Quick Guide to Biosynthetics
CONTENTS

1. Introduction
   1.1 Biosynthetics Working Group
   1.2 What are Biosynthetics?

2. The Big Picture
   2.1 A Brief History
   2.2 The Fossil Fuel Economy
   2.3 The Bioeconomy

3. The Textile Industry
   3.1 Continued Growth of Polyester
   3.2 Biobased Alternatives
   3.3 Current Stages of Research & Development
   3.4 Biosynthetic Fiber Options

4. Sustainability Status
   4.1 Potential Benefits
   4.2 Common Concerns

5. Standards and Certification
   5.1 Biobased Content
   5.2 Feedstock Sustainability
   5.3 Integrity

6. Conclusion

Notes & References

Appendix 1: The Supply Landscape

Appendix 2: Further Resources

Acknowledgements

aboutbiosynthetics.org is the latest in the suite of Textile Exchange’s “about” series, following on from aboutorganiccotton.org released in 2015. Both microsites aim to simplify and demystify the subject and provide sound information and market intelligence for businesses and consumers alike.
1. Introduction

Welcome to Textile Exchange's Quick Guide to Biosynthetics - a concise review of the opportunities offered by developments in this area. The Guide has been produced as a companion piece to accompany the release of Textile Exchange's new microsite, aboutbiosynthetics.org. Biosynthetics form part of Textile Exchange's portfolio of Preferred Fiber & Materials (PFMs) because of their potential to reduce the textile industry's dependence on fossil fuels and shrink its carbon footprint, while producing innovative, high performance materials.

1.1 Biosynthetics Working Group

Textile Exchange’s Biosynthetics Working Group, launched in October 2016, with an inaugural in-person meeting in Hamburg attracting much interest from attendees wanting to learn more about this emerging area. The Working Group agreed its focus to be on building knowledge and supporting the early stages of market penetration. The first task of the Working Group was to research and create a microsite (aboutbiosynthetics.org). This has involved the gathering and synthesis of available information and resources on biosynthetics, with the goal of informing the industry and enabling this relatively new material to become a larger part of a company’s strategy and PFM portfolio.

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We think the Textile Exchange microsite is a great way to provide much needed information on the benefits of biosynthetic materials to the textile industry. At Virent, we are in the final stages of commercializing a technology to use plant-based feedstocks to produce paraxylene, a key raw material for biopolyester fiber. We were pleased that Textile Exchange took on the challenge of developing the microsite and happy to support its continued development.

Stacey Orlandi, CEO, Virent

The next steps for the Working Group include: developing a biosynthetics pathway map to better inform brand and retailer decision making; exploring transparency and integrity options with tools to support the content claims of more sustainable feedstocks; and supporting the shift towards technologies that take us from first generation crops to the use of waste and biomass.
1.2 What Are Biosynthetics?

A biosynthetic fiber consists of polymers made from renewable resources, either wholly or partly.

Overview of the Biosynthetic Life Cycle (aboutbiosynthetics.org)

Biosynthetics are emerging as a potential alternative to conventional synthetic products. The main difference between biosynthetic fibers and conventional synthetic fibers lies in the raw materials used. Conventional synthetics, such as polyester, nylon and acrylic, use raw materials derived from fossil fuels - petroleum, natural gas and coal. Biosynthetic fibers can be made from 100 percent biobased as well as partially biobased resources.

Biosynthetic fibers that are commercially available today come from starches, sugars, and lipids derived from corn, sugar cane, sugar beets, and plant oils. These feedstocks are derived from crops and are sometimes called "1st generation". Various technologies are under development to produce biosynthetic fibers from a broader range of raw materials including biomass and waste from agriculture, forestry, and even food waste. There are also early examples of biosynthetics derived from biotechnology, sometimes referred to as novel feedstocks, such as algae, fungi, enzymes, and bacteria. While many of the alternative feedstocks have been piloted at concept level, they are not yet commercially available.
2. The Big Picture

2.1 A Brief History

1800’s

Packaging

In 1862, at the Great International Exhibition in London, a chemist and inventor Alexander Parkes, displayed a moldable material composed of nitrocellulose - the first manmade plastic. He called his material, “Parkesine,” and received a medal for his work. So, the very first plastic was, in fact, a Bioplastic! Biobased plastics were quickly superseded in the 1900’s with the invention of petroleum-based plastics.

Driven by both biorenewability and biodegradability trends, the demand these days for bioplastics in packaging is expected to grow to about 9.45 million metric tons by 2023 thus increasing the share of bioplastics in the packaging sector from 0.2 percent in 2013 to 2.4 percent by 2023.

1930’s

Automotive

Back in the 1930’s, Henry Ford used biobased materials (soybeans, hemp, wood pulp, cotton, flax and ramie) in the production of vehicle parts and components; and in 1941, Ford unveiled a prototype car that had plastic body panels made of 70 percent hemp fibers and 30 percent phenolic resins extended with soybean meal.

Although still in its infancy as a commercial option, the use of biobased materials in the automotive industry has been gradually accelerating over the last few years. Biobased plastics are now closer to meeting or exceeding performance and cost parameters versus conventional plastics than ever before.

