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Plant-based footwear

We are all familiar with sweetcorn or corn on the cob and many of us enjoy eating it boiled and coated in butter. Americans in particular are especially fond of it although less than 1% of all the corn grown annually in the USA is for human consumption. The remaining 99% is industrial corn or maize which is used for animal feed and for processing into a variety of other products. Among these is Bio-PDO or, to give it its commercial name, Susterra propanediol produced by DuPont Tate & Lyle Bio Products, which is used as a basis for a number of environmentally friendly materials, increasingly used in footwear manufacture.

The variety of corn involved is known as yellow dent and has a high starch content. After harvesting and drying, it is transported to Tate & Lyle's wet mill at Loudon, Tennessee. Using a wet milling process, the corn is separated into its four basic components: starch, germ, fibre and protein. The nutrient rich components are used for animal feed while glucose is derived from the remaining starch fraction and is the raw material used for making 1,3-propanediol. The process starts off with

a culture of a special microorganism in a small flask with the glucose. As it grows, it is transferred to a seed fermenter, followed by a ten-story high production fermenter. Fermentation takes place under exact temperature conditions and involves a patented process where the microorganism functions as a biocatalyst, converting glucose into bio-based 1,3-propanediol.

The resulting product is filtered to remove deactivated microorganisms, unfermented glucose and excess water. After separation, it is then passed through a bed of charged resin that attracts and removes any residual salts. The product is then steam distilled to a highly-purified state, removing any trace impurities. The resulting material, highly purified bio-based 1,3-propanediol, is checked against product specifications before being shipped for use in a variety of high-performance applications. This includes customers such as DuPont which makes Sorona fibres, personal care and cosmetic customers who make skin-friendly humectants and industrial customers who use Bio-PDO as the building block for a variety of high performance bio-based polyurethanes.

STRONG POINTS

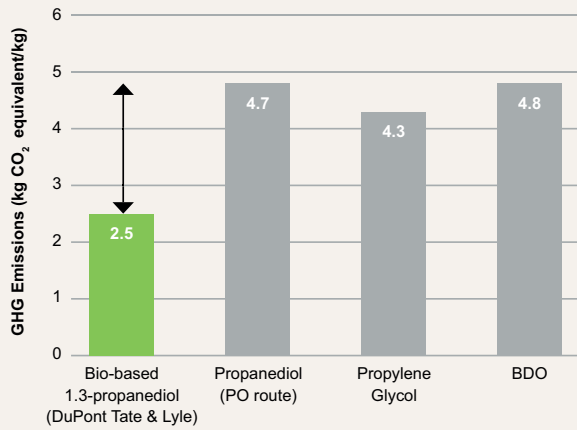
The company says that what is so good about it as a building block is that it is not only plant-based but is also sustainably produced. It has published a cradle to gate life cycle analysis (*Tables 1 and 2*) showing that it produces 47% less greenhouse gas emissions and consumes 49% less renewable energy than petroleum-based 1,3-propanediol. Compared with propylene glycol (PG), the reductions are 42% and 41%, and compared to butanediol (BDO), 48% and 46% respectively. At full capacity (scheduled for mid-2019) the process will achieve a greenhouse gas emission reduction equivalent to taking 40,000 passenger cars off the road for one year. As regards non-renewable energy it will save enough energy to power one million 100W incandescent lightbulbs for one year.

As Susterra propanediol is a building block for bio-based polyurethane chemistry, any footwear material or component that is currently made using polyurethane-based on traditional petroleum routes can now be bio-based. This includes microfibrils and other synthetic upper materials, outsoles, insoles and waterproof

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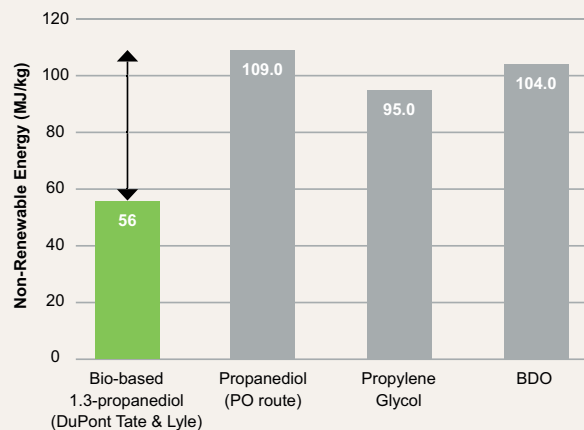


Table 1: Greenhouse gas emissions.



