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Survey on common bio fibers and polymers in recyclable textiles

Ali Ashjaran* and Reyhaneh Azarmi

Young Researcher and Elite Club, Yadegar-e- Imam Khomeini (RAH) - Shahre-Rey Branch, Islamic Azad University, Tehran, Iran

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ABSTRACT

In recent decade sustainability is a leading characteristic of textile fashion products. Textile fashion companies are focusing more on sustainable and recyclable products these days, so that they can meet the environmental and social aspects. For getting competitive advantage in fashion business the companies have to take care of social, political and economic issues and they must be aware of current trends of the market. Sustainable fibres provide solution for the companies facing issues regarding environmental problems. These fibres are also favorable to meet the market demands of quality products these days. Increasing awareness of textile recycling and its benefits to environment and economic issues are so important subjects for our life. Today, many countries in the world are already using the best technologies under all perspectives from raw material to waste to generating new products. There are different materials, which are used in the processing and making different kind of clothes and garments. This paper focuses on textile recycling value and facts and common recyclable bio fibers and polymers.

Keywords: Textile, Recyclable, Sustainable, Fiber, Environment.

INTRODUCTION

In 2013, the Environmental Protection Agency, noted that 7 million tons of textiles were going to the landfills each year. Clothing and household textiles currently make up 7.2% of the waste in landfills. A textile is any item made from cloth or an artificial fabric like vinyl. Textiles are used for clothing, linens, bedding, upholstery, curtains, carpets, and other items [1]. Recycling clothing and textiles decreases the use of natural resources, such as water used in growing crops and petroleum used in creating new clothing and textiles. It also decreases the need for chemicals used in manufacturing new textiles and the pollution caused by the manufacturing process.

While this may not seem like a large amount, it is when one considers that nearly 100% of the post-consumer waste is recyclable[2].The textile recycling industry partners with engineers, researchers and industry leaders to search for new viable value-added products made from used textile fiber. For consumers the most common way of recycling textiles is reuse through reselling or donating to charity. The textiles must be clean and dry for them to be accepted being recycled. Some companies accept their product back for recycling. Textile recycling equipment plays an important part in the textile recycling industry [3].Standard and high-efficiency textile recycling equipment is important for supporting the textile industry, so far, the most popular and widely accepted clothing recycling bin is designed and manufactured by JNZ enterprise, which uses a high safety chute that is easily opened and closed. The textile recycling industry is a viable industry working diligently to keep waste out of the landfills [4]. The increasing awareness and demand of consumers about sustainable products has put on many fashion companies to use the sustainable materials for making their products. With the increasing awareness of sustainability issues, consumers'

life style has been changed. The life style has become more sustainable they are looking for green and sustainable products. Consumer demand for organic products made of sustainable materials is increasing for their basic needs, like apparel, food and cosmetics. Recycling is significant for materials with high impacts in the production phase. Technology innovations may provide a means to extract longer fibres from used textiles, although a recent innovative business for carpet recycling failed to achieve profitability [5]. Textiles recyclable material used in automotive, furniture, home furnishings, mattress, coarse yarn, paper and other industries. Post-consumer textile waste is the waste of fleece, flannel, corduroy, cotton, nylon, denim, wool, and linen, which have already passed through the consumer market and are recycled and reconstituted into a product for the consumer market once again. Textile waste is a material that is deemed unusable for its original purpose by the owner. Textile waste can include fashion and textile industry waste, created during fibre, textile and clothing production, and consumer waste, created during consumer use and disposal. Natural and synthetic fibers which are biodegradable or can be broken into pieces to recycle and produce textile fibers again are called recyclable fibers. A large amount of fibrous waste is generated each year, consisting of a variety of synthetic and natural polymers. These are recycled to produce recycled fibers, and then converted into textiles. Recycled materials used in a wider and wider range of applications [6].

A: Zero-waste designs.
B: Design for disassembly, design for recyclability.
C: More and more take back programs with incentives.
D: Technology development for sorting and recycling [7].