1940’s

Textiles & Apparel

Although biosynthetics are being classed today as “emerging fibers,” they are not new within the textile arena. Studied from the late 1800’s, there was a flurry of development around the 1940’s when oil was in short supply. The polymers worked on, at this time, were lipid and protein based and branded as nylon Rilsan® from Arkema (available today) and Aralac protein based fibers, branded as Lanital, Merinova, and Ardil.
2.2 The Fossil Fuel Economy

When oil prices are low, biobased polymers are typically more expensive than petroleum-based polymers. However, brands should consider looking at biobased polymers as new materials with new and different features (i.e., more sustainable, lower carbon) rather than comparing them to petroleum-based materials. Undertaking strategic development work now will also ensure economies of scale and a diversified commercial portfolio for a time when oil prices increase and petroleum-based polymers costs also increase.

A pressing challenge related to fossil resource shortages is that all the best deposits are being used up, so in the future more investment of money and energy will be needed to exploit less convenient sites. This will drive up prices and may create conflict due to the uneven geographical distribution of the resources.\textsuperscript{8}

Based on BP’s Statistical Review of World Energy 2016, there are about 115 years of coal production, and roughly 50 years of both oil and natural gas remaining. While many worry about the possibility of fossil fuels running out, the Center for International Climate Research (CICERO) predicts that 65 to 80 percent of current known reserves will have to be left untouched in order to stand a chance of keeping average global temperature rise below the two degrees global target.\textsuperscript{9,10,11}

At current consumption trends, technology and proven reserve levels, there could be just half a century’s worth of oil and gas supply available.\textsuperscript{12} As the availability and stability of oil becomes a higher risk, biobased resources give us alternatives in the manufacturing of textiles and apparel, while opening up opportunities for new performance capabilities with a lower impact on resources and the environment.

Norrøna is excited about the possibilities biosynthetic fibers offer to reduce the textile industry’s dependence on oil. As a brand, Norrøna is committed to being a catalyst to maximize this opportunity through a clear roadmap, which will benefit the fiber producers, mills, brands, and consumers ensuring we reduce greenhouse gases as part of the biosynthetic development. Biosynthetics have the potential to be the biggest industry game changer since the original discovery of synthetic fibers over 90 years ago.

Brad Boren, Director of Innovation & Sustainability, Norrøna and Chair of the Textile Exchange Biosynthetics Working Group
2.3 The Bioeconomy

The bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, fiber, biobased products and bioenergy. The bioeconomy is comprised of agriculture, forestry, fisheries, food, and chemistry.\(^{14}\)

Moving from an economy based on limited nonrenewable resources to a bioeconomy is of importance to both the European Union and the United States along with many other parts of the world. Cutting waste and curbing climate change are key environmental aspirations. On the socio-economic side, the hope is that new jobs will be created from reindustrialization and development of rural areas.\(^{15}\)

The use of biobased resources, particularly for fuel, packaging and other plastics, has grown at a steady pace over the last decade. Today, the bioeconomy is already worth over €2.2 trillion (US$2.7 trillion) whilst providing over 18 million jobs in Europe.\(^{16}\)

A 2015 study commissioned by the German Bioeconomy Council identified that, in total, 45 countries have developed national policy strategies with significant impact on bioeconomy development.\(^{17}\)

Role of the Bioeconomy in Climate Change Mitigation

The climate change mitigation potential of the bioeconomy is estimated at 2.5 billion tons CO\(_2\) equivalent per year by 2030. Ahead of the Paris Climate Change Conference (COP21)\(^{18}\) in Paris in 2015, Parliamentarians and stakeholders in the European Parliament gathered to discuss the pivotal role of the bioeconomy in climate change mitigation. The benefits of a bioeconomy and biobased products were made clear by all stakeholders, particularly focusing on carbon sequestration and storage benefits, and the need to replace fossil-carbon-based materials. The need to look at new markets and identify efficient sources of biomass was also pointed out as vital for reaching the promise of a bioeconomy.\(^{19}\)

Also leading up to COP21, Novozymes, a global biotechnology company, put out this statement:

Novozymes believes that a transition towards a biobased economy that relies on renewable biological resources can assist the planet in being more resource efficient and tackle climate change. Its biosolutions typically offer customers reduced CO\(_2\) emissions due to lower energy, water, raw material and chemical consumption compared with conventional technologies.\(^{20}\)
Greener Chemistry

Back in 2005, biobased resources accounted for seven percent of global sales and around US$77 billion in value within the chemicals sector, with the European industry accounting for approximately 30 percent of this value.\(^2\) According to forecasts, the biobased share of all chemical sales will rise to 22 percent by 2020, with a compounded annual growth rate of close to 20 percent.\(^2\)

By 2020, the global market for biobased products is expected to grow to US$250 billion (€208 billion) and by 2030 one-third of chemicals and materials will be produced from biological sources, including biopolymers and bioplastics. This approximation lies broadly within the estimated growth of the industrial biotechnology market size, which is predicted to be between £150 billion and £360 billion (US$204 billion to US$489 billion) by 2025.\(^\text{23}\)

Ensuring a Sustainable Bioeconomy

A biobased economy is not, by definition, sustainable. Agriculture and forestry are already drivers of biodiversity degradation.\(^\text{24}\) Key to the successful and sustainable development and deployment of a biobased economy will be innovation in feedstocks that do not compete with food production or that are not dependent on high inputs of water, agrichemicals, etc. in agriculture, governance of land, and the management of natural resources.

