MATERIAL INNOVATION INITIATIVE

September 2020

TECHNOLOGY ASSESSMENT: MYCELIUM LEATHER

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EXECUTIVE SUMMARY

MII is optimistic about research and investment in mycelium-based alternative leather materials. Although there are only 5 companies in the space and no company is producing at scale, MycoWorks has produced a material that tests similar to bovine leather. The technology is promising, offering significant sustainability advantages over animal leather and other next gen technologies.

Advantages

The biggest advantage to mycelium material is the low environmental cost. It is less environmentally harmful than bovine leather in almost every measure including animal welfare, biological waste, chemical use, water use, emissions, land use, resource depletion, and biodegradability. Mycelium is grown on agricultural waste and thus requires very little land use. Mycelium also produces its own coating during growth, meaning the end product can be 100% mycelium and thus biodegradable.

Another advantage is that this material takes the shape of the container in which it is grown. Thus, the material can be grown in the exact mold of the end product, including in 3D, thus reducing production steps such as cutting and sewing.

Challenges

Our biggest concerns are that (1) the industry is young and small, with five primary companies producing mycelium-based materials that could be replacements for leather and (2) the cultivation cycle requires 7-14 days in a temperature- and humidity controlled environment. Although the production time, inputs, and waste are significantly better than animal leather, the energy required to maintain temperature and humidity is higher than the energy requirements for many of the mechanically produced next gen leathers. This issue can be solved, however, by placing manufacturing facilities in climates with similar temperature and humidity as the necessary growth environment.

Areas Showing Promise

We were initially concerned about the durability of mycelium materials although recent tests of MycoWorks' Reishi product have demonstrated improved durability and show promise for the overall material competitiveness of mycelium alternative leather.

White Space Opportunities

By changing the species of fungi, changing the medium, adjusting the humidity, temperature, and/or concentration of carbon dioxide, companies and researchers can produce different characteristics. In a kingdom of at least one hundred thousand species, only a few dozen fungi species have been tested as candidates for mycelium-based materials. An extensive white space opportunity exists in process development for continuous or roll-to-roll growth of mycelium material. Additional processing innovation is also needed to tune the surface treatment.

MYCELIUM LEATHER TECHNOLOGY

Mycelium is a naturally occurring, polymeric composite material composed of chitin, cellulose, and proteins. Although mushrooms and other fungi are not plants, making an analogy to plant growth can help clarify the formation of mycelium. Mycelium is analogous to the roots of plants, while the mushroom itself is like a flower. Unlike plants, which need sunlight for photosynthesis, mushrooms and other fungi grow by breaking down plants and other organic matter, creating a dense, root-like network of mycelium in the process.

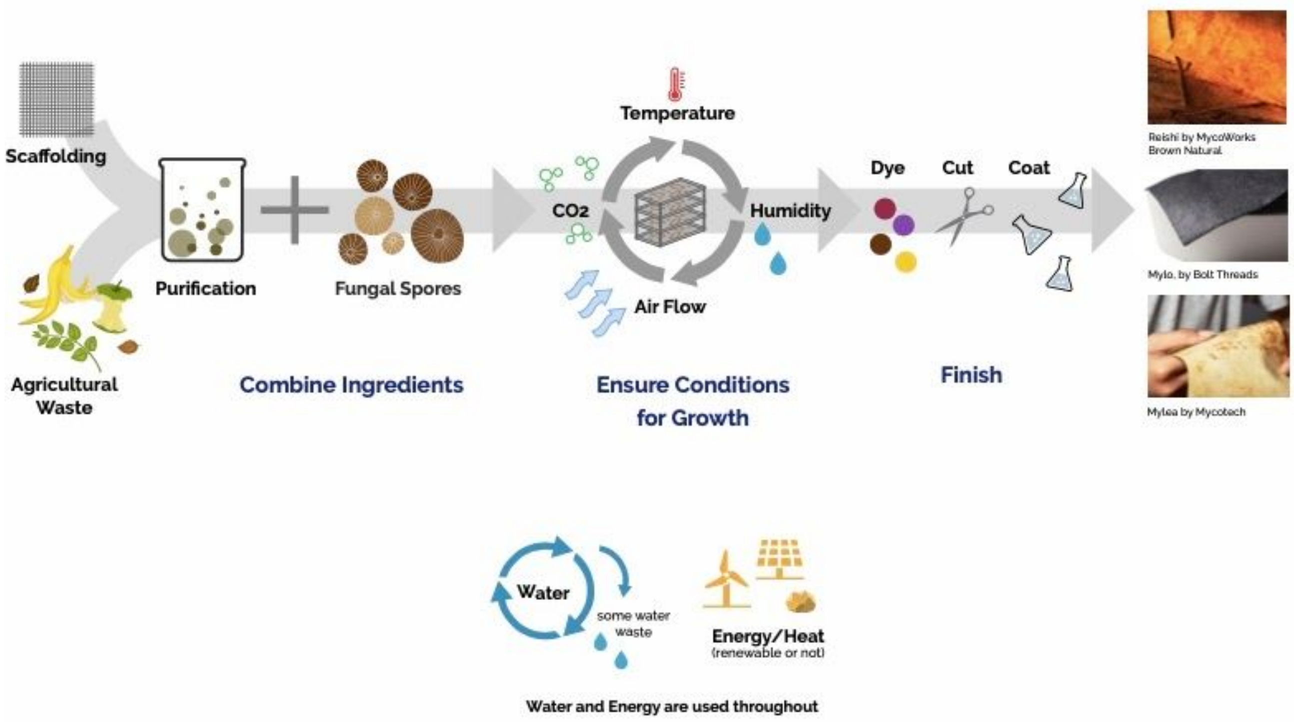
In controlled production facilities, chemical and physical processes can be used to restrict and specify the dimension, direction, and density of mycelial formation to achieve certain desirable properties. Most companies in this space use sterilized agricultural waste as the growth medium and a naturally derived textile such as cotton, hemp, or jute as a scaffold for strength. Mycelial leather production exploits the ability of mycelium to fuse its network with other substances to form a strongly bonded resulting material. Specific control of growth chamber conditions including temperature, CO_2, humidity, and air turbulence can be modified to affect growth. The final composite can then be pressed or textured, colored or tanned, and cut and shaped in a similar fashion to bovine leather.

Certain innate, biological characteristics of mycelium lend it aesthetic properties that mimic bovine leather. The proteins within mycelium form an outer 'skin' that behaves much like the skin formed via collagen in animal leathers. Additionally, the flexible cell walls of the mycelium lend suppleness and flexibility that are comparable to the malleability of leather. Other relevant properties such as surface homogeneity, abrasion resistance, and water repellency are largely influenced by the fungal species employed. The primary species currently used for alternative leather production are *Ganoderma lucidum* and *Schizophyllum commune*. Differences in media concentrations, scaffolding, and processing temperature also affect the characteristics of the end product.

Because mycelium grows relatively rapidly and does not require intensive processing methods, mycelium leather is a highly favorable alternative to conventional leather in terms of environmental impact.