Greenhouse Gas Emissions
 47% less than Propanediol
 42% less than Propylene Glycol
 48% less than BDO

Table 2: Non-renewable energy use.



Non-Renewable Energy Use
 49% less than Propanediol
 41% less than Propylene Glycol
 46% less than BDO

CREDIT: DUPONT TATE & LYLE BIO PRODUCTS

breathable membranes. DuPont is not only the parent company of DuPont Tate & Lyle Bio Products but, as mentioned, is also a customer which uses Susterra propanediol as the basis for its Sorona fibre. This is a bio-based PTT (polytrimethylene terephthalate) that is made from 37% Bio-TPU. It has a very soft hand, very good elasticity and at the same time is very long-lasting.

Susterra has been very much a story about performance and solving problems for different parts of a shoe. Paired with the right chemistry, DuPont says it can perform as well as—or better than—traditional TPUs based on those performance requirements, “Due to its unique molecular structure and low glass transition temperature, it provides increased flexibility in outsoles even at low temperatures.” For the same reasons, it can also enhance abrasion resistance and soften the hand of microfibres and other synthetic upper materials. The Lalo Tactical boot developed for use by US Navy Seals is a good example of a high-performance outsole that has been developed in conjunction with DuPont to exploit the added flexibility Susterra provides to cope with adverse conditions as varied as the wet deck of a ship or sand on a beach. It also helps to reduce the overall weight of the boot and lessen physical fatigue.

would have us believe. A recent report by the United Nations suggests that we may have only some 12 years left to cut CO₂ emissions by around 45%. If we do not, ice caps will shrink leading to rising sea levels and increased flooding. There will also be severe heat waves on a regular basis. Indeed, it may prove impossible to get climate change back under control and, if this happens as some predict, global temperatures could rise by as much as 5% by the end

of the century, leading to mass migrations to the northern hemisphere as other parts of the planet become increasingly uninhabitable.

It is also estimated that we produced somewhere between 21 and 22 million pairs of footwear in 2018. Most of these were made from petrochemical-based materials where the manufacturing processes create large amounts of carbon dioxide which contributes to the already serious effects of climate

The Lalo Tactical boot uses Susterra to add flexibility and save weight.
 CREDIT: LALO FOOTWEAR



HELPING THE ENVIRONMENT

Warnings of the dire implications of global warming are on the increase despite what certain world leaders

TABLE 3 – PRIMUS LIGHT BIO COMPOSITION AND BIO CONTENT

Upper	
100% Sorona fibre bio mesh knit	37%
50% Sorona fibre bio single mesh	19%
30% Susterra Bio-PDO TPU	30%
50% Sorona fibre bio webbing + Lace	19%
Lining	
50% Sorona fibre bio non-woven	19%
100% Bloom algae EVA	30%
Insole	
100% Bloom algae EVA	30%
50% Sorona fibre bio single mesh	19%
Outsole	
70% Susterra Bio-PDO TPU	70%
Branding	
70% Susterra Bio-PDO TPU	70%

change. The fact that the use of leather as an upper material is declining quite rapidly, is only making the situation worse as far as the footwear industry is concerned. While many prefer to turn a blind eye and say its adverse impact is small compared to many other industries, a few visionaries have viewed things differently.

One of these is UK brand Vivobarefoot that not only produces shoes that the company claims ‘will allow the feet to move like feet’ but also uses plant-sourced materials to the greatest extent possible in its new BIO range available from March this year in order to minimise environmental impact. Part of its quest to make earth positive shoes has been to look at

alternative materials. These bio-based shoes, first launched at outdoor retailer in Denver last autumn, are currently 40-50% made from plant based materials and it says that every 50,000 pairs is equal to saving greenhouse gas emissions from 247,948 miles driven by an average passenger vehicle or reducing CO₂ emissions from 11,286 gallons of gasoline consumed.