The best strategies will appreciate the possibilities of a range of biobased options but balance these with land use and securing development in a sustainable, even regenerative way. (e.g. avoiding competition with food, securing effective net mitigation of GHG emissions).\(^\text{25,26}\)
3. The Textile Industry

3.1 Continued Growth of Polyester

Synthetic fiber was estimated to total 64.8 million metric tons (MT)\textsuperscript{27} in 2016, making up the largest share (68.3 percent) of global fiber production (94.5 million MT).

At 52 million MT in 2016\textsuperscript{28}, polyester represents over half of the entire fiber market,\textsuperscript{29} and over 75 percent of all synthetic fibers. This represents a 7-fold growth since 30 years ago, when polyester production was estimated to be 6.5 MT.\textsuperscript{30}

The PCI Consulting Group predicts that the polyester market will be over 60 million MT by 2020. Recycled polyester will make up some of this growth.

At an estimated four million MT\textsuperscript{31} in 2016, \textit{recycled polyester currently makes up seven percent of the polyester fiber produced today}.\textsuperscript{22} Recycled polyester fibers are largely used in carpets, blankets, and clothing.

\textit{Biopolymers}, while currently a much more niche solution, are predicted to contribute to the overall growth in polyester (and other synthetics), although at a small percent in the early years.
3.2 Biobased Alternatives

Dependency on fossil-based resources is becoming more risky and increasingly undesirable to modern, progressive businesses. Biobased resources give us alternatives to manufacturing textiles and apparel, while opening up opportunities for new performance capabilities with less impact on resource use.

Biosynthetics are an emerging preferred fiber, gaining traction with clothing, footwear, and household brands and retailers due to their use of renewable resources and their potential to mitigate climate change compared to their petroleum-based counterparts. In line with a broader vision, biosynthetic textiles are part of the transition towards a biobased economy.

3.2.1 Building A Biosynthetic Fiber Portfolio

Already, a diverse range of textile products is being made from biosynthetic fibers. Products range from home and fashion to outdoor and technical textiles.

Biosynthetic fibers can be found in more and more products
A significant opportunity exists today to improve the sustainability performance in the apparel industry through the use of renewable, biobased materials, rather than petroleum. Finite petroleum risks market volatility and is used as the backbone of our most widely used synthetic fibers today, polyester and nylon. Renewable and bioderived chemistry offers up promising alternatives to produce, in general, chemically identical materials made from non-food biomass and further innovation opportunities in the future.

Sophie Mather, Founder, Biov8tion and inaugural Chair of the Textile Exchange Biosynthetics Working Group
3.4 Biosynthetic Fiber Options

For the textile industry, the shift from fossil based synthetic fibers to biobased is in its infancy, with biobased polyester being the best developed. Biobased alternatives for polyamides (nylons) are also being developed, along with entirely new synthetic materials such as artificial spider silk. Scaling production is currently underway. Biobased alternatives include:

Biopolyester

1. PLA (Polylactic Acid)

PLA is produced from 100 percent renewable resources. While PLA is considered a biobased alternative to polyester, both the Federal Trade Commission in the United States and the EU Commission recognize that PLA fibers are a completely new generic class of fibers. Leading PLA polymer suppliers include NatureWorks LLC with their brand product Ingeo™.

Today, the biggest percentage of PLA on the market is produced from cornstarch. As PLA is produced from lactic acid by fermentation of natural sugars, other starch- or sugar-based crops such as rice, sugar beets, sugarcane, wheat, or sweet potatoes, could be used in the future. Shifting the focus from food-dependent crops, the industry is also exploring the use of next generation sources such as cellulosic-based feedstock (bagasse, straw, wood, and biomass).³⁴

Example of PLA feedstock and production process:

![Biopolyester Process Diagram](image)

**Process Description**

After harvesting, the starch is separated from the other plant components and converted into dextrose (glucose). The dextrose is fermented into lactic acid, which is then dehydrated to produce lactide. The lactide is then polymerized using one of two methods, with the Ring Opening Process being the favored option today. The polymer is then extruded into polylactide chip. The chips are shipped to the manufacturer for fiber production or plastic molding.

2. Biobased PTT (Poly Trimethylene Teraphthalate)

Partially biobased PTT is commonly assigned to the polyester family; however its strict generic class in the United States, awarded by the Federal Trade Commission, is Triexta (a generic class in Europe is currently pending).³⁵ PTT is made up of two monomer units, 1,3-propanediol and purified terephthalic acid (PTA). A partially biobased polymer is possible where the 1,3-propanediol is derived
from annually renewable plant-based resources (Bio-PDO). In the case of DuPont™ Sorona®, the polymer is made up of 37 percent annually renewable plant-based resources by weight.\(^{36}\)

Example of Biobased PTT feedstock and production process:

![Biobased PTT process diagram]

**Process Description**

Utilizing two raw materials, a sugar produced through photosynthesis and a petroleum-based oil, makes partially biobased PTT. The end polymer is extruded via a melt spinning process. DuPont™ uses a proprietary polycondensation polymerization process in the production of Sorona®.\(^{37}\)

### 3. Biobased PET (Polyethylene Terephthalate)

Partially biobased PET is commercially available today, produced using biobased ethylene glycol. Ethylene glycol and terephthalic acid are monomers used in the synthesis of PET.