The graphic below shows a simplified production process for mycelium composites. Various agricultural waste products can be used as the substrate and/or scaffolding. Spores of different species of fungi can be used as well. FInishing methods vary.

Mycelium Leather Production Process



SCORECARDS

Rating Definitions

On Par

5 Stars
No foreseeable risks. The technology and material have strong track records of success. Significant improvement over industry standards.

4 Stars
No foreseeable risks except product is not yet at scale. The technology and material show significant potential for improvement over industry standards in almost all areas.

3 Stars
One or two minor risk areas which are unlikely to hinder success. Some concerns over ability to improve industry standards in a few areas. These risk areas can be mitigated through additional funding or research.

2 Stars
At least one risk area with the potential to impact success. Stronger concerns over ability to improve industry standards in important areas. It is unclear whether this risk can be mitigated.

1 Star
Multiple risk areas which compromise success. Serious concerns over ability to improve industry standards in key areas. Significant concern that risk(s) can be mitigated.

Not Rated

Sensory/Tactile Summary

Mycelium-derived alternative leather has some sensory advantages over other alternative leather sources. Aesthetically, the drape and sheen of mycelium-derived alternative leathers are subjectively closer to bovine leather. The growth structure lends a 'grain' very similar to natural leather when colored. In some cases, natural tannins can be used to color mycelium leather, which yields natural variation much like that found in tanned bovine leather. Mycelium leather is often much more pliable than petroleum-based or plant-based leather alternatives and can be folded without scoring.

Vartest, a certified third-party textile testing laboratory, conducted an evaluation of three of MycoWorks' materials. (See test results in Appendix B.) One concern is that the mycelium skin can lack abrasion resistance, although all of the MycoWorks materials resisted the formation of holes for over 1300 cycles of STOLL abrasion testing at 1 LBS load, 4 PSI air. Additionally, the strength and elongation of mycelium leather can be significantly lower than bovine leather, making mycelium an unlikely choice for shoe uppers. MycoWorks tests show significant promise in this area, however. In tests up to 50,000 flexes on three different types, the material showed "no damage" most of the time, with some showing "discoloration or thin cracks in the top finish coat only." In testing up to 100,000 flexes on three different materials, 2 samples show "no damage" and one sample showed "cracks large enough to see leather substrate below."

As the technology is still developing and still fairly expensive, we have been unable to test enough samples to feel strongly about our recommendations. With additional samples of new developments, we will update the analysis and our comfort level with the technology.

Sensory/Tactile scorecard

	Notes	Grade
Pattern/Print	The hyphae structure lends a 'grain' very similar to natural leather when tanned. In some cases, natural tannins can be used to tan the skin of the mycelium leather, which yields natural variation much like that found in bovine tanned leather. One company showed us a sample with a very beautiful pattern which we thought was even better than leather.	4 ★
Stability	Recent tests by Vartest on MycoWorks Reishi material show significant promise in stability and abrasion resistance. We still have concerns over other companies' material stability and abrasion resistance although MycoWorks has proved	3 ★

	mycelium's ability to meet industry requirements for most applications and we believe other companies will follow.	
Texture	The texture of mycelium leather can be very similar to bovine leather, and in some cases, even more pleasant.	4 ★
Weight	Most of the samples we saw weighed less than standard automotive, accessory, and home good needs. The weight was more in line with apparel. The technology should allow for heavier samples although the drying time would also increase. With heavier samples, we will increase this score to 4.	3 ★
Flexibility	The drape and flexibility of mycelium-based leathers is closer to bovine leather than some of the other alternative leathers. Mycelium leather is often much more pliable than petroleum-based or plant-based leather alternatives and can be folded without scoring. Recent tests of MycoWorks Reishi material showed little to no damage after flexibility tests.	4 ★
Thickness	Most of the samples we saw were thinner than standard automotive, accessory, and home good needs. The thickness was more in line with apparel. The technology should allow for thicker samples although the drying time would also increase. With thicker samples, we will increase this score to 4.	3 ★
Smell	Some of the mycelium leather samples we saw carried an earthy or yeast-like odor that some consumers may find unpleasant. This odor may fade over time. Other samples did not have this odor and thus the technology exists to remove this odor. We expect all companies to remove the odor before scale.	3 ★
Shine	Mycelium-based leathers can have a nice shine which is closer to bovine leather than some of the other alternative leathers. It is unclear how much the shine can vary without using coating.	3 ★
Colorfastness	Tests of MycoWorks Reishi showed varying degrees of colorfastness depending on the test. For wet and dry crocking, water, sea water, perspiration, and various solvents, the material generally showed no change or slight change. For colorfastness to light, "Reishi Brown Natural" showed "much" to "considerable" change with a "considerably darker and redder" color. "Black Embossed'' showed little change to colorfastness to light except the sample became glossy.	3 ★

Hand feel	The hand feel for some of the newer samples was similar to bovine leather. These samples from some companies showed significant improvement over earlier samples which were not as supple.	4/★

Sustainability Summary

Mycelium leather has a significant advantage over both bovine leather and polyurethane or PVC-based leathers in terms of environmental impact. Mycelium leather is fully biodegradable, uses waste products for its primary inputs, emits substantially fewer greenhouse gases than conventional leather, produces no biological waste, and contains no animal products. Critically, mycelium leather does not require the intensive chemical processing that conventional leather does, and the chemicals that are used (such as citric acid and isopropyl alcohol) have a negligible environmental impact. While conventional leather production requires significant water use, both in raising the animal and processing the resulting material, mycelium leather production requires only enough water to maintain appropriate humidity during mycelial growth.

Because it has a natural exterior coating, mycelium has an advantage over many plant-based leather alternatives that require a polymer coating. By eliminating the need both for petroleum-based coatings and for cattle production, mycelium leather's carbon footprint is dramatically low in comparison to other alternative leathers. In addition to carbon savings, mycelium production has far less eutrophication potential or contribution to persistent, toxic, and bioaccumulative substances compared to tanned animal hides or polyurethane or PVC coated leather alternatives.

MII's biggest concern with regard to mycelium's environmental sustainability comes from its energy use: production requires moderate energy use for sterilizing growth media and maintaining the controlled environment necessary for growth. With a cultivation period of 7-14 days, energy use could be significant. There are ways to reduce energy use by building production facilities in more moderate climates. Additionally, mycelium leather may be difficult to recycle. However, its ability to decompose completely indicates a biodegradation end of life scenario.

