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Vegan Leather Guide Part 2: Coated Materials

What exactly is vegan leather? Get to know all about apple leather, cactus leather, pineapple leather and co.

Autor: Julia Alles and Melina Bucher, October 26th, 2021

Updated April 7th, 2024

The market for leather products is in upheaval - innovations that attempt to replace fossil-based polymers with biogenic and fully biodegradable materials are especially in demand. A large number of established companies, but especially startups, are developing these new innovative materials. New terms like “vegan leather”, “plant-based” or “bio-based” arouse to differentiate oneself from the typical synthetic “faux leather”, also leading to a confusion about the actual content of the different materials.

So what do those terms actually mean? Are pineapple leather, apple leather and cactus leather really as sustainable as the name suggests? As we have taken a closer look at animal leather and vegan mono-materials in the Vegan Leather Guide Part 1, in this article we will provide you with information about the different types of coated materials. At the very end of the article, you will also find an overview table with the key features of the most popular material innovations and their technologies.

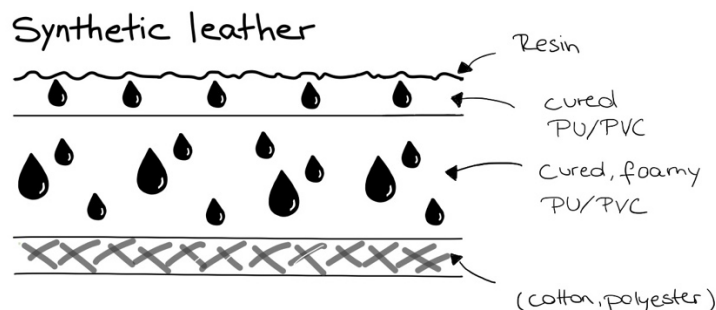
Synthetic Leather

Technology: Synthetic leather usually consists of a textile carrier coated with two or more synthetic polymer layers. The carrier materials used are, for instance, polyester, recycled polyester, cotton or viscose, which are coated with polyvinyl chloride (PVC, vinyl) or polyurethane (PU). The leather-like surface appearance is imitated by the embossing of a grain structure.¹ Attention: Not every synthetic leather is also automatically vegan – it depends on the colors, adhesives and other raw materials used in the process.

¹ Meyer et al., 2021, p. 2.

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Figure 1: Material cross section synthetic leather



Source: own illustration²

Performance: Synthetic leather - also known as "faux leather" - is often associated with poor quality. This reputation is mainly due to the cheaply produced imitation leather variants of fast fashion companies. However, synthetic leather is almost unrestricted in terms of its quality and properties.

The quality depends on the raw materials used (base material, coating) as well as the processing. Moreover, unlike its animal counterpart, the properties such as water resistance, flexibility and durability can be modified flexibly and even surpass the performance of animal leather.³ High-quality synthetic leather is used primarily in the automotive industry for interior trim. Unlike animal leather, synthetic leather offers water resistance, is easy to care for and neither needs to be waxed nor impregnated.

Did you know that even traditional luxury brands use coated leather or synthetic leather as particularly durable materials in their collections - Gucci and Louis Vuitton's famous monogram bags are made of coated faux leather, and Prada's Saffiano leather is a machine-grained and waxed leather.

Sustainability: Synthetic leather has its pros and cons. The extraction of the crude oil for production is intensive in terms of resources and the potential release of microplastics (albeit more present for textiles you wash often) is an issue. The environmental impact across categories like GHG emissions, water usage and chemicals used vary as much as the quality of the material: depending on the

² Kumar, 2021, p. 43.