Toray's Ecodear®PET is a partially biobased polyester fiber containing approximately 30 percent biobased synthetic polymer content. Toray has also produced laboratory-scale samples of fully renewable biobased PET. The success of this trial was proof that PET can be industrially produced from fully renewable biomass feedstock alone. Far Eastern New Century (FENC) worked with Virent to convert Virent's BioFormPX® paraxylene to terephthalic acid and then biopolyester, and produce the first 100 percent biopolyester fabric and shirt.

Example of biobased PET feedstock and production process:

![Biobased PET process diagram]
Biobased Polyamides (Nylon)

Castor oil, from the seeds of the castor plant Ricinus Communis L. (Eurphorbiaceae Family), is the major raw material used in the production of biobased polyamides (nylons). Castor oil is characterized by the high percentage of ricinoleic acid, almost 85 percent, a unique aliphatic acid that is not found in the oil of other plants.

Sebacic acid and undecenoic acid are the primary components of castor oil used in the production of biobased polyamides. Research and development activities are expected to expand the application area of biobased polyamides, which are likely to become an important opportunity for textiles over the coming years. 38

Biobased DA10 and DC10 are used in the production of PA6,10, PA10,10 and PA10,12. Fulgar’s EVO® PA10,10 is 100 percent biobased, as is Arkema’s PA11, branded as Rilsan®.

1. Biobased Polyamide 11 (PA11)

PA11 is produced from castor oil, by Arkema, under the trade name Rilsan®. It is produced by polymerization of 11-aminoundecanoic acid. From the castor oil, Amino 11 monomer is synthesized by the amination of undecenoic acid, this is dehydrated, then polymerized and extruded into polyamide 11 pellets. As with other nylon polymers these pellets can be turned into fibers or molded components through standard processes. Similarly to other thermoplastic polymers, additives can be compounded into the material during processing to modify its properties as required. 39

2. Biobased Polyamide 10,10 (PA10,10)

PA10,10 is also a polyamide and bioplastic, and a member of the nylon family of biobased polymers. It is a long-chain AABB type polyamide, made from castor oil. It is produced by the polymerization of sebacic acid and decamethylene diamine.

Example of Biobased PA 10,10 feedstock and production process:
Process Description

The castor oil is purified to produce Ricinoleic Acid, a key intermediate, which through a process of pyrolysis can be synthesized into Sebacic Acid (the diacid) and with a further specific amination of this; Decamethylene Diamine (the diamine) is produced. The polymerization of these two components, followed by extrusion, produces PA10,10 pellets suitable for injection molding, industrial filaments and other typical applications of thermoplastic polymers. Through a process developed in the Fulgar Labs, it is possible to generate a final fiber suitable for the nylon textile filaments market.40

Other Biobased Fibers

Synthetic Spider Silk

Spider silk is made of proteins that are stored as a water-based solution in a spider’s silk glands, before being spun into a fiber. Because of its strength, resilience, and flexibility, spider silk holds great promise for commercial and consumer applications. However, spiders are cannibals, making it impossible to farm them like silkworms.42

Several companies have been working to commercialize spider silk fiber synthetically, using techniques based on genetic engineering. Research is being carried out at institutions such as the Swedish University of Agricultural Sciences in Uppsala, the Karolinska Institute in Stockholm, and the University of Cambridge in the UK.

Commercial technologies are being developed by companies such as Spiber Inc. in Japan, the German company, AMSilk, with their biosteel® product, Bolt Threads, and Kraig Biocraft in the United States.

Further Biobased Developments

Research, development, and investment are also going into finding biobased alternatives to other products used within the textile and apparel industry. While beyond the scope of this document, it is worth mentioning the work going into biobased alternatives for synthetic leathers (polyurethane), wetsuits (neoprene), textile coatings and finishings, alongside work on biobased synthetic fibers.

- Neoprene-free wetsuits made from biobased materials
- Biobased alternative coatings and finishings for textiles
- Biobased alternatives to synthetic leather
Biosynthetics utilize renewable resources, and have the potential to mitigate climate change (through the use of CO\textsubscript{2} during the growing phase) when compared to petro-based fibers. Many biosynthetics are chemically identical to their fossil fuel counterparts and can be processed on the same equipment.

The ultimate goal is to collect and collate metrics and life cycle data for biosynthetics to the same level as that of other preferred fibers. Quantifying the sustainability impacts will help demonstrate the benefits of using biosynthetics within a preferred fiber portfolio.

There is already a developing portfolio of Life Cycle Assessment (LCA) data on which to base the sustainability impacts of biosynthetics. However, as an emerging fiber, these metrics are currently inconsistent in terms of: depth of work studied, framework of LCA boundaries and methodology, use of open sourced data, and breadth of data to represent variations in global regions and supply bases. Furthermore, the lack of standardized LCA benchmarking for virgin synthetics makes it challenging to compare and draw conclusions on the sustainability of biosynthetics.