Sustainability scorecard

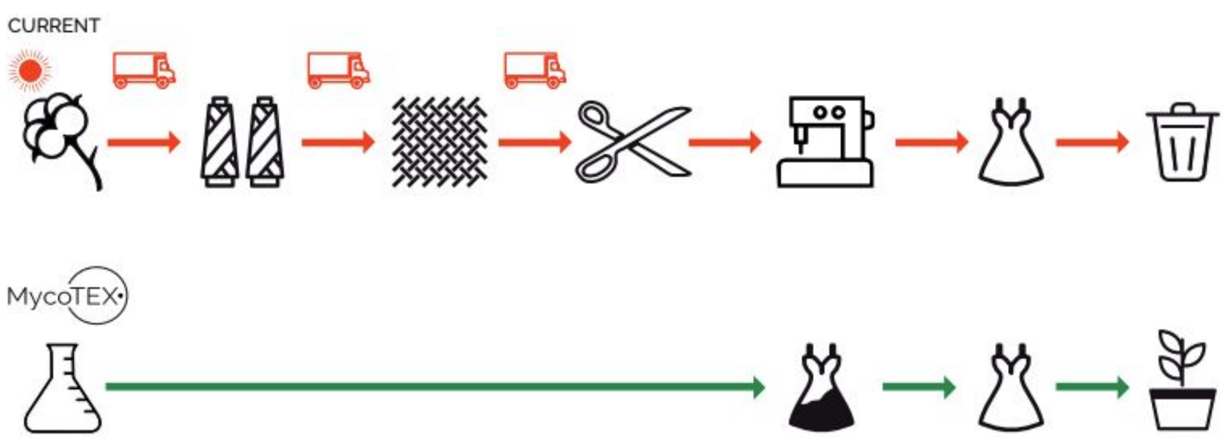
	Notes	**Grade**
Animal Welfare	No known use of animal products.	5/★

Biological waste	No biological waste is generated in the current production processes.	5 ★
Chemical use	Mycelium cultivation uses few chemical inputs. Some low impact chemistry is used, e.g. isopropyl alcohol, citric acid. Some chemicals may be used for tanning and coloring.	4 ★
Land use	Agricultural land use is very low, as most mycelium products use agricultural waste as growth media. Although production could use virgin raw material inputs, it would not be cost effective. Most of the land use will be from the size of production facilities at scale, although this amount of land is still significantly less than used for animal agriculture.	5 ★
Resource depletion	Virtually no impact on resource depletion because the production method uses agricultural waste sources for mycelial growth. As mentioned above, it is not cost effective to use virgin raw material inputs.	5 ★
Emissions	Very few emissions result from mycelial growth, especially compared to animal leathers.	5 ★
Energy use	Unlike plants and animals, mycelium does not require light to grow. Moderate energy is needed to sterilize the growth media and to maintain the controlled environment necessary for growth and processing. The production facilities should be located in moderate climates to reduce the amount of energy needed to control the temperature.	5 ★
Water use	Significantly less water is used in growth and processing of mycelium leather as compared to animal leather. Humidity is important for growth and can be tweaked to alter the properties of the material, but variation is minimal.	5 ★
Recyclable	Mycelium leather is unlikely to be recyclable at the end of life due to low durability. However, it may be downcycled.	3 ★
Biodegradable	Mycelium leather will biodegrade, given that all inputs are also biodegradable. Mycelium produces a natural coating during growth, eliminating or significantly reducing the need for additional coating.	5 ★

Sourcing Summary

Scalability is currently the primary disadvantage of mycelium-derived leather alternatives. Since the mycelium must be cultivated within a growing medium over 7-14 days, it requires significant space to produce material at scale volumes. The vast space required is also costly to build out and support, requiring consistent humidity, pressure, temperature and airflow controls.

One major advantage to mycelium products is the production cycle can be shortened as the product can be made into the exact size and even form of the end product thus reducing the cutting and sewing time, process, transportation, and waste. NEFFA produced the following graphic outlining the shorter production cycle for their MycoTEX mycelium leather material. This graphic describes the potential shorter production cycle for all mycelium-based leather materials.



Graphic from MycoTEX by NEFFA website

Sourcing scorecard

	Notes	Grade
Width	Mycelium-based leathers can be made in any width and are highly customizable. This allows for very little product waste.	5/★
Continuity	The continuity in product should be better than leather and on par with other alternative leathers due to the standard production techniques.	4/★

Price	As the technology is not as developed as other alternative products, it is hard to predict the price at scale. The cost of the raw materials is low as most are from agriculture waste and, as the product can be made to the exact shape necessary, there is little to no scrap material. However, the cost of the production facilities will likely be higher.	2 ★
Scalability	Production requires significant space to produce material at scale volumes. The vast space required is also costly to build out and support, requiring consistent humidity, pressure, temperature, and airflow controls.	2 ★
Lead Time	With a cultivation period of 7-14 days plus drying time varying from hours to a few days, the lead time for mycelium-based leathers should be significantly less than animal-based materials, but not as short as other plant-based leather alternatives.	3 ★

SWOT ANALYSIS

Here we briefly summarize the strengths, weaknesses, opportunities, and threats of mycelium leather through the lens of sustainability, sensory, sourcing, and scaling considerations.

Strengths Potential for fully degradable alternative leather product Abundant waste stream feedstock is available for growth Biological technology innovation that does not rely on genetic modification	**Weaknesses** Tenacity and abrasion resistance are lacking compared to other next gen leathers Coloration and tanning processes are currently limited Large area of moisture and temperature controlled environment required to scale
Opportunities Thousands of fungal species exist, could be tested for ability to create material with desirable properties Processing innovation could rapidly improve scalability	**Threats** Cultivated leather technology produces actual animal leather which will likely be superior to mycelial leather Precision fermentation produces animal collagen which will much more similar to animal leather than mycelial leather Mechanical/chemical leather may have reduced water and energy requirements in production process thus potentially cheaper

COMPANIES

Mushroom Leather by Ecovative Design

Founded: 2007
Headquarters & Production Facilities:
Green Island NY
Phase: Production
Websites:
https://boltthreads.com/
https://boltthreads.com/technology/mylo/
Material: MycoFlex™ Mushroom Leather

Eben Bayer and Gavin McIntyre developed and patented a method for growing mycelium-based insulation called Greensulate as part of a course project at Rensselaer Polytechnic Institute. In 2007, the pair founded Ecovative Design to use mycelium to grow materials that replace plastics and reduce animal slaughter. Since their founding, the company has received numerous awards and holds dozens of patents for mycelium-based packaging and materials, including a leather alternative. Investments and partnerships in 2011 allowed the company to increase their staff and open a 35,000 ft^2 (~3250 m^2) Mycelium Foundry in Green Island NY. In 2019, the company announced an investment of $10 million to open an advanced research facility for mycelium in California with an initial focus on mycelium-based meat.

Ecovative Designs has developed three platforms: Atlast™ for mycelium meat (Their spinoff Atlast Food Co. released mycelium bacon in 2020); MycoComposite™ for mycelium-bound composites for packaging and building materials; and MycoFlex™ for 100% mycelium foams and leather alternatives. Ecovative Design creates Mushroom Leather using their MycoFlex™ platform and a non-toxic tanning process. This mycelium material can be used in a variety of applications in fashion, accessories, and footwear. Mushroom Leather sample pictured.