Revived interest in natural fibres and their development
A: Nettle projects in the Netherlands and the Himalayas
B: Marginal fibres in research and development Alpaca – Kenaf – Kapok – Coir – Pineapple and Banana fibres
C: Better and better, finer and finer- Better Cotton Initiative - 10.4µ wool –Crailar® technology for hemp and linen[8].

2. WHAT CAN BE RECYCLED?

All the materials can be recycled:
1. All clean and dry clothing can be donated & recycled.
2. All used clothing, even pieces with stains or missing buttons, can be re-used and repurposed.
3. Footwear is recyclable
4. Shoes, sandals, sneakers, cleats, boots, flip flops, slippers all can be re used or repaired.
5. Even shoes with worn heels, uppers or in need of a good shine are highly recyclable.
6. Household textiles
7. Household textiles like curtains, pillows, drapes, comforters, sheets, pillowcases, towels, tablecloths and linens are all recyclable.
8. Stuffed animals
9. Stuffed toys including stuffed animals and dolls can also be recycled.
10. Some shirts, pants, suits donations, hats, gloves, socks, underwear, belts, ties, purses and handbags [9].

3. TEXTILE WASTE RECYCLING

Today, the technology has changed the way to business for organizations. Recycling technology is not new invention, but this is the oldest system of recycling among other processes of productions [10].Textile Waste recycling is the process to take into reuse all kind of recyclable material, from material making different types of products for customers use. Furthermore, waste is the process to dispose of or destroy the things which are not in use or we do not need them anymore. Instead of through them away, there are other options which can complete the demand of needy persons while using the charities. Textile waste recycling is the process which tends to recycle clothes and make new clothes to reuse in the different form of other products and the same kind of clothes depending on the nature and substance and type of recyclable [11].The idea of textile waste recycling system is quite old but it has been neglected for a years. In 2011, the Massachusetts Department of Environmental Protection (Mass DEP) announced its support for a new campaign to increase public awareness of textile recycling which supports local businesses and reduces the amount of waste sent to landfills and waste combustors. The outreach campaign is sponsored by the Secondary Materials and Recycled Textiles Association (SMART), non-profit, trade association whose members reclaim, convert and recycle textiles across the globe. SMART's primary mission is to increase public awareness of textile recycling to remove clothing and textile products from the world's waste stream [12].

4. TEXTILE RECYCLING FACTS

A. Over one million tons of textiles are discarded annually, mostly from domestic sources, of which 25% are recycled [13].This breaks down in the following way:
70% second hand clothes and shoes
8% fibre reclamation
9% filling materials
7% industrial wiping cloths, 6% waste
B. It is estimated that up to 95% of the textiles that are land filled each year could be recycled.
C. Over 70% of the world's population use second hand clothes. There are about 3,000 textile banks nationwide, but clothes banks are only operating at about 25% capacity. The average lifetime of a garment is about three years.
D. Consumers purchase 2.15 million tons of new clothing and shoes each year in the UK.
E. Reduces the need to create more landfill space.
F. Reduces pollution created by incinerators.
G. Provides low cost clothing to low-income households all over the world.
H. Clothing that is damaged is recycled into wiping rags, paper, yarn, insulation and padding for carpets.
I. Saves the environment from tons of harsh chemicals, waste products and waste water used in the manufacturing of clothing.

5. Fabrics THAT CAN RECYCLE

5.1. COTTON

Cotton is a main part of textile industry and has been produced since ancient times. According to the foods and nutrition encyclopedia cotton was grown for the first time in Mexico about 8000 years ago. The species (*Gossypium hirsutum*) grown at that time is the mostly planted species today in the world and is known as American Upland Cotton. The textile industry hasn't been sitting idle with regards to sustainability all these years. Jasanisays that, according to a study by cotton.Incorporated, from late 1990 to late 2009, overall, the textile industry reduced the water, energy, and chemicals used in processing cotton by 50%. "On average, the130 to 200 liters of water per kilogram of fabric were reduced to 65 to 70 liters of water per kilogram of fabric processed," says Jasani. "Chemical use was reduced about 40%, and energy consumption was reduced as much as 50%[14].