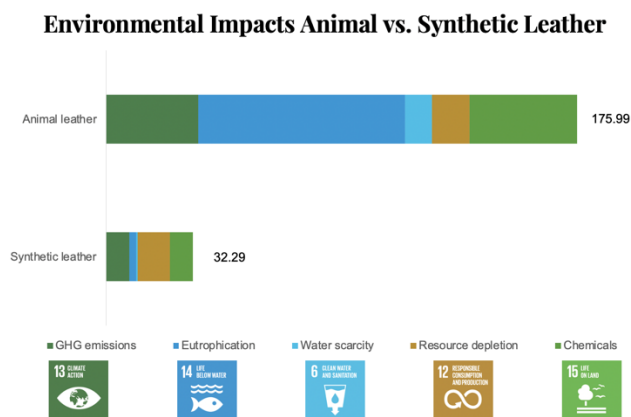
³ Meyer et al., 2021, p. 2.

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production country and site, raw materials used and material thickness, the environmental impact differs. However, scientific studies comparing standard materials used in the footwear, fashion and automotive space, show that, on average, the production of synthetic leather consumes significantly less resources than the production of animal leather.⁴

Figure 2: The environmental impact of animal and synthetic leather



Source: own illustration⁵

Disposal: High-quality synthetic leather is characterized in particular by its durability. That being said, it also gives rise to problems when it comes to disposal: The material is very difficult to biodegrade, and recycling is not yet widespread in practice.⁶

Deployment in the fashion industry: A large number of accessories, such as handbags and belts, are made from high-quality synthetic leather. Stella McCartney's luxury designer handbags, for example, are made from a blend of polyester (PL/PES) and polyurethane (PU). It is also widely used for the famous monogram handbags of luxury fashion houses like Louis Vuitton and Burberry (so-called "coated canvas").

⁴ Herva, 2011, p. 1879; Kering, 2020a, p. 7; Kering, 2020b, Material Intensities Database. <https://kering-group.opendatasoft.com/pages/material-intensities-2019/>; Gottfridsson & Zhang, 2015, p. 35.

⁵ Environmental Impact of Animal Leather vs. Synthetic Leather. The higher the number, the more harmful is a material for the environment. (HIGG Co, 2021, Material Sustainability Index, <https://portal.higg.org/>).

⁶ Studies have identified both fungi and bacteria that decompose PU. However, biodegradability strongly depends on the exact chemical composition of the PU material used. (Howard, 2002, p. 245; Howard, 12, p. 374-381).

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Synthetic coated textiles are also widely used in footwear and fashion, for example for leather-like jackets or skirts.

Plant-Synthetic Hybrids (AppleSkin, Desserto, Pinatex, VEGEA, Ohoskin, Oleatex)

Peoples' ever-increasing interest in sustainability regarding fashion is also impacting their relationship with synthetic materials. Since synthetic leather is made from raw oil and its disposal is difficult, consumers are seeking other vegan alternatives. As a result, several textile developers are trying to replace as much of the fossil-based raw materials as possible with plant fibers or mineral fillers. Thus, a number of so-called "plant-based" leathers have emerged in recent years.

Management consulting and market research firm Infinium Global Research published a market report regarding the vegan leather market in February 2021. According to the report, the global vegan leather market is expected to grow at a compound annual growth rate (CAGR) of 48.1 percent during the forecast period from 2020 to 2026. The report includes profiles of companies such as Ananas Anam Ltd, Desserto, Bolt Threads Inc and VEGEA SRL, among others.⁷

Technology: Plant-based vegan leathers are coated textile materials in which fruits, leaves or other plant-based components are industrially processed together with stabilizers in order for the final material to have the visual and tactile characteristics of animal leather.