MYLO™ BY BOLT THREADS

Founded: 2009
Headquarters & Production Facilities:
Emeryville, CA
Phase: R&D
Websites:
https://boltthreads.com/
https://boltthreads.com/technology/mylo/
Material: Mylo

Bolt Threads, originally named Refactored Materials, was founded in 2009 by Dan Widmaier, David Breslauer, and Ethan Mirsky to use biotechnological innovation to create materials. Dan Widmaier initially developed this idea during his Ph.D. in Chemical Biology. The company has since grown to a team of nearly 100 employees. In 2012, they introduced spider silk fibers and launched Mylo in 2018. Mylo is made from mycelium grown on agricultural waste and by-products. Mylo is still in the R&D phase. It has been used in a limited-edition bag and made into a prototype in collaboration with fashion designer Stella McCartney. In October, 2018 they launched a Kickstarter campaign for various Mylo products. As of the end of January, 2020 they raised $72,285 from 290 backers.

Reishi™ by MycoWorks

Founded: 2013
Headquarters Facilities: San Francisco CA
Phase: TBD
Websites:
https://www.mycoworks.com/
https://www.madewithreishi.com/
Material: Reishi

Artist and inventor Philip Ross began using mycelium in the 1990s as a medium for sculpture. In 2013, he co-founded MycoWorks with Sophia Wang. MycoWorks first produced mycelium bricks for building and containers. In 2016, the company created a leather-like material and has continued to innovate in this space.

In February 2020, MycoWorks presented Reishi™ Fine Mycelium™ at New York Fashion Week to accolades from influencers and designers in the fashion industry. Reishi sheets are grown in MycoWorks' production facilities in California and tanned without chromium by partners in Europe. According to the company and to independent tests, Reishi can provide brands with the same performance, quality, and aesthetics as leather without the use of animals or plastic.

Also in February 2020, MycoWorks announced that the company had raised $17 million in Series A financing to bring Reishi to market, led by DCVC Bio, with major participation from Novo Holdings and 8VC, among others. This funding will allow MycoWorks to expand production by opening a third facility with the capacity to produce 80,000 square feet (approximately 7400 square meters) per year. MycoWorks will also be able to increase the number of partnerships and support launches of products already prototyped and tested for nearly two years.

Vartest, a third-party testing company, tested MycoWorks Reishi mycelium leather across hundreds of samples and protocols and released data from the most recent version in January 2020 (see Appendix B). Three types of Reishi have been tested: Brown Natural, Brown Natural High Strength, and Black Emboss and the results indicate that Reishi matches the strength and durability of bovine leather.

Vartest results: Reishi varieties

Test	Reishi™ Brown Natural	Reishi™ Brown Natural High Strength	Reishi™ Black Emboss	Cowhide Leather
Tensile strength (MPa)	5.6 - 7.4	8.8 - 12.5	9.2 - 10.2	> 8.0
Elongation (%)	16 - 36 %	55 - 80 %	51 - 52 %	10 - 80 %
Tongue tear strength (N)	6.7	52.6	9.9	> 20
Stoll abrasion (cycles, 1lb)	> 1,300	> 1,300		> 1,300
Bally Flex (cycles)	> 20,000	> 100,000		> 10,000
Colorfastness to distilled water (1-5 rating, 5 is high)	4.5		4	4.5 - 5
Colorfastness to sea/salt water (1-5 rating, 5 is high)	4.5		4	4.5 - 5
Colorfastness to perspiration (1-5 rating, 5 is high)	4.5		4.5	4.5 - 5
Colorfastness to water spotting (1-5 rating, 5 is high)	5 after drying		5 after drying	4.5 - 5
Colorfastness to solvent wicking (1-5 rating, 5 is high)	5		3.5 - 5	4.5 - 5
Colorfastness to crocking (dry and wet) (1-5 rating, 5 is high)	5 dry, 4 wet		4 dry	4.5 - 5
Colorfastness to machine washing (1-5 rating, 5 is high)	One wash: slight change		Not recommended	Not recommended
Colorfastness to UV exposure (1-5 rating, 5 is high)	1.5		4.5	5

Published February 2020

MycoTEX by NEFFA

Founded: 2014
Headquarters: Soest, the Netherlands
Phase: R&D
Website: https://neffa.nl/
Material: MycoTEX

MycoTEX is leather-like mycelium fabric created in the textile innovation lab NEFFA, launched in 2014 by Aniela Hoitink in partnership with Utrecht University. Using a 3D-modelling process, NEFFA uses MycoTEX to create custom-fit garments without the need for cutting or stitching. MycoTEX, is designed to plug into the fast-fashion paradigm by leveraging low-cost, renewable materials that consumers can easily compost at home when the garment has outlived its desired use.

In 2017, NEFFA participated in the Fashion for Good early-stage accelerator program and went on to win the H&M Foundation Global Change Award the following year for its material and technology.

NEFFA made the dress from MycoTEX pictured in 2016 as proof of concept. Dress and jacket never worn, vest worn on catwalk only.

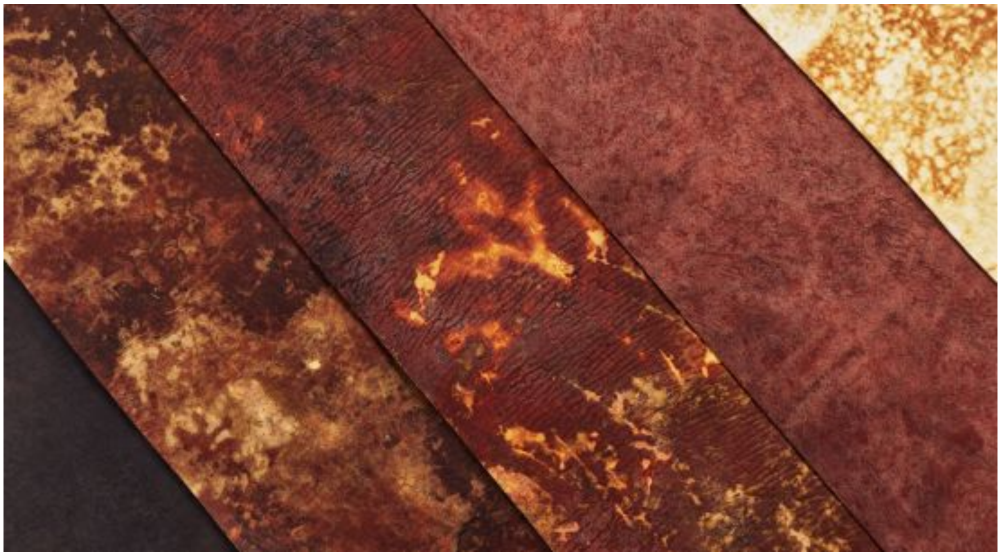
Mylea by MYCL

Founded: 2015 as Mycotech, rebranded June 2020
Headquarters: Bandung, Indonesia
Phase: Small scale production
Website: https://mycl.bio/
Material: Mylea

Adi Reza Nugroho, Ronaldiaz Hartantyo, Robby Zidna Ilman, M. Arkha Bentangan L, and Annisa Wibi Ismarlanti came together as gourmet mushroom producers in 2012. Inspired by tempeh, a traditional Indonesian dish, they began doing makeshift research using pressure cookers to grow new materials. To create tempeh, soybeans are bound together by the mycelial growth of the fungus Rhizopus oligosporus. Using a similar process, the company has been growing mycelium on agricultural waste since 2015.