5.2. FLAX

Flax is a stem plant and the fibre content of the dry stem (straw) is about 25%. Flaxfibres have been used in textile fabrics for ages and the use of substitute for glass fibres, asbestos, reinforcement of polymers and papers is very promising. The flax fibre is a strand of cells, its thickness depends upon the number of these cells in anyone fibre cross-section, and it seems that about 3 to 6 cells or elementary fibres constitute a macro flax fibre with thickness varying from 10 to 20 μm. Flax is more crystalline than that of cotton having a relatively high modulus and tensile strength make it very suitable for a number of technical applications. Flax also possesses a high heat resistance compared with many natural fibres. Also hemp flax offers businesses and consumers the opportunity to flesh out their environmental responsibilities. The sustainable chain works with the universal idea of intelligent people and is aimed at preserving the ecological cycle as environmental much as possible. Entrepreneurs, managers, banks and consumers must make an effort to take advantage of the opportunities hemp flax brings about [15].

5.3. BAMBO

Bamboo serves the environment and has properties to serve the desires and needs of the world in the sustainable ways. Bamboo is the world fastest growing plan that requires very less water and grows without using fertilizers, pesticide and herbicides. Bamboo can grow anywhere even on hills and inclined surfaces where other trees survive hardly and after cutting of bamboo grass it helps in soil stability. Bamboo grows to maximum height in 4 months and becomes mature in 3-4 years having all ecofriendly properties. They are producing organic baby products, organic towels, bamboo clothing's, organic baby cloths, bamboo sock, bamboo beddings and bamboo towels. They have vision to go for more fashion product made of bamboo. They are mentioned few famous designers name that recognize the awesome features of bamboo fiber in different sectors and recommend and trying to design the fashion item having bamboo fibers in it[16].

5.4. CARBON FREE REINFORCED POLYMER

The increasing use of carbon free reinforced polymers (CFRPs) has raised an environmental and economic awareness for the need to recycle the CFRP waste. CFRP is now used in a widening range of applications and in growing content in most of them example, with the new Boeing 787 and Airbus A350 having up to 50% of their

weight in CFRP, and military aircraft showing a similar trend. Despite all advantages associated with CFRPs, the increasing use generates an also increasing amount of CFRP waste 2011. It is clear that turning CFRP waste into a valuable resource and closing the loop in the CFRP life cycle is vital for the continued use of the material in some applications, e.g. the automotive industry [17].

5.5. POLYAMIDE

Polyamide 2000 in Germany was another large commercial carpet recycling facility. With a capacity to recycle 120 thousand tons of unsorted carpet each year, it was in operation from 2001 to 2003.A major source of carpet supply was the. Carpet Recycling Europe (CRE). It employed a process similar to the"6ix Again" sequence to depolymerize nylon 6, and produced resin compounds from nylon 6, 6 face fibers[18].

5.6. NYLONE 6

Nylon 6 is made by polymerizing a single monomer, the caprolactam, and the process may be reversed. Chemical recycling of nylon 6 carpet face fibers has been developed into a closed-loop recycling process for waste nylon carpet. The recovered nylon 6 face fibers are sent to a depolymerization reactor and treated with superheated steam in the presence of a catalyst to produce a distillate containing caprolactam. The crude caprolactam is distilled and depolymerized to form nylon 6.The caprolactam obtained is comparable to virgin caprolactam in purity. The repolymerized nylon 6 is converted into yarn and tufted into carpet. The carpets obtained from this process are very similar in physical properties to those obtained from virgin caprolactam [19]. Recycled Nylon Like polyester, virgin nylon fiber is made from crude oil. Recycled nylon comes from postindustrial waste fiber andyarn collected from spinning and processed into reusable nylon fiber. The benefits of recycling nylon come from the reduced energy needed to produce the final fiber, reduced dependence on oil, and the diversion of waste from landfills. The final product can be recycled again at the end of its life.