Susterra-based materials feature prominently in the equation as an analysis of its Primus Light Bio model clearly shows (Table 3). This analysis demonstrates how far the use of plant-based material can extend in a sneaker/athleisure shoe. The inclusion of Bloom EVA is also significant as this is derived from toxic algae harvested

from lakes in China and used to produce a sustainable natural additive to EVA (ethylene vinyl acetate) to improve its performance while at the same time removing an environmental menace (see *World Footwear* September/October 2017). The very fact that shoes of this type will be mainly worn by Millennials makes the use of such materials not only positive in an environmental sense but also sensible commercially as it is this group of consumers that is most sensitive to environmental issues. They are often also increasingly concerned about animal welfare issues and possibly sympathetic to veganism, so Susterra-based materials would cover this aspect too.

SPORTS SHOE BRANDS

Some major sports shoe brands are also taking steps down this road. Reebok has launched its first shoe under the Cotton + Corn sustainable products initiative that it announced in 2017 with the aim of producing footwear from ‘things that grow’ rather than from non-renewables such as those derived from hydrocarbons. Named NPC after the Newport Classic, an iconic 1980s Reebok product, it has an upper constructed entirely from cotton and a sole made from TPU (thermoplastic polyurethane) that incorporates Susterra propanediol. In addition, the insole uses material derived from castor oil and packaging is 100% recycled.

Bill McInnis, head of Reebok Future says that with some 20 million plus pairs of shoes being produced per year and athletic footwear made using petroleum to create synthetic rubber and foam cushioning systems, the



Vivobarefoot's Primus Lite Bio shoe.
CREDIT: VIVOBAREFOOT

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The upper on Anta's NASA co-branding shoe uses Sonora bico filament backing fibre. CREDIT: ANTA SPORTS

situation is no longer sustainable. Reebok says it also cares about what happens to its shoes when people are finished with them and claims that using plant-based raw materials such as corn and cotton allow for easier compostability. The ultimate goal is to create a broad selection of bio-based footwear that will be composted after use and the compost returned to the soil to help grow the materials for more shoes. Reebok says that the NPC UK Cotton + Corn is the only footwear product on the market with such a high proportion of its content—75% in total—certified by the US Department of Agriculture as bio-based.

Chinese brand Anta Sports has also entered the fray with its A-Flashfoam sneaker which uses Sorona instead of spandex. The yarn used is actually 80%

viscose and 20% Sorona bico fibre so the plant-based content is effectively 84%. When cellulose-based fibres such as viscose are combined with Sorona fibres, the result is an extremely soft fabric with greater resilience in stretch, recovery and dimensional stability. Whilst Spandex replacement is nothing new as far as Sorona fibres are concerned, this is the first time a footwear company has done so with a knitted footwear fabric. The shoe is said to be extremely comfortable to wear even without socks and to offer long-lasting stretch and recovery for maximum shape retention. In January, Anta launched its NASA co-branding shoe where the upper is made from a fabric that has 33% Sorona bico filament as a backing fibre with the other 67% being golden/silver PET fibre.

With leather losing ground as the upper material of choice and with more more new manufacturing technologies appearing, the opportunities for new footwear materials has never been greater. While oil-based materials—particularly for soling applications—are still the most widely used, there is growing interest in renewable plant-based technologies. Cork has been used for centuries but more recent developments include Tencel (viscose), Pinatex (pineapple leaf fibre) bamboo, rice husks, etc. These all have limitations as to what part of the shoe can be produced from them. Susterra's strength lies in the diversity of its potential footwear applications as demonstrated by Vivobarefoot's/bio-based products. 🌱



Reebok's Cotton + Corn shoe has a TPU sole containing Susterra propanediol.

CREDIT: REEBOK