2:8)
Pure substituted guar gum	100%	SGG

Nonetheless, the addition of alginate to the SGG paste alters the properties of the combination, minimizing the disadvantages (color strength and fabric stiffness) and increasing the advantageous behaviors (paste add-on% and penetration%). As a result, the optimal mixture may be 80%-60% alginate and 20%-40% SGG. These combinations produced an appreciable good color yield, sharpness unaltered white ground, and good color fastness rating to wash and rub with soft handle as well as elastic print paste. Some features are dye dependent in general. SGGs with turquoise blue printed textiles reveal comparable color depth and white ground by losing their handling with minimal color fastness grade reduction.[50]

- **Ink-jet printing process for lyocell:**

As ink-jet printing becomes more common in textile printing, print technicians and designers are growing more interested in it, especially [22] given its promise to provide improved production flexibility and responsiveness. [51] Ink penetration is a crucial component in the creation of colours with high saturation because ink-jet printing is a non-contact method. It has been extensively studied how ink penetration phenomena related to ink-jet printing on paper affect light scattering in the substrate, which has an impact on the chromatic values of printed colour. It has been found that increased ink penetration on a paper substrate reduces the colour gamut and tone reproduction.

Textile substrates, which present a more complicated situation due to their topological character, have not been subjected to the same examination as paper in terms of the association between colour qualities and ink penetration. A pretreatment procedure is required for ink-jet printing on cellulosic fabrics in order to effectively fix reactive colours and provide good print quality. [33-35]

Pre-treatment and printing procedure

On the basis of manufacturer guidelines, fabric pre-treatments were created using urea (a moisture-retentive agent), sodium bicarbonate (alkali), a synthetic polyacrylic acid-based migration inhibitor, a nonionic penetration agent, and sodium m-nitrobenzenesulphonate (a reduction inhibitor). Additionally, a concentration of 15 g l)1 of the reduction inhibitor Lyoprint RG was added to each formulation. By padding with 75–80 percent pick-up, the liquors were applied to the fabrics after they had been cut to A4 size. The materials were conditioned for 24 hours at 20°C and 65 percent relative humidity after being dried for 5 minutes at 120°C. To make colour measuring easier, ink-jet printing was done in a single pass at a resolution of 1440 dpi using a solid square print pattern.

After being air dried for five minutes, printed samples were steamed at 102 C for the relevant durations as determined by the experimental design. A boil wash at 95-100 C for 10 min in an aqueous solution of nonionic detergent (Synperonic BD100, 1 g l)1, a warm (ca. 40 C)rinse, and lastly a cold rinse were all required during the wash-off to remove unreacted and hydrolyzed dye using deionized water. Following that, the samples were dried for analysis. Compared to cotton, lyocell fibres had a greater level of colour fixing. Standard

Out of the three fibres, Tencel provided the strongest colour retention. Tencel A100 allows for significant reactive dye uptake, resulting in high fixation but weak colour intensity. We have suggested that this could be due to the unique characteristics of its crosslinked structure, which result in fixed dye being positioned inside the fiber's core rather than at the surface.

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Author Declarations

The authors declare that the data supporting the findings of this study are available in the article

The authors declare that there is no conflict of interest.

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