5.7. POLYESTER

Polyester is made from petroleum, a nonrenewable resource that creates damaging environmental impacts during the extraction process. However, when considering the whole lifecycle of the fibre, from the raw materials, through the use phase to the end of the lifecycle, polyester is not as environmentally damaging as believed. It has lower energy impacts during the washing and cleaning phase and is also completely recyclable at the end of its life. Polyester textile recycling has been developed using the clear plastic water bottles, or PET as the raw material, a source of plastic that would otherwise go into landfill. The most common form of textiles made using recycled polyester is fleece, a knitted pile fabric often used by outdoor clothing companies to make jackets. The most common form of textiles made using recycled polyester is fleece a knitted pile fabric often used by outdoor clothing companies to make jackets. Patagonia is the most well-known promoters of polyester recycling and have partnered up with Teijin, a Japanese company who have developed their own closed-loop polyester recycling system. Kate Golds worthy is a textile designer and researcher exploring 'design for disassembly' and 'mon materiality' as a way to produce 'interim' textile products utilizing manufacturing technologies and the recycling of PET polymer waste. Fleece jacket made from recyclable PET plastic bottles. This product has strong success in market and a lot of other companies start coping and follow the same procedure and start making fleece jackets from PET bottles and this give rise to cheap fleece jackets in the low standard market. Recycled Polyester is polyester that has been manufactured by using previously used polyester items such a PET bokles or used polyester clothing. The benefits of recycling polyester come from the reduced energy needed to produce the final fiber, reduced dependence on oil and the diversion of waste from landfills. One considers 3 on in the recycling of PET area 3 mony, which is present in 80-85 percent of all virgin PET. It is converted to a 3 mony trioxide at high temperatures that are necessary during recycling, releasing this carcinogen from the polymer and making it available for intake into living system stem. Polystyrene includes Styrofoam coffee cups, food trays, and "clamshell" packaging, as well as some yogurt tubs, clear carry-out containers, and plastic cutlery. Foam applications are sometimes called EPA, or Expanded Polystyrene. Some recycling of polystyrene is taking place, but is limited by it low weight-to-volume ration and its value as a commodity [20].

5.8. CARPET

Carpet collection involves collecting carpet in individual stations, sending the carpet to a regional warehouse, and then to the processing facilities. Sorting can be done either as the carpet is collected or at central location. A portable infrared spectrometer has been developed by Kip et al which is a lightweight, battery operated unit. It is designed to identify the common carpet face fibers: nylon 6, nylon 6,6, polypropylene, polyester, and wool. Because of the higher value of nylon resin in comparison with other polymers used in carpet, nylon carpet has been looked at as raw

material for making virgin nylon via depolymerization [21].The majority of polyamides used commercially are nylon 6,6 and nylon 6.The waste carpets are collected, sorted and then subjected to a mechanical shredding process before depolymerization. Nylon 6 is made by polymerizing a single monomer, the caprolactam, and the process may be reversed. Chemical recycling of nylon 6 carpet face fibers has been developed into a closed-loop recycling process for waste nylon carpet [22,23].The recovered nylon 6 face fibers are sent to depolymerization reactor and treated with superheated steam in the presence of a catalyst to produce a distillate containing caprolactam. The crude caprolactam is distilled and repolymerized to form nylon 6.The caprolactam obtained is comparable to virgin caprolactam in purity. The repolymerized nylon 6 is converted into yarn and tufted into carpet. The carpets obtained from this process are very similar in physical properties to those obtained from virgin caprolactam.

5.9. POLYETHYLENE TEREPHALATE

Polyethylene terephthalate (PET) is the most readily recyclable material at this time. It includes 1- and 2- liter clear soda bottles, as well as some bottles containing liquor, liquid cleaners, detergents, and antacids.