In partnership with the Indonesian government research agency and with laboratories in Singapore and Switzerland, Mycotech (as the company was first known) created mycelium composite panels called BIOBO as their first product. In 2019, they ran a kickstarter campaign to scale up their leather alternative Mylea and offered the Mylea-band watches, traveller's journals with Mylea covers (center top & left), and Mylea card wallets pictured below. Their catchphrase "not leather, but better" showcases their commitment to creating sustainable and affordable products from renewable resources. In June 2020, they announced their rebranding as MYCL (Mycotech Lab) and their certification as a B Corporation.

Mylea is currently available in 4 colors (brown & light brown, deep black, and brick red; in thicknesses ranging from 0.1 - 0.9 mm, and in 15 x 20 cm (~ 6 x 8 inch) sheets. The texture can be customized.



MYCL mylea

Mylea Product Specification

Standard Test	Test	Mylea Genuine		Mylea Essential
		Original	Black	
ASTM D2209 – 00 (2015)	Tensile Strength (MPa)	8 - 11	8 - 11	6 – 8
ASTM D2209 – 00 (2015)	Elongation (%)	22 - 35	22 - 35	38 – 47
ASTM D4533/D4533M – 07 (2013)	Tear Strength (N)	24	24	-
ISO 5470-2 : 2003	Abrasion Martindale	-	> 50.000	> 50.000
SNI : ISO 105-C06:2010 A1M	Colorfastness Wash	-	4	4.5
SNI : ISO 105-E04:2010	Colorfastness Perspiration Acid	-	4.5	4.5
SNI : ISO 105-E04:2010	Colorfastness Perspiration Alkali	-	4.5	4.5
SNI : ISO 105-X12:2012	Colorfastness Wet Crocking	-	3.5	4.5
SNI : ISO 105-X12:2012	Colorfastness Dry Crocking	-	4.5	4.5
SNI : ISO 105-B02:2010	Colorfastness UV (Xenon)	-	-	> 4

Product specification available here:
https://mycl.bio/storage/app/media/mylea/MYCL-Mylea%20Product%20Specification.pdf

APPENDIX A: Mycelium white space analysis

Opportunity 1: Cross-Industry Research

It is useful to examine mycelium in other products, because the processes for production are so similar. A number of researchers have developed applications from mycelium for use in packaging, especially as a sustainable substitute for petroleum-based polymers. Bricks and other building materials, as well as foam and insulation, have been produced using mycelium. As these companies have already conducted the research on mycelium, it would be advantageous to talk to them to see if they have considered applying their technology to leather replacements.

For example, the Mogu company creates acoustic panels from mycelium and textile residues for use in interiors. Their floor tiles are also mycelium composites, coated with 90% bio-based resins. It may be useful to investigate the performance of these resins as a possible coating for mycelium leather. The designer Danielle Trofe uses Ecovative's technology to grow lampshades in large molds with mycelium. MushLume is uncoated and can be composted at the end of its life.

Opportunity 2: Examination of Other Fungal Species

Around 120,000 species of fungi have been categorized by taxonomists but at least one estimate suggests that there may be between 2.2 and 3.8 million species. Only several dozen species of fungi have been grown for mycelium products. There is significant opportunity for academic or public-private research to support knowledge building to improve understanding of the best species to select for rate of growth, density, and thickness, among many other properties.

Opportunity 3: Growth media and scaffolding

A range of opportunities exists for research into types of growth media and scaffolding for mycelium composites. Most companies growing mycelium for products other than food and medicine use agricultural plant waste as a substrate and as scaffolding for composites because plant waste is relatively inexpensive, renewable, and easy to acquire. The types of plant waste can vary greatly, however, and have an impact on the characteristics of the end product. A comprehensive database of scaffolding for composites and the properties of the resulting mycelium material could allow innovators to make the best selection for the material they want to produce. Similarly, best processes for mycelial growth inputs (e.g., temperature, humidity, and carbon dioxide range) could be shared, further decreasing production costs.

Opportunity 4: Roll-to-Roll Growth

An extensive white space opportunity exists in process development for continuous or roll-to-roll growth of mycelium material. Currently, mycelium grown for fashion applications are grown, at maximum in yard by yard (meter by meter) sheets. In the automotive industry, for example, leather used for seats needs to be consistent throughout. Mycelium leather would need to be grown in a large enough mold or form in order to achieve the desired length. It may be useful to investigate how mycelium composites are grown for other large-scale products such as acoustic tiles and flooring. It may be possible to use similar processes for continuous or roll-to-roll growth of mycelium leather.

Opportunity 5: Processing Innovation

Additional opportunities exist for processing innovation, especially for sustainable (non-petroleum based) tanning, coloring, and coatings. Some companies use plant-based dyes or colorings and one is using a proprietary tanning process. The Mogu company claims to use a 90% bio-based resin as a coating for their mycelial flooring products. Coating is particularly critical in order to increase the durability of mycelium leather products.

APPENDIX B: Vartest Certified Third Party Test Reports of MycoWorks Reishi™

Vartest Laboratories

Quality Assurance & Compliance Testing
Utilizing Textile & Related Technologies
19 West 36th Street, 10th Floor
New York, NY 10018
Tel: 212 947 8391 Fax: 212 947 8719

www.vartest.com

ISO/IEC 17025 Certified Third Party Test Report

DATE ISSUED: January 27, 2020 **FILE:** MYCOWO.A011720B
DATE REVISED: January 29, 2020

CLIENT: MycoWorks
San Francisco, CA

SAMPLE IDENTIFIED BY CLIENT AS:

Fabrics Submitted
Name: Reishi Black Emboss
Color Black

TEST PROCEDURES:	**TEST RESULTS:**
FABRIC WEIGHT (ASTM D3776):	
- SPECIMEN 1:	16.45 oz/sq yd
- SPECIMEN 2:	17.16 oz/sq yd
- SPECIMEN 3:	16.54 oz/sq yd
- SPECIMEN 4:	17.60 oz/sq yd
	16.94 oz/sq yd average
THICKNESS OF LEATHER SPECIMENS (ASTM D1813):	
- SPECIMEN 1:	0.725 mm
- SPECIMEN 2:	0.782 mm
- SPECIMEN 3:	0.652 mm
- SPECIMEN 4:	0.681 mm
	0.710 mm average
APPARENT DENSITY OF LEATHER (ASTM D2346):	
- SPECIMEN 1:	0.769 grams/cm^3
- SPECIMEN 2:	0.744 grams/cm^3
- SPECIMEN 3:	0.860 grams/cm^3
- SPECIMEN 4:	0.877 grams/cm^3
	0.813 grams/cm^3 average

