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Renewable sources and recycling in the textile industry

Summary

The pursuit of consumers and employees in the textile and fashion market in general has prioritized alternative materials with transparency and authenticity, contributing to more sustainable production and symbolic value. This way we think allows us a vision of an environment whose social creations transform consumer goods with a concept of renewable and less polluting sources. Requests in favor of environmental benefits such as eco-friendly, environmentally responsible, eco-safe actions, recycling and green materials are increasing. These actions have often been used to describe and promote products that in principle have minimally negative environmental impacts. These terms have been used in many different types of products and in many different ways. However,

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Introduction

The problem that we face today with the textile industry and its consumers is the poor and little information that we have about the environmental impacts generated by the products that are consumed.[1]

This article aims to clarify the concepts of renewable sources and recycling within the textile industry, showing emerging levels of the possibility of new dependent and independent information within this scenario, with a view to renewable sources and alternatives for the textile industry and the possibility of follow paths with less pollutants. The research was carried out through a literature review, through which we sought to highlight the issue of producing with alternative inputs.

Today we are faced with cost-effective options for finding recyclable and renewable raw materials based on scientific research to provide the comfort to the touch of natural fibers while having the performance, cost and easy-care characteristics of synthetics. Innovation takes place through discourse aligned with sustainability, encouraging sufficient and efficient consumption. Taking a natural approach is one way to manufacture environmentally responsible products. The Brazilian Association of the Textile Industry (ABIT) understands that the textile sector "is considered one of those that best understands environmental legislation, but this is not yet known by society, partly due to the lack of measurable information".[2]

This compliance with the legislation can be understood as the control of the quality parameters of liquid effluents. The use and maintenance of the product directly affects the environment, for this reason, some actions carried out by society are configured as an effective alternative generating results for the environment, such as, for example, using parts that are more durable or durable produced with fibers stronger and of better quality, which, in addition to financial savings in the purchase, are considered environmentally responsible, as their replacement occurs less frequently and, therefore, have a minimal negative impact on the environment when discarded in landfills[1] as well as avoiding items that require dry cleaning. With textile market consumption increasing annually, it is important that concerns about the environmental impacts associated with the production, maintenance and disposal of textiles grow at the same rate.[3,4]

The main concerns related to the production of textiles are related to issues of raw material removal and toxicity of chemical residues from the production process.[5]

In addition, the use of water and energy resources must also be considered, leading manufacturers to review and optimize the production process. We can conclude that the need for creation or increase of strict regulations by governments to guarantee an environmentally responsible production. The textile industry chain is made up of research, design, development, manufacturing and product distribution processes, with electrical and thermal energy being the most used types of energy.[6–8] As an example, it is possible to report that in a weaving sector 50% of electrical energy and 50% of thermal energy are used, while in a finishing sector with dyeing and drying it can use 75% of the total energy to generate heat.[9]

In this way, efficient use of energy can be achieved by adopting green manufacturing, a manufacturing method that minimizes waste and pollution through a sustainable approach to product design and process development. In addition to improving the quality of the process and consequently the quality of the product, the aim is also to reduce the environmental impacts of energy production and distribution.[8,10]

In this sense, the creation of certification programs for textile products meant that many products began to comply with requirements that directly mitigate the environmental impacts related to production.[10,11]

Renewable sources

When we talk about renewable sources, we are encouraging the textile sector's strategies to expand its field of action, showing its final consumer the opportunity to see and live with alternative sources without harming the environment and thus giving a chance to the continuous and necessary improvement that we need to contribute to positive environmental impacts and exploitation of raw materials.

Cellulose is one of the renewable polymer resources available to mankind, being biodegradable and biocompatible allowing recent advances in technology to utilize its natural raw material resources to be processed into synthetic fibers.[12]

As a result of this process we obtain regenerated cellulosic fibers, which can be produced by two processes by cellulose derivation or by

dissolution. Viscose and cellulose acetate are examples of derivation regeneration process and lyocell is an example of the process by direct dissolution in N-methylmorpholine N-oxide (NMMO),[13] as shown in Figure 1.