5.10. HIGH-DENSITY POLYETHYLENE

High-Density Polyethylene (HDPE) is currently recyclable in some areas. This class includes milk, juice, and water jugs, base cups for some plastic soda bottles, as well as bottles for laundry detergent, fabric softener, lotion, motor oil, and antifreeze.

5.11. POLYVINYL CHLORIDE

Polyvinyl Chloride (PVC, also referred to simply as “vinyl”) includes bottles for cooking oil, salad dressing, floor polish, mouthwash, and liquor, as well as “blister packs” used for batteries and other hardware and toys.

5.12. LOW- DENSITY POLYETHYLENE

Low-Density Polyethylene (LDPE) includes grocery bags, bread bags, trash bags, and a variety of other film products. LDPE is currently being recycled by some of the major retail chains.

5.13. POLYPROPYLENE

Polypropylene includes a wide variety of packaging such as yogurt containers, shampoo bottles, and margarine tubs. Also cereal box liners, rope and strapping, combs, and battery cases.

5.14. RAYON

Derived from wood pulp, often relies on clearing old growth forests to make way for water-hungry eucalyptus trees, from which the fiber is derived.

5.15. OTHER

Can refer to application which use some of the above six resins in combination or to the collection of the individual resins as mixed plastic (e.g., camera film can include several types of plastic resins). Technology exists to make useful items such as plastic “lumber” our of mixed plastic resins, but generally the materials are more useful and valuable is separated into the generic resin types described above.

6. RENEWABLE ENERGY AND RESOURCE EFFICIENCY

There are two important measures of sustainable energy use the source from which itis derived and how efficiently. It is utilized. With the impacts of climate change becoming increasingly evident, the importance of using renewable forms of energy becomes obvious. Victor is fortunate to have access to a renewable source of energy, hydroelectric, which is used to power 80% of our manufacturing operations. The other 20% of our energy mix comes from natural gas that, while also a fossil fuel, when burned releases significantly fewer emissions for particulates, CO_2, sulfur and nitrogen oxides than coal and oil derived.

7. PROCESS

Fiber reclamation mills grade incoming material into type and color. The color sorting means no re dying has to take place, saving energy and pollutants. The textiles are shredded into "shoddy" fibers and blended with other selected fibers, depending on the intended end use of the recycled yarn. The blended mixture is carded to clean and mix the fibers and spun ready for weaving or knitting. The fibers can also be compressed for mattress production. Textiles sent to the flocking industry are shredded to make filling material for car insulation, roofing felts, loudspeaker cones, panel linings and furniture padding. For specialized polyester based materials the recycling process is

significantly different. The first step is to remove the buttons and zippers then to cut the garments into small pieces. The shredded fabric is then granulated and formed into small pellets. The pellets are broken down polymerized and turned into polyester chips. The chips are melted and spun into new filament fiber used to make new polyester fabrics [24].

CONCLUSION

Recycling may be defined as the reprocessing of materials into new products. Recycling generally prevents the waste of potentially useful materials, reduces the consumption of raw materials and decreases energy usage. These result in less greenhouse gas emissions compared to virgin production. Recycling has been a common practice throughout human history. In pre-industrial times, scrap made of bronze and other precious metals were collected in Europe and melted down for perpetual reuse. The definition of the term "sustainable" is highly variable and each company needs to be transparent in how they define this idea and implement it in their manufacturing of products. Clothing fabric generally consists of composites of cotton (biodegradable material) and synthetic plastics. The textile's composition will affect its durability and method of recycling. Recycling is nothing but process of using old or waste products into new products. It makes us feel proud of taking an important step towards reducing pollution and recycling is a fun activity especially when done in groups. Surprisingly, recycling process may not always be beneficial and has shocking effects; unknown to most of us. Recycling helps to reduce energy usage, reduce the consumption of fresh raw materials by reducing the need for "conventional" waste disposal and also reduces greenhouse gases emissions. Advantage of recycling is Protects Environment, Reduces Energy Consumption, Reduces Pollution, Reduces Global Warming and Create Green Job

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