Biobased solutions are a way for us to reduce our collective impact while also improving technical attributes to drive very high performing textiles. We are exploring biobased polymers and materials in our strategy to reduce impacts and lower our reliance on petroleum based raw materials, in addition to increasing responsible natural fibers (hemp, cotton, cellulosics, and wool) and recycling innovations (regenerated cellulose and closed loop synthetic recycling). Solutions we are researching include biobased textile chemistry with our Tin Shed Ventures partner Beyond Surface Technologies, and biobased equivalents of virgin polymers.

Claudia Richardson, Materials Innovation Manager, Patagonia

4 Sustainability Status

4.1 Potential Benefits

The benefits to industry and society of a shift to biobased materials could be significant. Biosynthetic fibers have the potential to produce fewer greenhouse gases over their lifecycle than products made from fossil fuels. A key advantage of renewable feedstock is their short reproduction cycle, which ranges between several days for algae and several years for trees, compared to the much longer reproduction cycle of fossil feedstock.

The ownership of the biorefining facilities and the scale of these facilities are significant issues for rural communities that are looking to biobased production as a foundation for new and sustainable economic development. However, decent work, human rights, and land rights issues must be assessed to ensure positive outcomes are achieved for farmers, foresters, and their communities. The region of origin will be an important aspect in terms of risk assessment.
4.2 Common Concerns

Alongside the potential benefits associated with biosynthetic fibers, there are a number of concerns that require further discussion and, indeed, may influence decision-making within a company. Four of the most commonly raised concerns are discussed here.

**Feedstock Source**

While biobased products can be a great alternative to fossil fuel-based materials when considering resource scarcity and climate change, deriving feedstocks from input-intensive agriculture can negatively impact ecosystems and human health.

Biobased materials currently need land to be grown and can be competing with land required for food production, or require new land to be transformed into agriculture. Whether a biobased product is a better choice or not will depend upon the type of feedstock, country of production, and agricultural techniques, among other considerations.

The potential impacts of growing crops (for biobased products) using conventional chemical-based agriculture include:

- Loss of biodiversity associated with monoculture.
- Greenhouse gas emissions associated with the use of fertilizers (nitrous oxide is a greenhouse gas 298 times stronger than CO₂).
- Toxicity associated with the use of pesticides, which can impact human health and the environment.
- Overuse of water through inefficient irrigation practices.
- The use of fossil fuels to grow, transport, and process the biobased products.
- Genetically Modified Organisms (GMOs) are discussed separately.

See the Quick Guide to Organic Cotton for information on the benefits of organic agriculture.

It is also important to remember that there are big differences in terms of impact between crop-based- and waste-based feedstocks. Crop-based corresponds generally to commodity crops such as corn or sugar cane. Biomass or waste-based feedstocks utilize agricultural residues and organic waste. Feedstocks from waste, while not yet as developed for textiles, will most likely be more environmentally preferred and more efficient, as they generally don’t require new production of crops and they reutilize residues that would otherwise end up discarded.
Use of GMOs

Discussions and debate continue over the use of genetically modified organisms (GMOs) in crop production where the feedstock is often cornstarch. **The use of GM crops is not a technical requirement for the production of any biobased material** that is commercially available today, although dominating corn production in many countries, such as the United States. If GM crops are used, the reasons usually lie in the regional feedstock supply situation.

GMO use in third-generation feedstocks (i.e. in the laboratory rather than on the farm) carry a different set of concerns, which should also be considered. The industry is split with regards to the use/non-use of GMOs. There are very strong views each way. This was touched on in Textile Exchange’s previous Biosynthetics work and needs to be addressed as a much larger topic moving forward.

End-Of-Life

Recycling and disposal of biosynthetic products could be a potential problem for certain biomaterials, especially impacts on the current recycling and disposal infrastructure. For example, while biobased PET can be recycled in existing PET recycling infrastructure, bottles made with polylactic acid (PLA) can contaminate the recycling of polyethylene terephthalate (PET) bottles. Most recycling technologies are unable to distinguish between the two types of plastic. **Many recyclers therefore oppose the use of PLA until the recycling technology is capable of separating out products made with PLA.**

End-Of-Life concerns need to be addressed so that the benefits of biopolymers are maximized without impeding their commercial viability. This will likely require a combination of policy incentives and regulations, private-public engagement and support, and market development that supports economic, environmental, and social objectives.

Biodegradability and Compost-ability

Stemming from the packaging industry where biodegradability is of primary importance, **there is a misconception that all biopolymers are automatically biodegradable. This is not the case.**

Important aspects on biopolymer recycling, biodegradability, and compost-ability:

- Not all biopolymers degrade safely, with some actually off-gassing detrimentally if not treated appropriately.
- Not all geographical regions around the world have industrial compost facilities to safely and efficiently process biopolymers through a biodegradable route.
- In general, clothing products are not developed out of one material or another (they are blended together) so composting is only an option once materials have been separated.
- Unless the product being composted can return nutrients to the soil, the higher value option would be to recycle or upcycle products at the end of their intended lifetime.
5. Standards and Certification

In recent years, there has been a concentration of new certifications developed for the biobased industry, but these have been mainly to support packaging and pharmaceutical businesses. There is currently a market opportunity to assess the market readiness for textile-specific certification. In this section, we look at some of the standards/labeling schemes available for communicating biobased content, feedstock sustainability, and chain of custody.