Similar to synthetic leather, they consist of a base material which is coated with one or multiple layers. This is where the plant-based raw component comes in: in the base material or coating, some of the synthetic raw materials are replaced by plant-based components. So, for example, some synthetic PVC/PU coating can be replaced by agricultural waste products.⁸ Such examples are apple leather (AppleSkin, now called Uppeal, by Mabel Srl. and Leap by Beyond Leather), wine leather (VEGEA) or cactus

⁷ Infinium Global Research, 2021, <https://www.infiniumglobalresearch.com/reports/global-vegan-leather-market>

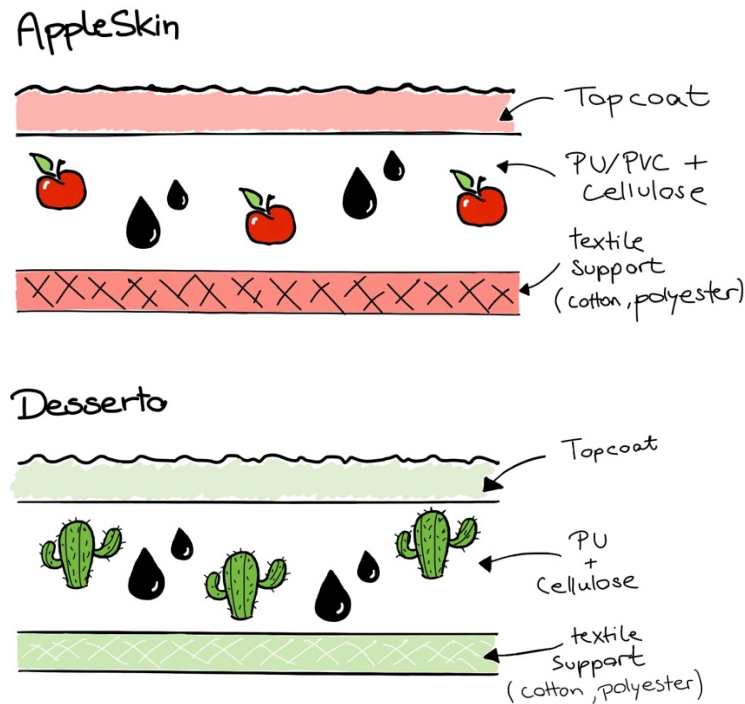
⁸ Meyer at al., 2021, p. 3.

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leather (Desserto) as well as Ohoskin (made partially with sicilian oranges and cactus) and Oleatex (made with residues of the olive industry).

Figure 3: Material cross sections Appleskin and Desserto



Source: own illustration ⁹

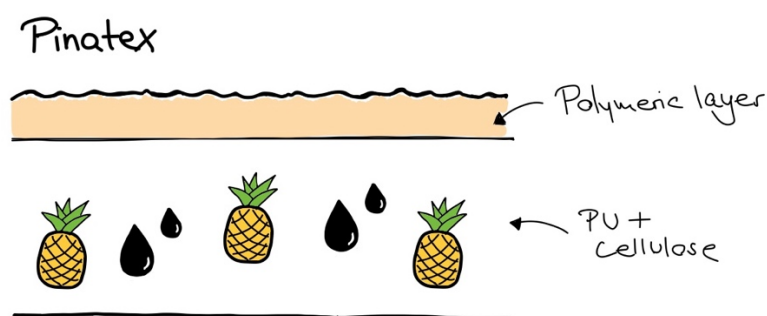
In the case of Pinatex on the other hand, the pineapple leather from the manufacturer Ananas Anam, the base material is replaced: plant fibers from pineapple leaves (PALF = Pineapple Leaf Fibre) are coated with PLA (Polylactic Acid) and PU.¹⁰

Figure 4: Material cross section Pinatex

⁹ Exemplary representation of the material cross-section of Appleskin and Desserto, based on Meyer et al., 2021, p. 5-6.

¹⁰ Using the example of Piñatex® ORIGINAL Amazon Green, <https://store.ananas-anam.com/collections/original/products/original-amazon-green>

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Source: own illustration ¹¹

Beware of greenwashing: Although manufacturers advertise with terms such as "plant leather", "plant-based" or "apple leather made from apple residues", the materials are in fact only partial of plant origin.

Performance: Hybrid leathers offer very similar basic visual and tactile characteristics to those of synthetic leather. Thereby, the synthetic components mostly serve as a stabilizer of the bio-based component, or to ensure that the qualitative requirements to which leather is subject can also be met.