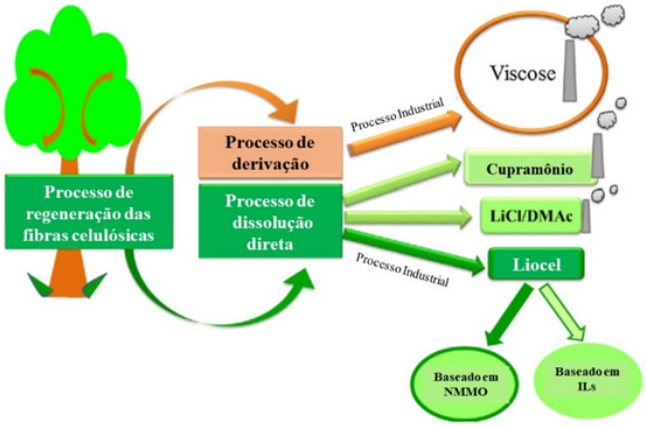

Figure 1 Cellulose fiber regeneration process.

Source: Adapted from Anwar[13]

Rayon

Rayon was the first regenerated cellulosic fiber produced, created in Europe in 1846 and produced in the USA 1911 by the American viscose company. Initially it was called "Artificial Silk". In 1924, a committee formed by the US Department of Commerce and several trade associations decided to use the name "rayon" for "Artificial Silk".[14]

It was called "rayon" for one of two reasons: because of its sheen and its structure which is similar to that of cotton (sun = ray, on = cotton). The name Viscose was derived from the word "viscous" which means sticky spinning solution from which "Rayon" was manufactured.[15]

Rayon was used for clothing, accessories, and home furnishings including socks, sweaters, blouses, curtains, and bed spreads. Rayon products were durable, noted for their comfort, softness, absorbency, and low cost compared to silk, rayon was produced by two methods: viscose and cuprammonium processes.[16]

Viscose rayon: The name Viscose was derived from the word "viscous" which means sticky spinning solution from which "rayon" was manufactured. Thus, the innovative cellulosic derivative received the current name of "viscose rayon". Unlike most man-made fibers, rayon is not synthetic, as it is made from wood pulp, a natural raw material based on cellulose. Therefore, viscose rayon is not defined as synthetic base polymer, but as natural base polymer.[17] Therefore, the properties of viscose rayon are more similar to natural cellulose fibers such as cotton or linen rather than petroleum-based synthetic fibers such as nylon or polyester.[15]

Features of viscose rayon:

a. **Wires:** Do not accumulate static electricity. Easily dyed in bright colors, used as embroidery thread, chenille, cord, new yarn.

b. **Garment:** It drapes well, which is one of the reasons it is so desirable as a garment fabric. Thus, it is popularly used in the manufacture of blouses, dresses, saris, jackets, lingerie, linings, headgear (hats), pants, sports shirts, sports clothes, suits, ties, work clothes.

c. **Fabrics:** These are the most absorbent of all cellulose fibers. Therefore, rayon absorbs perspiration and allows it to evaporate from the skin, making it an excellent summer fabric. Its high absorption applies equally to dyes, allowing for beautiful, deep and rich colors.

d. **Home textiles:** Fabrics made from viscose rayon have silk-like aesthetics with excellent drapery and feel, used in bedspreads, blankets, curtains, curtains, sheets, covers, tablecloths and upholstery.

e. **Industrial textiles:** Because of its high tenacity, viscose rayon is used as reinforcement for mechanical rubber products (tires, conveyor belts and hoses), aerospace, agricultural and textile applications, braided ropes, tapes. It is also used for medical surgery products, non-woven products, tire cords, etc.

f. **Others:** Rayon is an important raw material in the production of carbon fiber.[18]

Rayon cuprammonium: Cuprammonium fibers are manufactured by extruding a solution of cellulose in aqueous cuprammonium hydroxide and treating with an acid. Subsequently, the filaments obtained are treated with diluted sulfuric acid to remove copper salts.[19] The uneconomical cuprammonium rayon process fell out of favor in the late 1980s. The best-known brand using this process was Bemberg, which ceased production in 1975.[17] In the beginning, cuprammonium rayon was obtained only from cotton linter, the cotton linter is constituted by a layer of short fibers that are adhered to the surface of the cotton seeds, which makes it a more expensive raw material than the pulp. Wooden.[20] The wood pulps used, called ''dissolving pulps'', are mixed with the necessary amount of ammonium hydroxide, copper sulphate and sodium hydroxide until a blue solution is obtained. Subsequently, a 9-10% cellulose content is diluted and filtered, the solution is extruded through a mold containing 0.8 mm diameter holes, and the water accompanying the extrudate on its way removes most of the ammonia and of copper.[21]

Pollution during manufacturing: The polluting effects of carbon disulfide, zinc and other by-products from the viscose and cuprammonium rayon production process limited production volume in 1996, although rayon is made from wood pulp, a relatively cheap and renewable resource, processing requires high water and energy consumption.[16]