5.1 Biobased Content

Certification of biobased content refers to biobased carbon or biomass and can be applied to base, intermediary and finished products. Content standards include the BioPreferred Program operating in the US and the Biobased Content Scheme in use in Europe.

BioPreferred Program

The United States Department of Agriculture (USDA) has developed the BioPreferred program and certification scheme, including a product category for “fibers and fabrics.” The USDA remains the focal organization for globally recognized biobased content certification.

Through the Voluntary Labeling Initiative, companies may apply for certification to display the USDA Certified Biobased Product label on a product that states its third-party tested and verified biobased content. The USDA has established minimum biobased content standards for many product categories. A product must meet or exceed the minimum biobased content percentage in its given category in order to qualify for certification.

Biobased Content Scheme

The European Biobased Content Certification Scheme is used to specify and validate the amount of biomass in a biobased product, based on the European standard EN 16785-1:2015. This standard provides a method of determining the biobased content of solid, liquid and gaseous products using the radiocarbon analysis and elemental analyses.

Organizations can use the Biobased Content Certification Scheme to demonstrate the (minimum share of) biobased content in their products and label them with this claim. The Scheme describes the rules for certification including the tasks and responsibilities of the applicant, testing laboratory and certification body as well as the rules for the use of the biobased content label and logo. DIN CERTCO, Germany and TÜV Austria Belgium are accredited to provide certification.
5.2. Feedstock Sustainability

To be sustainable, a non-fossil feedstock base (biobased content) is not enough. Other aspects, such as agricultural practices, environmental and social issues, have to be considered to ensure that a product is contributing to greater sustainability outcomes across its lifecycle.53

Feedstock sustainability standards should be third party and multi-stakeholder approved, with regular audits carried out by accredited certification bodies.54 Examples of feedstock sustainability standards and initiatives that could be suitable for our industry include the following:

**Roundtable on Sustainable Biomaterials**

The Roundtable on Sustainable Biomaterials (RSB) is a global, multi-stakeholder independent organisation that drives the development of a new world bioeconomy through sustainability solutions, certification, innovation and collaborative partnerships.56

**International Sustainability and Carbon Certification (ISCC) for Biobased Products and ISCC+**

ISCC is a globally leading certification system covering the entire supply chain and all kinds of feedstocks and renewables.57

**Organic Feedstocks**

Organic feedstocks must be grown and certified to a standard approved in the IFOAM Family of Standards. The IFOAM Family of Standards allows multilateral equivalence between organic standards and technical regulations.58

**BonSucro Sugar Initiative**

BonSucro provides both a production and a chain of custody standard. The Production Standard helps farmers and mills to measure their productivity and key environmental and social impacts.59

**Forest Stewardship Council (FSC)**

FSC forest management certification confirms that the forest is being managed in a way that is more sustainable. There is both a forest level, and a chain of custody, standard.60
5.3. Integrity

Supply chain integrity, and the corresponding product integrity, is the linchpin of sustainability in the textile industry. Certification to a Chain of Custody standard is one of the strongest ways to ensure that product claims are accurate and able to be verified.

Chain of Custody

Biobased feedstocks produced to a sustainability standard can be traced through the supply chain using a chain of custody standard such as Textile Exchange’s Content Claim Standard (CCS).61

There is more work to be done on developing an integrity program and best practices for bioderived materials in biosynthetic textiles. The development of tools and standards will be driven by the demand and appetite of the industry for biosynthetics alongside growth in the market. European retailer, H&M, discussed the importance of traceability and integrity in biosynthetics at the 2017 Textile Exchange conference in Washington D.C.

“It’s important to have a traceability system in place so that, when we claim something as a biosynthetic, we know exactly what feedstock was used, where it came from, and the way in which it was sourced.”

Mattias Bodin, Sustainability Business Expert, Materials & Innovation, H&M
6. Conclusion

Of growing interest is the opportunity to design a new strategy for the development of biopolymers, and other synthetics. This growing interest is due to industry and consumer interest in more sustainable products, concern for the emissions of greenhouse gasses associated with fossil-based products, need to limit future fossil fuel use to achieve targets to limit global warming, and opportunity to mitigate the potential rise of petrochemical prices as oil prices increase.

In the rapidly developing biosynthetics field it is essential to balance the natural enthusiasm of those who advocate the wholesale adoption of these new materials with the precautionary principle, which reminds us to think about the unintended consequences of our progress.

Competition for land and crops, which would otherwise feed the population, is the most obvious danger, and there is more work to do to fully understand which approach to feedstock is the more sustainable.

Textile Exchange will continue to monitor developments and keep its analysis up to date, consulting with a wide range of stakeholders to ensure accuracy and balance.
Notes & References


2. Bioplastics https://4bioplastics.wordpress.com/the-history/

3. Note the difference between biorenewable and biodegradable: Biorenewable means the product is derived from natural renewable sources, and not necessarily biodegradable. Biodegradable materials are designed to biodegrade in specific environments.


12. A note on reserves: The number of 50 years of oil and gas remaining is based on proven reserves, which means oil and gas reserves that can be produced economically with today's technologies at today's prices. It prices and/or technology changes in the future then this figure changes.