Currently, there are hardly any scientifically based studies comparing the mechanical properties based on common parameters in materials science. Initial studies, however, indicate that performance depends in particular on the strength of the base material. ¹² In our own in-house testing, apple leather and cactus leather could be processed like synthetic leather. Unfortunately, pineapple leather was not so scratch-resistant in previous material tests that it would be suitable for the quality we require for designer handbags. However, for individual applications like patches on a shoe it works perfectly.

Sustainability: Even though the manufacturers of plant-plastic hybrids advertise the sustainability of their materials, there is little to no scientific data on the environmental impact to date. Desserto has published initial results of an LCA study¹³ for its cactus leather, but the survey methodology is not yet publicly available. Therefore, the

¹¹ Representation of the material cross-section of Pinatex, based on Meyer Meyer et al., 2021, p. 5-6.

¹² Meyer et al., 2021, p. 7.

¹³ Life-cycle assessments (LCA): These studies evaluate the totality of all energy and material flows within the value chain and calculate various potential environmental impacts. CO2 emissions, water consumption and toxicity, for example, are measured and evaluated.

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question of how materials such as apple leather, cactus leather or pineapple leather compare to animal or synthetic leather cannot be answered sufficiently.

One advantage of the hybrid material is certainly that some of the fossil raw materials are replaced by agricultural waste. For example, the apple powder of the manufacturer Mabel Srl., used for apple leather, is made from waste from the fruit juice production industry. The fruit content of the apple leather is about 20-30 %, the remaining 70-80 % being PU, polyester, and cotton.¹⁴ Desserto is made with 33% cactus and 67% PU in the coating and a 55% polyester / 45% cotton textile backing in its standard material. Meanwhile, most of those companies also offer the possibility to fashion brands to customize their material, meaning that the actual bio-content can differ from product to product.

In addition, these young companies often provide information on manufacturing locations and conditions in a more transparent manner than is common in the animal leather or synthetic material industry. Surprisingly, however, the base material in the standard version of the materials is often polyester or polyester-cotton blended fabric, even though the companies advertise that they do not use fossil raw materials.

Disposal: Since the plant-based materials are mixed with synthetic components, biodegradability is not a given. Recyclability has also not yet been addressed, but in principle mixed materials should be even more difficult to recycle than pure synthetic materials.

Deployment in the fashion industry: So far, the materials have proven themselves for the use in the production of accessories and can be processed in the same way as synthetic leathers. The German company Nuuwai, for instance, produces bags from Apple Skin and Sylven New York uses the material to make high-quality shoes. Since 2021, Karl Lagerfeld creates items in collaboration with Amber Valetta, including handbags made with cactus leather. The same material from Desserto was also used by BMW for a show car and a special edition Hublot watchband. Pinatex for example,

¹⁴ AppleSkinTM, <https://luxtralondon.com/pages/apple-skin>

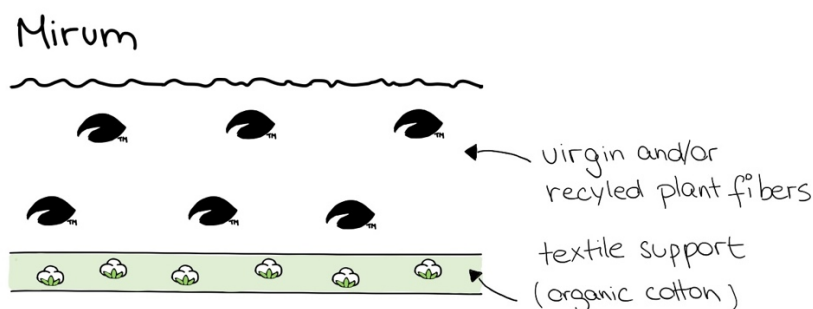
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which has unique design features due to its special surface texture, was used for shoes in a collection of HUGO BOSS.