The modernization of factories and processes, is aimed at reducing product cost as well as pollution, which also added zinc-free technology to reduce pollution. Domestic spinning-finishing equipment for fiber and yarn production has been improved in recent years to create highly efficient and unified equipment and to guarantee the required hygienic-sanitary conditions.[15]

Tencel

With the generic name lyocel, tencel is a regenerated cellulosic fiber like rayon made from wood pulp. It was first introduced in the early 1990s and was marketed as a type of rayon with no negative environmental impact.[1] The production of tencel comes from wood pulp that is harvested from trees that are grown specifically for this use. All solvents used in tencel filament production are then recovered, purified and recycled. Because it is a non-chemical process without the emission of polluting waste, it is the fiber that currently least harms the environment, being classified ecologically correct, unlike other regenerated cellulose fibers.[22]

Tencel fabrics are characterized by their silky feel, distinctive drape and fluidity, they can be used in the production of underwear

and apparel and are an excellent alternative to cotton. Tencel can be used in technical textiles, nonwovens and sheets due to its great advantage in adaptation and can be easily mixed with other fibers.[23] Although it is compared to rayon, tencel production has less negative environmental impacts, it is still apparently considered as a new fiber and its usage is lower than rayon.

Corn fiber

With limited oil reserves, all industries, including textiles, are forced to look for alternative resources. For textile materials, plants have the potential to meet a range of social needs. For example, textile fibers have been successfully made from non-traditional sources such as dextrose extracted from corn. Corn is being used as a source of dextrose due to its abundance and low cost[24] and can be seen in Figure 2.

Figure 2 Corn fiber.

Source: Reis[25]

Fabrics made from corn fiber feel like they have the comfort and feel of natural fibers while having the performance, cost, and easy-care characteristics of synthetics.[24,25]

Recycling

Textile recycling generally refers to the reprocessing of pre- or post-consumer textile waste for use in new textile or non-textile products.[26]

Pre-consumption is made up of by-products from the production of fibres, yarns or fabrics and post-consumer waste consisting of any type of clothing or household textiles that the owner no longer needs and decides to dispose of.[1] Approximately 75% of pre-consumer textile waste is diverted from landfills and recycled into new raw materials for the automotive, furniture, mattress, decoration, paper, etc. industries. Of recovered post-consumer textile waste, only about 48% is recycled as second-hand clothing (mostly sold to developing countries), while the remainder is discarded in the trash and goes to municipal landfills. Fast fashion, due to population growth and exacerbated consumerism, especially affects the environment with the production of low-quality clothes for short-term use, mostly produced with synthetic fibers, increasing textile waste.[27] Although pre-consumer waste recycling has a good recycling rate, the industry still suffers from the amount of post-consumer waste that ends up being disposed of incorrectly and the difficulty in recycling post-consumer waste due to the presence of different components in a product. product, such as different fibers, dyes and all kinds of accessories.[1] Textile recycling is typically classified as mechanical, chemical or, less often, energy.[26] Are processes for recovering the fabric and/or fiber so that it can be reused for the same purpose or processes that recover different materials so that they become able to become a fiber.[1] Another perceived classification in recycling is related to the original product, this is called downcycling. In contrast, if a recycled material product is of higher value (or quality) than the original product, it is termed upcycling.[26] It is possible to separate the recycling classification as open or closed circuits. Open-loop, also called cascade recycling, refers to processes in which material from one product is recycled and used in another product, and closed-loop refers to when material from one product is recycled and used in another product. a product is recycled and used in a (more or less) identical product[28] and can be seen in Figure 3.

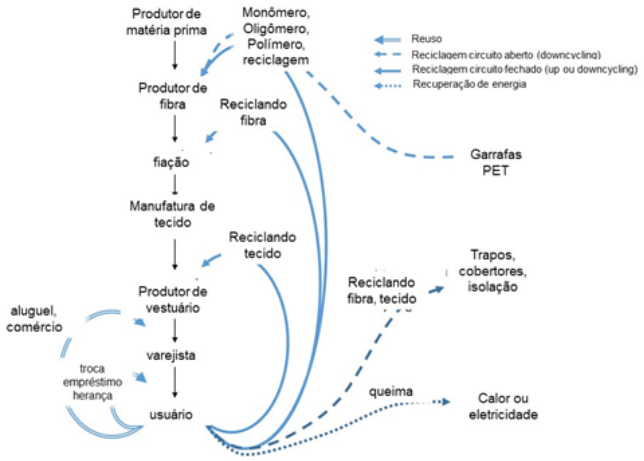

Figure 3 Summary of classification of various forms of reuse.