16. Bioeconomy Report 2016, JRC http://publications.jrc.ec.europa.eu/repository/bitstream/JRC103138/192866/3en.pdf. The bioeconomy in the EU-28 employed around 18.6 million people in 2014, constituting about 8.5% of the jobs in all economic sectors. The agricultural sector (9.6 million jobs) and the manufacture of food, beverages and tobacco (4.5 million jobs) together provide three quarters of the total employment in the European bioeconomy. The other sectors of the bioeconomy [food and forest-based, blue bioeconomy, bioenergy, bio-based industry] contribute less than 9% each to the total number of people employed in the bioeconomy.

17. Published in the International review of Bioeconomy Strategies with a focus on waste resources by the Institute for European Environmental Policy.

18. At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C.


24. ICUN - Building a true & sustainable biobased economy.

25. ResearchGate: Sustainable development potentials and pathways for biobased economy options: an integrated approach on land use, energy system and economy and environment.


27. Statista, Global chemical fiber production from 2000 to 2016


31. Recycled Polyethylene Terephthalate (PET) Market Analysis By Product Type, By End-use, And Segment Forecasts, 2014 – 2025.


34. Textile Exchange Materials Summary: Polylactic Acid (PLA).

35. Textile Exchange Materials Summary: Partially Biobased PTT (Poly Trimethylene Terephthalate)
36. Information supplied by DuPont™

37. Textile Exchange Materials Summary: Partially Biobased PTT (Poly Trimethylene Terephthalate)


40. Information provided by Fulgar.


42. Fung Global Retail & Tech https://www.fungglobalretailtech.com/research/innovations-fabric-materials/ 

43. Ibid.


48. Sustainable Brands: Sustainability Mythbusters: Are Biobased Products Always Preferable to Oil-Based? 


52. Biobased Content Scheme http://www.biobasedcontent.eu/ 


55. Note more work needs to be done in this area, and the list below is not complete nor meant to represent a “preferred selection of standards and initiatives.


57. ISCC http://www.iscc-system.org/process/certification-scope/iscc-for-feed/iscc-for-biobased-products/ 


60. FSC https://www.fsc.org/ 


62. Recent developments and future prospects on biobased polyesters derived from renewable resources: A review.
## Appendix 1: The Supply Landscape

### Biobased POLYESTER (bPET, PLA, bPTT)

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Product</th>
<th>Category</th>
<th>Product Type</th>
<th>Feedstock</th>
<th>Bio Content Share</th>
<th>Production Locations</th>
<th>Volume (MT)</th>
<th>Expected Growth</th>
<th>LCA</th>
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<tbody>
<tr>
<td>Anellotech</td>
<td>bParaxylene</td>
<td>chemical</td>
<td>biomass/waste</td>
<td>N/A</td>
<td>USA</td>
<td>no data</td>
<td>no data</td>
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<tr>
<td>DuPont</td>
<td>Sorona®</td>
<td>bPTT</td>
<td>polymers</td>
<td>plant sugars</td>
<td>30% (piloting 100%)</td>
<td>China, Taiwan</td>
<td>500</td>
<td>↑</td>
<td>✓</td>
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<tr>
<td>Far Eastern</td>
<td>TopGreen®</td>
<td>bPET</td>
<td>chips to garment</td>
<td>plant sugars</td>
<td>30%</td>
<td>China, Taiwan</td>
<td>3,600</td>
<td>↑</td>
<td>✓</td>
</tr>
<tr>
<td>Far Eastern</td>
<td>bPTT</td>
<td>filament</td>
<td>plant sugars</td>
<td>− 30%</td>
<td>China, Taiwan</td>
<td>450</td>
<td>↑</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Far Eastern</td>
<td>Ingeo®</td>
<td>PLA</td>
<td>staple fiber</td>
<td>plant sugars</td>
<td>100%</td>
<td>Taiwan</td>
<td>725</td>
<td>↑</td>
<td>✓</td>
</tr>
<tr>
<td>Indorama</td>
<td>bPET</td>
<td>PLA</td>
<td>plant sugars</td>
<td>30%</td>
<td>Thailand</td>
<td>no data</td>
<td>no data</td>
<td>in dev’t</td>
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</tr>
<tr>
<td>NatureWorks</td>
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<td>PLA</td>
<td>polymers</td>
<td>plant sugars</td>
<td>100%</td>
<td>USA</td>
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<td>staple fiber</td>
<td>plant sugars</td>
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<td>USA</td>
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<td>✓</td>
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<td>PLA</td>
<td>PLA</td>
<td>yarn</td>
<td>plant sugars</td>
<td>100%</td>
<td>Switzerland</td>
<td>5,000</td>
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<tr>
<td>Toray</td>
<td>ECODEAR® PET</td>
<td>bPET</td>
<td>resin, filament,</td>
<td>plant sugars</td>
<td>30%</td>
<td>China, Indonesia,</td>
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<td>ECODEAR® PLA</td>
<td>PLA</td>
<td>filament</td>
<td>plant sugars</td>
<td>100%</td>
<td>Japan</td>
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<td>no data</td>
<td></td>
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<tr>
<td>Toray</td>
<td>ECODEAR® PTT</td>
<td>bPTT</td>
<td>fabric</td>
<td>plant sugars</td>
<td>− 30%</td>
<td>Czech Republic, Japan, Malaysia</td>
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<td>no data</td>
<td>✓</td>
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<tr>
<td>Virent</td>
<td>BioFormPX®</td>
<td>bParaxylene</td>
<td>chemical</td>
<td>plant sugars</td>
<td>N/A</td>
<td>USA</td>
<td>no data</td>
<td>not yet commercial</td>
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### Biobased POLYAMIDE (bPA)