MIRUM® (100 % bio-based vegan leather based on natural rubber)

Technology: A new, very exciting material is MIRUM® from Natural Fiber Welding, a US biotech company specialized in natural rubber chemistry. What makes it special: Natural Fiber Welding is the first company to succeed in developing a 100 % bio-based and plastic-free vegan leather. Like the other materials, MIRUM® uses a base material - which currently consists of organic cotton, cotton or Tencel. However, for the first time, the coating as well as the curing processes are not synthetic but are made with 100 % natural inputs.¹⁵ The process has been patented and promises to eliminate the use of fossil oil following the motto "Plants not Plastic".

Figure 5: Material cross section MIRUM®™



Quelle: own illustration ¹⁶

Performance: The material performs like animal leather in terms of its visual and haptic properties. During manufacturing, it is a slightly stubborn material that needs special skills to work with. During the last years, the performance increased tremendously, achieving technical performance required by the automotive industry. There is even a first show car showing MIRUM® in a seating application, one of the hardest to achieve applications for leather-like materials.

¹⁵ Natural Fiber Welding (NFW), <https://MIRUM®.naturalfiberwelding.com>

¹⁶ Representation of the material cross-section of MIRUM®, based on <https://MIRUM®.naturalfiberwelding.com>

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Sustainability: The manufacturer states that the production of MIRUM® requires only a fraction of the CO2 emissions and energy of animal and synthetic leather production. Furthermore, no water is consumed in the production process. A first LCA study conducted by Natural Fiber Welding in 2022, showed promising results with a calculated carbon footprint of 2.1 kg.¹⁷ That is around 90% less than animal leather. They are currently re-assessing their impact for their new production line.

MIRUM® consists of only natural raw materials such as natural rubber, plant-based oils, natural pigments and minerals. The raw materials are partly waste materials from other industries. Natural Fiber Welding uses FSC certified rubber for their material and also initiated a project with Terra Genesis in 2023 to create a regenerative supply chain for latex (the basis for natural rubber) together with latex farmers in Thailand.¹⁸

MIRUM® has a clear advantage over other vegan leathers as it is made only from natural ingredients. The first versions have already received USDA biobased certification. "Biobased" referring to the fact that only biogenic raw materials are used for the material instead of fossil fuels or other nonrenewable resources. Moreover, no PU coating and no synthetic adhesives or dyes are used in the production process. This also makes it possible for MIRUM® to be recycled or to go back to nature safely.¹⁹

Disposal: MIRUM® is "circular by design" – The material was developed for the circular economy.²⁰ Natural Fiber Welding initiated the EndWell program to recycle off-cuts from MIRUM® into new products. Due to its natural origin, the material can alternatively biodegrade and return to nature, although it does not currently need biodegradability according to some specific country standards, where a material is only considered biodegradable if it decomposes in under a year.²¹

Deployment in the fashion industry: MIRUM® had several market launches in the last years in the footwear, apparel and leather goods space. We were the first

¹⁷ NFW, <https://blog.nfw.earth/MIRUM®-lca-carbon-footprint>

¹⁸ NFW, 2024, <https://online.fliphtml5.com/hpmqh/ofct/#p=22>

¹⁹ NFW, <https://blog.nfw.earth/MIRUM®-lca-carbon-footprint>

²⁰ The circular economy aims to reuse used materials. Ideally, product cycles are closed according to the cradle-to-cradle principle. See also Meyer, at al., 2021, p. 1.