Source: Adapted from Sandin[26]

CO_2

Currently, several states have implemented programs to provide pollution prevention guides (Delaware Department of Natural Resources and Environmental Control, 1996) or fact sheets (Pollution Prevention for the Dry Cleaning/Wet Cleaning Industry, 2003), and other online programs to help the dry cleaning industry successfully reduce pollution.[29] The International Fabricare Institute has also made courses such as "Dry Cleaning and the Environment" available on the web to provide educational resources for dry cleaners.[30]

By now, companies in many states have implemented these waste reduction programs. However, most dry cleaning establishments produce hazardous waste due to the nature of the solvents used in the cleaning process. Treating or disposing of this waste is a significant cost to the business. The key solution to reducing pollution in dry cleaning is the development of new solvents. For example, liquid CO_2 has been developed as an eco-friendly alternative solvent for dry cleaning.[31] which is not only non-toxic, but is also much better in the environmental review of textile cleaners because of its gas-like properties that can penetrate small openings in textiles to lift dirt. It is evident that many voluntary efforts have been put in place to change the negative environmental impacts of textile manufacturing. However, there are still many areas of textile dyeing and finishing that generate effluents and pose issues to be resolved. The responsibility and challenges for industries, in the context of sustainable development, are not restricted to pollution control, but also include new commitments, such as producing more with less, using resources more efficiently, adopting technologies for greater productivity and less pollution.[32,33]

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In Brazil, some textile industries have been modernizing their production lines in order to reduce greenhouse gas (GHG) emissions from their processes. Tavex Brasil SA and Vicunha Têxtil SA are examples, however, such data provided by the companies do not directly and specifically refer to clothing articles, but to some of their industrial processes as shown in Table 1.

Table 1 Innovations in textile industries in relation to the reduction of CO_2 emissions

Company	Innovation	Result
Tavex Brasil SA	Project to neutralize industrial waste using the carbon dioxide coming from its boilers.	Elimination of the use of sulfuric acid in the treatment of effluents and an annual reduction of 4.5% in CO_2 emissions from boilers.
Vicunha Têxtil SA	Replacement of diesel with cashew nut shells and sugarcane bagasse in boilers.	Reduction of monthly CO_2 gas emissions by 10 thousand tons.

Research carried out

The research was carried out through a literature review, in which we sought to highlight the issue of producing more with less inputs, the entire foundation of this research seeks to show options and improvements already developed in order to change the scenario that is presented to us within the Textile industry. Today we are faced with economical options to find recyclable and renewable raw materials based on scientific research to provide comfort to the touch of natural fibers, while offering performance, cost and easy care characteristics. Innovation takes place through discourse aligned with sustainability, encouraging sufficient and efficient consumption. Taking a natural approach is one way to manufacture environmentally responsible products.

Analysis and conclusion

It was possible to identify that some results depend on the vast majority of consumers in relation to the use and washing of the products. Actions taken by a large part of society would help in the textile recycling process, such as avoiding items that require dry cleaning, using detergent that does not contain chlorine bleach, optical brightener, phosphate or unnecessary additives, avoiding frequent washing when using parts that don't show stains easily, using parts that are more durable or long-lasting (e.g. stronger, better quality fibres), which in addition to saving money, are environmentally responsible as they need to be replaced less often and therefore can be reduce the negative impact on the environment of landfill disposal. The donation of these items would be another sustainable way of circulating textiles. These decisions have a direct impact on the industry for more "green" or sustainable production, making it necessary for information to be easily accessible and, with that, to increase the population's awareness of responsible consumption.

With the consumption of the textile market increasing annually, it is important that concerns about the environmental impacts associated with the production, maintenance and disposal of these grow in the same proportion.

The main concerns related to the production of textiles are related to the renewal of raw materials and the toxicity of chemical residues from the production process. In addition, the use of water and energy resources must also be considered, leading manufacturers to review and optimize their production processes.

With regard to the maintenance of textiles, special attention should be given to the chemicals used in washing, especially materials that require dry cleaning and, finally, the recyclability and biodegradability of textiles are the precautions that are associated with the disposal of materials.

Also important is the need for governments to create or increase strict regulations to ensure environmentally responsible production. In this sense, the creation of certification programs for textile products has led many producers to comply with requirements that directly mitigate the environmental impacts related to production.

Thus, it is essential for textile manufacturers to consider during the design of a new product, in addition to environmental issues, fiber production, product manufacturing processes, as well as what will happen to textiles during and after the end of their lives. Useful.

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Conflicts of interest

Authors declare that there is no conflict of interest exists.

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