

Research on the most popular bio fibres and polymers used in reusable textiles

Shakti Prasad Jena^{1*}, P.Paulpandian²

^{1*} Associate Professor, Department of Mechanical Engineering, Nalanda Institute of Technology, Bhubaneswar, Odisha, India

² Assistant Professor, Department of Mechanical Engineering, Nalanda Institute of Technology, Bhubaneswar, Odisha, India

*Corresponding author e-mail: shaktiprasad@thenalanda.com

ABSTRACT

Sustainability has emerged as a key feature of modern textile fashion products. These days, textile fashion companies are putting more of an emphasis on recyclable and sustainable products in order to balance social and environmental concerns. Companies in the fashion industry must consider social, political, and economic issues as well as stay up to date on market trends if they want to gain a competitive edge. Businesses with environmental concerns can find a solution in sustainable fibres. These fibres are also advantageous for satisfying the market's current need for high-quality goods. Raising people's knowledge of textile recycling, the advantages it has for the environment, and related economic issues is crucial for our daily lives. Many nations throughout the world are currently utilising the latest technology from all angles, from the production of raw materials to the disposal of waste to the creation of new products. Several materials are utilised in the processing and creation of various types of clothing and garments. This essay focuses on the importance of textile recycling, as well as on typical biopolymers and fibres that are recyclable.

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

INTRODUCTION

According to the Environmental Protection Agency, 7 million tonnes of textiles are disposed of in landfills annually. At the moment, 7.2% of garbage in landfills is made up of clothing and home textiles. Any product made of cloth or an artificial fabric, such as vinyl, is a textile. Clothing, linens, bedding, furniture, curtains, carpets, and other objects are made from textiles [1]. Recycling textiles and apparel reduces the need for natural resources like petroleum and water, which are both used in the production of new clothing and textiles. Also, it reduces the demand for chemicals used in the production of new textiles and the pollution produced during production.

Although though this might not seem like a lot, it is when you take into account that almost all post-consumer waste is recyclable[2]. The textile recycling sector collaborates with engineers, academics, and business pioneers to find fresh, marketable goods with value-added textile fibre. Reusing textiles by reselling them or giving them to charity is the most popular method of recycling for customers. For the textiles to be accepted for recycling, they must be dry and clean. Some businesses allow customers to recycle their products. The industry of textile recycling relies heavily on textile recycling equipment [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 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. Jasani says 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, the 130 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].

FLAX

Flax is a stem plant and the fibre content of the dry stem (straw) is about 25%. Flax fibres 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].

BAMBOO

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 plant 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].

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].

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 "Six Again" sequence to depolymerize nylon 6, and produced resin compounds from nylon 6, 6 face fibers [18].

NYLON 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 and yarn 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.

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].

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.

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.

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.

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.

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.

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.

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.

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" out 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 it is 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. It 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, CO₂, 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-dyeing 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

The reprocessing of materials into new goods might be referred to as recycling. In general, recycling reduces the use of raw materials, energy use, and waste of products that could be valuable. Compared to virgin production, these produce fewer greenhouse gas emissions. Recycling has been a typical human activity for all of recorded history. Bronze and other precious metal refuse was gathered in Europe during the pre-industrial era and melted down for enduring reuse. The phrase "sustainable" has a wide range of meanings, therefore it's important for businesses to be open about how they define it and use it when producing products. Typically, clothing fabric is made of blends of cotton (a biodegradable substance) and synthetic polymers. The composition of the cloth will have an impact on its recycling strategy and durability. Recycling is simply the practice of turning waste or obsolete items into new ones. Recycling is an enjoyable activity, especially when done in groups, and it makes us feel good to have made a significant contribution to lowering pollution. Paradoxically, recycling has unexpected implications that the most of us are unaware of and may not always be advantageous. Recycling lowers the demand for "traditional" trash disposal, which in turn lowers the consumption of fresh

raw resources and lowers greenhouse gas emissions. Recycling benefits the environment, lowers energy use, lowers pollution, lowers global warming, and creates green jobs.

REFERENCES

- [1] F Hawley. *Family J. Consumer Sci.*,**2004**,5(1), 833-843.
- [2] A Bohnhoff; J Petershans; *A Decentralised. Presentation at 7th Annual Conference on Recycling of Polymer. North West Georgia.*,**2002**.
- [3] MM Nir. *Recycling Implications of Post-consumer Plastic Waste*, 2nd Edition, International standard Publisher, New York, **1990**, 29-35.
- [4] H Kindler, A Nikles. *Energy Expenditure in the Manufacturing of Raw Materials*, Calculation, 3rd Edited, Woodhead Publishers & Kunststoffe, New York, **1980**; 802-808.
- [5] YA Gowayed; R Vaidyanathan; M El Halwagi, *Elastomers and Plastics J. Material Sci.*, **1995**,27(13), 79-90.
- [6] A Kotliar, DP Fountain. *Synthetic Wood from Waste Fibrous Products*, 2nd Edition, John Wiley & Sons Publisher, New York, **2003**; 725-730.
- [7] SS Dagli; M Xanthos; JA Biesenberger, *American J. Chemical Symposium Sci.*, **1992**, 513(2), 241-257.
- [8] P Nousiainen; P Talvenmaa Kuusela. *presented at International conference on Globalization Technological, Atlanta, GA*,**1998**.
- [9] JM Henshaw; W Han. *Thermoplastic J. Composite Materials sci.*, **1996**,9(3), 4-20. [10] S Shim, *Clothing and Textiles Research J. Consumer Sci.*,**1995**,13(2), 38-48.
- [11] L Divita. *presented at International conference on Recycling, Columbia, USA*,**1996**. [12] J Hawley. *Family J. Consumer Sci.*,**2009**, 4(1), 833-843.
- [13] M Braun; AB Levy; B Braun; M Levy; AB Sifniades, *Polymer-Plastics J. Technology & Engineering Sci.*,**1999**, 3(1) 471-484.
- [14] S Pimenta; ST Pinho. *Elsevier J. Waste Management Sci.*,**2011**, 31(5), 378-392. [15] W Carberry; AERO Boeing. *Eng J. Mater Sci.*, **2008**, 15(5), 22-27.
- [16] S Line, *presented at International Conference Fibre Recycling and Reuse of Intertech Pira, Hamburg, Germany*, **2009**.
- [17] B Skuturna; T Valivonis; P Vainiūnas; G Marčiukaitin; M Daugevičius. *Baltic of Road & Bridge J. Engineering Sci.*,**2008**, 3(1), 145-151.
- [18] HP Kasserra. *Recycling of Polyamide 66 and 6 Science and Technology of Polymers and Advanced Materials*, 2nd Edited, Plenum Press Publisher, New York, **1998**; 629-630.
- [19] T Brown. *presented at annual conference on recycling of polymer, Dalton, Georgia*, **2001**.
- [20] CC Elam; RJ Evan; S Czernik. *Chemical Sociel J. Division of Fuel Chemistry Sci.*, **1997**, 42(5), 993-997. [21] PS Mukherjee; KG Satyanarayana. *springer J. Material Sci.*, **1986**, 21(5), 4162-4168.
- [22] P Bajaj; ND Sharma, *springer J. Material Sci.*, **1997**, 21(5), 4162-4168.
- [23] R Henshaw; JMW Han. *Thermoplastic J. Composite Materials Sci.*, **1998**,17(5), 4-20.