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<tr>
<th>Supplier</th>
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<th>Product Type</th>
<th>Feedstock</th>
<th>Bio Content Share</th>
<th>Production Locations</th>
<th>Volume (MT)</th>
<th>Expected Growth</th>
<th>LCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fulgar</td>
<td>Evo®</td>
<td>bPA.10.10</td>
<td>filament</td>
<td>castor bean</td>
<td>100%</td>
<td>Italy</td>
<td>no data</td>
<td>↑</td>
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</tr>
<tr>
<td>RadiciGroup</td>
<td>Radion</td>
<td>bPA.6.10</td>
<td>yarn</td>
<td>castor bean</td>
<td>64%</td>
<td>Italy</td>
<td>10,000</td>
<td>↑</td>
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<td>Biofeel</td>
<td>bPA.5.10</td>
<td>yarn</td>
<td>castor bean</td>
<td>100%</td>
<td>Italy</td>
<td>5,000</td>
<td>↑</td>
<td>✓</td>
</tr>
<tr>
<td>RadiciGroup</td>
<td>Dorix 6.10</td>
<td>bPA.6.10</td>
<td>staple fibre</td>
<td>castor bean</td>
<td>64%</td>
<td>Italy</td>
<td>6,000</td>
<td>↑</td>
<td>✓</td>
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<tr>
<td>Toray</td>
<td>ECODEAR® PA 6.10</td>
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<td>filament</td>
<td>castor bean</td>
<td>no data</td>
<td>Japan</td>
<td>no data</td>
<td>no data</td>
<td></td>
</tr>
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Appendix 2: Further Resources

**Biobased Content (EU)**
The “Biobased Content Certification Scheme” is the European certification scheme that enables independent assessment of claims about the biobased content of products based on the European standard EN 16785-1.

Website: [http://www.biobasedcontent.eu/](http://www.biobasedcontent.eu/)

**Bioplastic Feedstock Alliance (BFA)**
The BFA seeks to help guide the responsible selection of feedstocks for biobased plastics in order to encourage a more sustainable flow of materials, helping to create lasting value for present and future generations.

Website: [http://bioplasticfeedstockalliance.org/](http://bioplasticfeedstockalliance.org/)

**BioPreferred Program (United States)**
Managed by the United States Department of Agriculture (USDA), the goal of the BioPreferred program is to increase the purchase and use of biobased products.

Website: [https://www.biopreferred.gov/BioPreferred/faces/Welcome.xhtml](https://www.biopreferred.gov/BioPreferred/faces/Welcome.xhtml)

**European Bioplastics**
European Bioplastics serves as both knowledge partner and business network for companies, experts, and all relevant stakeholder groups of the bioplastics industry.

Website: [http://www.european-bioplastics.org/](http://www.european-bioplastics.org/)

**Roundtable on Sustainable Biomaterials (RSB)**
A global, multi-stakeholder independent organization that drives the development of a new world bioeconomy through sustainability solutions, certification, and collaborative partnerships.

Website: [http://rsb.org/](http://rsb.org/)

**Sustainable Biomaterials Collaborative (SBC)**
The Sustainable Biomaterials Collaborative is dedicated to spurring the introduction and use of biobased products that are sustainable from cradle to cradle.

Website: [http://sustainablebiomaterials.org/](http://sustainablebiomaterials.org/)

**Textile Exchange**
Biosynthetics microsite: [https://aboutbiosynthetics.org/](https://aboutbiosynthetics.org/)
Material Snapshots & Summary series [http://textileexchange.org/publications/#material-snapshots](http://textileexchange.org/publications/#material-snapshots)
## Acknowledgements

Textile Exchange would like to thank Sophie Mather of biov8tion, Textile Exchange’s Biosynthetics Working Group, and all those who contributed to the development of the biosynthetics microsite and the contents of this Quick Guide, including:

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<td>biov8tion</td>
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About Textile Exchange

Founded as Organic Exchange in 2002, Textile Exchange expanded from a focus solely on organic cotton in 2010 to include other preferred (sustainable) fibers such as lyocell and recycled polyester to promote a portfolio approach for brands and retailers to adopt at a strategic level. While the organization name changed to reflect the expanded remit, Textile Exchange continues to have a strong focus on expanding the use of organic fibers as a market-driven solution to address poverty, biodiversity and food security.

Textile Exchange is a global non-profit organization that works closely with our members to drive industry transformation in preferred fibers, integrity and standards, and responsible supply networks. We identify and share best practices regarding farming, materials, processing, traceability, and product end-of-life in order to create positive impacts on water, soil, air, animals, and the human population created around the world by the textile industry.

Textile Exchange has also developed several important industry standards, including the Organic Content Standard, the Responsible Down Standard, the Responsible Wool Standard, the Recycled Claim Standard, and the Global Recycled Standard.

A truly global organization, Textile Exchange is headquartered in the U.S. with Staff and Ambassadors located around the world. To learn more about Textile Exchange, visit: www.TextileExchange.org and follow us on Twitter at @TextileExchange.