²¹ Natural Fiber Welding, <https://mirum.naturalfiberwelding.com/faq?hsLang=en>

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worldwide to launch the handle bag BAILEY made with MIRUM® in 2022, for which we were awarded the PETA Vegan Fashion Award and the German Sustainability Award in Design. Other great designers like ASK Scandinavia, Burggraf Burggraf, Anita Dongre or vegan brand Sentient also launched handbags out of this game-changing material. In the footwear space, Unless Collective and Nooch created a completely biobased sneaker with MIRUM®. PANGAIA used it in a capsule collection for a vest and some small leather goods. BMW is an investor in Natural Fiber Welding and they recently announced their first BMW Vision Neue Klasse with MIRUM® seating and interior. Until now, the material is only available in neutral colors like black, brown and off-white. Since, unlike synthetic leathers or plant-synthetic hybrids, it is not dyed with chemical dyes, but the color is created by minerals and other natural inputs, further colors are in development.

Uncaged (> 99 % bio-based vegan leather based on grain protein)

Technology: Uncaged is a material by the female-founded startup Uncaged Innovation. The material is a coated textile with a coating based on grain proteins. The biotech startup tested thousands of biomaterial combinations to obtain a material with the best performance characteristics. By utilizing grain proteins, they mimic the structural function of collagen in an animal hide. Besides grain, the raw materials include natural rubber, coffee cherry and plant-based lipids.

Performance: Uncaged is still under development. First handfeel tests in our manufactory showed that the material is very soft and an excellent material comparable to standard synthetic and animal leather materials. Official test results for typical mechanical performance are not yet publicly available, but also promising. They already showed their materials can be manufactured in a roll-to-roll production process.

Sustainability: Uncaged utilizes different plants to mimic the characteristic of animal leather. The backing as well as the coating is 100% biobased and plastic-free. Right now, the company uses a spray-coating, that makes about 1% of the material thickness, that is partially synthetic (67% plant-based and 33% synthetic). The material is available in a range of colors that are derived from plants or

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minerals, including some pops of colors like a red from cherry coffee. The backer is usually an (organic) cotton. A LCA study was not yet conducted.

Uncaged was founded by Stephanie Downs, a long-experienced founder and animal advocate. She is an ethical vegan that has also founded a vegan food startup in the past and worked for the Material Innovation Initiative. We love a fellow vegan joining this space, who will surely use its technology for the good.

Disposal: The material is > 99% biobased. How the partially synthetic coating influences biodegradation, still has to be determined. Tests to recycle the material are also to be conducted in the future.

Deployment in the fashion industry: Uncaged is a promising material still under development. They plan to launch first products in 2024 with selected brand partners. In 2023, they secured funding of \$2 million including funding from Jaguar Land Rover, who supports them in developing the material further for automotive applications.

Treekind (100 % bio-based vegan leather based on leaves)

Technology: Treekind is a material by the female-founded startup Biophilica from UK. The material is a coated textile with a coating based on lignocellulose feedstocks from local urban parks and gardens, agricultural waste and a natural binder. Like MIRUM®, it is made of 100% natural inputs and completely plastic-free.

Performance: While the material is still under development, it already achieved good test results in performance parameters like flexibility, tensile strength or abrasion.²² As it is currently rather compact, it is best used in boxy shaped designs.

Sustainability: Treekind offers excellent sustainability parameters. It is a completely biobased, plastic-free material. A first LCA study conducted by the Bangor University, shows that the material only emits 2.19 kg of CO₂, which is ca. 90% less than animal leather, as well as ca. 0.1% of water compared to an average leather tanning process. The material is either undyed in different natural hues like

²² Biophilica, 2024, <https://www.biophilica.co.uk/treekind>

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brown, dark red or dark green or it can be dyed with natural pigments. The backer typically consists of an undyed cotton.

Disposal: Treekind is the only vegan leather that is certified home compostable.²³ According to Biophilica, it can also be recycled, although this was only tested on lab scale so far.