Vartest Laboratories

Quality Assurance & Compliance Testing
Utilizing Textile & Related Technologies
19 West 36th Street, 10th Floor
New York, NY 10018
Tel: 212 947 8391 Fax: 212 947 8719
www.vartest.com

ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A011720B

SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Black Emboss
Color Black

TONGUE TEAR STRENGTH OF LEATHER (ASTM D4704):

- TEAR IN MACHINE DIRECTION:

Specimen	Thickness (mm)	Coating Tear (kgf)	Force per Thickness (kgf/cm)	Substrate Tear (kgf)	Force per Thickness (kgf/cm)	Maximum Load (kgf)	Max Load / Thickness (kgf/cm)
1	0.662	N/A	N/A	1.209	18.26	1.647	24.88
2	0.632	N/A	N/A	1.261	19.94	1.261	19.94
3	0.664	0.017	0.25	1.095	16.49	1.165	17.54
4	0.842	0.129	1.53	1.137	13.50	1.188	14.11
5	0.748	N/A	N/A	1.143	15.28	1.430	19.11
6	0.776	0.291	3.74	0.722	9.30	1.094	14.66
Average	**0.721**	**0.145**	**1.84**	**1.094**	**15.46**	**1.297**	**18.38**

- TEAR IN CROSS-MACHINE DIRECTION, MATTE FABRIC:

Specimen	Thickness (mm)	Coating Tear (kgf)	Force per Thickness (kgf/cm)	Substrate Tear (kgf)	Force per Thickness (kgf/cm)	Maximum Load (kgf)	Max Load / Thickness (kgf/cm)
1	0.730	0.215	2.95	1.226	16.79	1.551	21.25
2	0.650	0.453	6.97	0.736	11.33	0.956	14.70
3	0.718	0.080	1.11	1.250	17.41	1.277	17.78
4	0.774	N/A	N/A	1.048	13.54	1.072	13.85
5	0.756	0.104	1.38	0.617	8.16	0.827	10.94
6	0.766	0.315	4.11	0.626	8.18	0.967	12.63
Average	**0.732**	**0.233**	**3.30**	**0.917**	**12.57**	**1.108**	**15.19**

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ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A011720B
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Black Emboss
Color Black

TENSILE STRENGTH & ELONGATION OF LEATHER (ASTM D2209 & ASTM D2211):

- MACHINE DIRECTION:

Specimen	Maximum Load (kgf)	Extension @ Max Load (mm)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (MPa)	Thickness (mm)	Width (mm)	Area (mm^2)
1	11.85	58.85	57.93	13.15	0.736	12.0	8.83
2	8.17	54.62	53.76	9.69	0.678	12.2	8.27
3	8.50	55.31	54.44	8.26	0.848	11.9	10.09
4	4.74	42.77	42.09	5.59	0.692	12.0	8.3
Average	**8.31**	**52.89**	**52.05**	**9.17**	**0.739**	**12.0**	**8.9**

- CROSS-MACHINE DIRECTION:

Specimen	Maximum Load (kgf)	Extension @ Max Load (mm)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (MPa)	Thickness (mm)	Width (mm)	Area (mm^2)
1	10.33	52.08	51.26	12.91	0.654	12.0	7.85
2	7.86	55.89	55.01	10.42	0.616	12.0	7.39
3	5.86	54.93	54.07	5.99	0.806	11.9	9.59
4	10.45	43.61	42.92	11.42	0.754	11.9	8.97
Average	**8.63**	**51.63**	**50.81**	**10.19**	**0.708**	**12.0**	**8.5**

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FILE: MYCOWO.A011720B
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Black Emboss
Color Black

COLORFASTNESS TO CROCKING (AATCC 8, Flat) GRAY SCALE:
Dry: Class 4.0
Wet: Class 1.0

COLORFASTNESS TO LIGHT (ASTM G154), QUV 340:
- AFTER 40 HOURS:
Class 4.5
(Sample became glossy.)

COLORFASTNESS TO WATER (AATCC 107):

Shade Change: Class 4.5

Staining:		
	Acetate	Class 4.5
	Cotton	Class 4.5
	Nylon	Class 4.0
	Polyester	Class 5.0
	Acrylic	Class 5.0
	Wool	Class 4.5

(Sample became stiffer.)

COLORFASTNESS TO SEA WATER (AATCC 106):

Shade Change: Class 4.5

Staining:		
	Acetate	Class 4.0
	Cotton	Class 4.0
	Nylon	Class 4.0
	Polyester	Class 4.5
	Acrylic	Class 4.5
	Wool	Class 4.5

(Sample became stiffer.)

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FILE: MYCOWO.A011720B
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Black Emboss
Color Black

COLORFASTNESS TO PERSPIRATION (AATCC 15):

- **ACID:**	Shade Change:	Class 4.5	
	Staining:	Acetate	Class 4.5
		Cotton	Class 4.5
		Nylon	Class 4.5
		Polyester	Class 5.0
		Acrylic	Class 4.5
		Wool	Class 4.5

(Sample became stiffer.)

COLORFASTNESS TO WATER SPOTTING (AATCC 104), EVALUATION PROCEDURE 1:

- **AFTER 2 MINUTES:** Class 3.0
- **AFTER DRYING:** Class 5.0

COLORFASTNESS TO SOLVENT SPOTTING (AATCC 157):

Solvent Type	Staining Rate Degree of Blotter Paper Used
Acetone	4.0
Ethanol	3.5
Ethyl Acetate	5.0
Isopropanol	5.0

KEY TO DEGREE OF ALTERATION IN SHADE AND STRENGTH:

Class 5, Negligible or no change
Class 4, Slightly changed
Class 3, Noticeably changed
Class 2, Considerably changed
Class 1, Much changed

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ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A011720B
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Black Emboss
Color Black

APPEARANCE AFTER HYDROLYSIS PER ASTM D3690 Sec 6.11.3, 24 HOURS EXPOSURE @ 70±1°C, 95±5% RH:	No noticeable discoloration. Sample became slightly to noticeably glossy. No cracking, delamination or other changes.

Signed For The Company By

Joseph Lin
Laboratory Manager

JG/01...JG/01...JG/01

VARTEST Tested & Evaluated LABORATORIES

Stacy Sadowy
Quality Assurance Manager

Vartest Laboratories

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ISO/IEC 17025 Certified Third Party Test Report

DATE ISSUED: January 24, 2020 **FILE:** MYCOWO.A011720A
DATE REVISED: January 31, 2020 MYCOWO.A012820A

CLIENT: MycoWorks
San Francisco, CA

SAMPLE IDENTIFIED BY CLIENT AS:

Fabric Submitted
Name: Reishi Brown Natural - High Strength

TEST PROCEDURES:	**TEST RESULTS:**
FABRIC WEIGHT (ASTM D3776):	13.35 oz/sq yd average
COMMENT:	Three specimens tested.
THICKNESS OF LEATHER SPECIMENS (ASTM D1813):	1.065 mm average
COMMENT:	Three specimens tested.
APPARENT DENSITY OF LEATHER (ASTM D2346):	8.40 grams/cm^3 average
COMMENT:	Three specimens tested.

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ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A011720A
MYCOWO.A012820A

SAMPLE IDENTIFIED BY CLIENT AS:
Fabric Submitted
Name: Reishi Brown Natural - High Strength

TONGUE TEAR STRENGTH OF LEATHER (ASTM D4704):

- TEAR IN MACHINE DIRECTION:

Specimen	Thickness (mm)	Substrate Tear (kgf)	Force per Thickness (kgf/cm)	Maximum Load (kgf)	Max Load / Thickness (kgf/cm)
Average	1.004	6.17	61.45	7.34	73.17

- TEAR IN CROSS-MACHINE DIRECTION:

Specimen	Thickness (mm)	Substrate Tear (kgf)	Force per Thickness (kgf/cm)	Maximum Load (kgf)	Max Load / Thickness (kgf/cm)
Average	1.097	4.77	43.53	6.85	62.44

COMMENT: Three specimens tested in machine direction.
Four specimens tested in cross-machine direction.
Variation observed in performance of tested specimens.

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ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A011720A
MYCOWO.A012820A
SAMPLE IDENTIFIED BY CLIENT AS:
Fabric Submitted
Name: Reishi Brown Natural - High Strength

TENSILE STRENGTH & ELONGATION OF LEATHER (ASTM D2209 & ASTM D2211):

SAMPLE MYCOWO.A011720A:
- MACHINE DIRECTION:

Specimen	Maximum Load (kgf)	Extension @ Max Load (mm)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (MPa)	Thickness (mm)	Width (mm)	Area (mm^2)
Average	10.82	55.47	54.59	8.75	0.99	12.20	12.08

- CROSS-MACHINE DIRECTION:

Specimen	Maximum Load (kgf)	Extension @ Max Load (mm)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (MPa)	Thickness (mm)	Width (mm)	Area (mm^2)
Average	11.75	81.43	80.15	9.34	1.02	12.07	12.35

COMMENT: Three specimens tested in each direction.
Variation observed in performance of tested specimens.

SAMPLE MYCOWO.A012820A:
- MACHINE DIRECTION:

Specimen	Maximum Load (kgf)	Extension @ Max Load (mm)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (MPa)	Thickness (mm)	Width (mm)	Area (mm^2)
Average	20.18	43.89	43.20	12.51	1.311	12.1	15.8

- CROSS-MACHINE DIRECTION:

Specimen	Maximum Load (kgf)	Extension @ Max Load (mm)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (MPa)	Thickness (mm)	Width (mm)	Area (mm^2)
Average	16.17	56.03	55.15	10.09	1.311	12.0	15.7

COMMENT: Three specimens tested in each direction.
Variation observed in performance of tested specimens.
Testing performed on sample under report file number MYOCOW.A012820A.

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ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A011720A
MYCOWO.A012820A

SAMPLE IDENTIFIED BY CLIENT AS:
Fabric Submitted
Name: Reishi Brown Natural - High Strength

ABRASION RESISTANCE OF TEXTILE FABRICS, INFLATED DIAPHRAGM METHOD (ASTM D3886), 1 LBS LOAD, 4 PSI AIR PRESSURE, 1300 CYCLES:

FACE SIDE AS MARKED:

- **SPECIMEN 1:** No hole observed after 1300 cycles.
- **SPECIMEN 2:** No hole observed after 1300 cycles.
- **SPECIMEN 3:** No hole observed after 1300 cycles.

BALLY FLEX RESISTANCE (ASTM D6182):

FACE SIDE AS MARKED, AFTER 20,000 FLEXES:

MACHINE DIRECTION:

- **SPECIMEN 1 :** Rank 2
- **SPECIMEN 2:** Rank 1
- **SPECIMEN 3:** Rank 1

CROSS-MACHINE DIRECTION:

- **SPECIMEN 1:** Rank 2
- **SPECIMEN 2:** Rank 1
- **SPECIMEN 3:** Rank 1

FACE SIDE AS MARKED, AFTER 50,000 FLEXES:

MACHINE DIRECTION:

- **SPECIMEN 1:** Rank 2
- **SPECIMEN 2:** Rank 1
- **SPECIMEN 3:** Rank 1

CROSS-MACHINE DIRECTION:

- **SPECIMEN 1:** Rank 2
- **SPECIMEN 2:** Rank 1
- **SPECIMEN 3:** Rank 1

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FILE: MYCOWO.A011720A
MYCOWO.A012820A

SAMPLE IDENTIFIED BY CLIENT AS:
Fabric Submitted
Name: Reishi Brown Natural - High Strength

BALLY FLEX RESISTANCE
(ASTM D6182):
FACE SIDE AS MARKED,
AFTER 100,000 FLEXES:
MACHINE DIRECTION:

-	**SPECIMEN 1:**	Rank 4
-	**SPECIMEN 2:**	Rank 1
-	**SPECIMEN 3:**	Rank 1

CROSS-MACHINE DIRECTION:

-	**SPECIMEN 1:**	Rank 4
-	**SPECIMEN 2:**	Rank 1
-	**SPECIMEN 3:**	Rank 1

RANK OF DAMAGE:

Rank 1, No damage.
Rank 2, Discoloration or thin cracks in top finish coat only.
Rank 3, Cracks into base coats.
Rank 4, Cracks large enough to see leather substrate below.
Rank 5, Finish cracks and peels back or flakes off.

Signed For The Company By

Joseph Lin
Laboratory Manager

JG/01...JG/01...JG/01...JG/01

VARTEST LABORATORIES Tested & Evaluated

Stacy Sadowy
Quality Assurance Manager

Vartest Laboratories

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ISO/IEC 17025 Certified Third Party Test Report

DATE ISSUED: January 2, 2020 **FILE:** MYCOWO.A121619A
DATE REVISED: January 31, 2020

CLIENT: MycoWorks
San Francisco, CA

SAMPLE IDENTIFIED BY CLIENT AS:

Fabrics Submitted
Name: Reishi Brown Natural

TEST PROCEDURES:	TEST RESULTS:
FABRIC WEIGHT (ASTM D3776):	
- **SPECIMEN 1:**	15.88 oz/sq yd
- **SPECIMEN 2:**	15.76 oz/sq yd
- **SPECIMEN 3:**	21.12 oz/sq yd
	17.59 oz/sq yd average
THICKNESS OF LEATHER SPECIMENS (ASTM D1813):	
- **SPECIMEN 1:**	1.023 mm
- **SPECIMEN 2:**	1.121 mm
- **SPECIMEN 3:**	1.338 mm
	1.161 mm average
APPARENT DENSITY OF LEATHER (ASTM D2346):	
- **SPECIMEN 1:**	0.526 grams/cm^3
- **SPECIMEN 2:**	0.477 grams/cm^3
- **SPECIMEN 3:**	0.535 grams/cm^3
	0.513 grams/cm^3 average

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ISO/IEC 17025 Certified Third Party Test Report

FILE: MYCOWO.A121619A
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Brown Natural

TONGUE TEAR STRENGTH OF LEATHER (ASTM D4704):
- TEAR IN MACHINE DIRECTION:

Specimen	Load Observed @ 1st Peak (lbf)	Force per Thickness (kgf/cm)	Thickness (mm)
1	0.624	3.148	0.899
2	0.985	4.091	1.092
3	2.405	9.159	1.191
Average	1.338	**5.466**	**1.061**

- TEAR IN CROSS-MACHINE DIRECTION:

Specimen	Load Observed @ 1st Peak (lbf)	Force per Thickness (kgf/cm)	Thickness (mm)
1	0.915	4.344	0.955
2	1.144	5.347	0.970
3	2.210	7.972	1.257
4	2.229	9.457	1.069
Average	**1.624**	**6.780**	**1.063**

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FILE: MYCOWO.A121619A
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Brown Natural

TENSILE STRENGTH & ELONGATION OF LEATHER (ASTM D2209 & ASTM D2211):

- MACHINE DIRECTION:

Specimen	Maximum Load (lbf)	Extension @ Max Load (in)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (psi)	Thickness (in)	Width (in)	Area (in^2)
1	17.42	0.60	15.01	1033.91	0.0351	0.48	0.017
2	26.09	0.62	15.50	1065.57	0.0510	0.48	0.024
3	21.98	0.67	16.68	1098.23	0.0417	0.48	0.020
Average	**21.83**	**0.63**	**15.73**	**1065.90**	**0.0426**	**0.48**	**0.020**

Specimen	Maximum Load (kgf)	Stress @ Max Load (MPa)
1	7.90	7.13
2	11.83	7.35
3	9.97	7.57
Average	**9.90**	**7.35**

- CROSS-MACHINE DIRECTION:

Specimen	Maximum Load (lbf)	Extension @ Max Load (in)	Strain (Elong) @ Max Load (%)	Stress @ Max Load (psi)	Thickness (in)	Width (in)	Area (in^2)
1	9.97	1.22	30.43	505.32	0.0420	0.47	0.020
2	29.16	1.68	42.09	1204.74	0.0515	0.47	0.024
3	16.26	1.48	37.09	877.75	0.0386	0.48	0.019
4	12.56	1.33	33.34	636.62	0.0411	0.48	0.020
Average	**16.99**	**1.43**	**35.74**	**806.11**	**0.0433**	**0.48**	**0.021**

Specimen	Maximum Load (kgf)	Stress @ Max Load (MPa)
1	4.52	3.48
2	13.23	8.31
3	7.38	6.05
4	5.70	4.39
Average	**7.71**	**5.56**

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FILE: MYCOWO.A121619A
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Brown Natural

ABRASION RESISTANCE OF TEXTILE FABRICS, INFLATED DIAPHRAGM METHOD (ASTM D3886), 1 LBS LOAD, 4 PSI AIR PRESSURE, 1300 CYCLES:

FACE SIDE AS MARKED:

- **SPECIMEN 1:**	No hole observed after 1300 cycles.
- **SPECIMEN 2:**	No hole observed after 1300 cycles.

COMMENT: Two specimens tested due to sample size.

Abradant changed and specimens checked for hole every 300 cycles.

BALLY FLEX RESISTANCE (ASTM D6182):

FACE SIDE AS MARKED, AFTER 20,000 FLEXES:

MACHINE DIRECTION:

- **SPECIMEN 1:**	Rank 1
- **SPECIMEN 2:**	Rank 1
- **SPECIMEN 3:**	Rank 1

CROSS-MACHINE DIRECTION:

- **SPECIMEN 1:**	Rank 1
- **SPECIMEN 2:**	Rank 1
- **SPECIMEN 3:**	Rank 1

RANK OF DAMAGE:

Rank 1, No damage.
Rank 2, Discoloration or think cracks in top finish coat only.
Rank 3, Cracks into base coats.
Rank 4, Cracks large enough to see leather substrate below.
Rank 5, Finish cracks and peels back or flakes off.

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FILE: MYCOWO.A121619A
SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Brown Natural

COLORFASTNESS TO CROCKING (AATCC 8, Flat): GRAY SCALE	Dry: Class 5.0 Wet: Class 4.0		
COLORFASTNESS TO LIGHT (ASTM G154), QUV 340:			
- **AFTER 40 HOURS:**	Class 1.5 (Became considerably darker and redder.)		
COLORFASTNESS TO WATER SPOTTING (AATCC 104), EVALUATION PROCEDURE 1:			
- **AFTER 2 MINUTES:**	Class 1.0		
- **AFTER DRYING:**	Class 5.0		
COLORFASTNESS TO WATER (AATCC 107):	Shade Change:	Clss 4.5	
	Staining:	Acetate	Class 5.0
		Cotton	Class 5.0
		Nylon	Class 4.5
		Polyester	Class 5.0
		Acrylic	Class 5.0
		Wool	Class 4.5
COLORFASTNESS TO SEA WATER (AATCC 106):	Shade Change:	Class 4.5	
	Staining:	Acetate	Class 4.5
		Cotton	Class 4.5
		Nylon	Class 4.5
		Polyester	Class 5.0
		Acrylic	Class 5.0
		Wool	Class 4.5
COLORFASTNESS TO PERSPIRATION (AATCC 15):			
- **ACID:**	Shade Change:	Class 4.5	
	Staining:	Acetate	Class 5.0
		Cotton	Class 5.0
		Nylon	Class 5.0
		Polyester	Class 5.0
		Acrylic	Class 5.0
		Wool	Class 5.0

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SAMPLE IDENTIFIED BY CLIENT AS:
Fabrics Submitted
Name: Reishi Brown Natural

COLORFASTNESS TO WATER SPOTTING (AATCC 104), EVALUATION PROCEDURE 1:

- **AFTER 2 MINUTES:**	Class 1.0
- **AFTER DRYING:**	Class 5.0

COLORFASTNESS TO SOLVENT SPOTTING (AATCC 157):

Solvent Type	Staining Rate Degree of Blotter Paper Used
Acetone	5.0
Ethanol	5.0
Ethyl Acetate	5.0
Isopropanol	5.0

KEY TO DEGREE OF ALTERATION IN SHADE AND STRENGTH:

Class 5, Negligible or no change
Class 4, Slightly changed
Class 3, Noticeably changed
Class 2, Considerably changed
Class 1, Much changed

APPEARANCE AFTER HYDROLYSIS PER ASTM D3690 Sec 6.11.3, 24 HOURS EXPOSURE @ 70±1°C, 95±5% RH:

No noticeable discoloration or color change.
No cracking, delamination or other changes.

Signed For The Company By

Joseph Lin
Laboratory Manager

JG/12...JG/01...JG/01...JG/01

VARTEST Tested & Evaluated LABORATORIES

Stacy Sadowy
Quality Assurance Manager