Deployment in the fashion industry: Treekind is a very exiting material that is still under development. Been London has created some first bags and small leather goods, which are not yet commercially available. The Swiss watch brand ID Genève sells watch bands made with Treekind for their watches Circular 1 and Circular S. This very watch was also lately worn by Leonardo DiCaprio.²⁴

NUVI (100 % bio-based vegan leather based on algae)

Technology: NUVI is a German startup creating biobased, plastic-free materials from algae polymers, plant and mineral fillers and a flax backing. All raw materials are sourced within the EU. Although some of the companies' materials look leather-like, they specialize in materials reflecting the unadulterated characteristics of nature. NUVI is still under development, but already showed their materials can be manufactured in a roll-to-roll production process. They use for example marble powder, which leads to a material that has the same fine sheen to it as a marble rock. What was once a hard rock leads to a soft and drapery material, which gives designers new creative possibilities.

Performance: NUVI is still under development, but already showed their materials can be manufactured in a roll-to-roll production process. The company states that their materials can be used for applications like leather goods, footwear, interior or automotive, depending on the specific material, and that it has performance parameters similar to animal leather.

Sustainability: NUVI is a completely biobased, plastic-free material. All raw materials are sourced within the EU and the materials are manufactured in

²³ Home Compostable according to ISO 14855-1 testing procedure; Biophilica, 2024, <https://www.biophilica.co.uk/treekind>

²⁴ Something about Rocks, 2023, <https://somethingaboutrocks.com/article/leonardo-dicaprio-invests-in-eco-watch-brand-id-geneve/>

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Germany. The material is either undyed, showing the natural characteristics of the raw ingredients, or it can be dyed with natural pigments. The backer typically consists of an undyed flax. A LCA study was not yet conducted.

Disposal: NUVI is made from natural raw materials only, and thus should readily be biodegradable. An official biodegradability test is planned.

Deployment in the fashion industry: NUVI promises new exciting design possibilities. The material is not yet commercially available. We have created a first showcase bag made with their chalk and marble material for the Future Fabric Expo in January 2024.

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Comparison table*

	Animal leather	Mycelium-based biomaterials	Muskin ("mushroom leather")	Bacterial cellulose-based biomaterials	Collagen-based biomaterials	Synthetic leather (Polyurethan/PU coated textiles)	Plant-Synthetic Hybrids	Latex-based biomaterials (MIRUM®)	Other Plant- and mineral based biomaterials
Companies creating material (material name)		Squim (Ephea) MycoWorks (Reishi) Bolt Threads (Mylo)	Grado Zero Innovation	Polybion (Celium) Modern Synthesis	Modern Meadow (Bio-Alloy)	Contintental Limonta	Marbel (AppleSkin) Desserto (Desserto) Ananas Anam (Pinatex) Vegea	Natural Fiber Welding (MIRUM®)	Biophilica (Treekind) Uncaged NUVI (Creta)
Production/ Technology	Animal skin is processed into leather in chemical and mechanical processes ("tanning")	Net-like biological mass (mycelium) is processed into leather-like material in chemical and / or mechanical processes	Caps of the phellinus ellipsoideus are treated in a chemical + mechanical process similar to animal leather	Bacteria are fed with agricultural waste in bioreactors and produce (nano-)cellulose, which is then processed into leather-like material in chemical and / or mechanical processes	Collagen as a building block is created in the lab and mixed with other bio and / or synthetic inputs to create a composite biomaterial	Textile backing (cotton / polyester) + synthetic poly layer	Textile backing (cotton / polyester) + polymer layer Part of the base material or coating is replaced by plant fibers.	Textile backing (organic cotton, cotton or Tencel) + coating Coating and adhesives of 100% plant and mineral origin: 47% natural rubber, 25% plant and mineral fillers, 28% natural waxes and oils	Textile backing (natural textile like cotton, flax, viscose) + coating Treekind: lignocellulose and other plants and minerals NUVI: Algae polymer, chalk, polyol, dye Uncaged: grain protein, natural rubber, coffee cherry, plant-based lipid
Performance	Collagen as building block delivers strength, performance dependent on tanning + coating Otherwise not durable against moisture and water	Performance depending on processing + coating / backing Material "Reishi High Strength" surpasses animal leather in mechanical measurements (synthetic coating / backing)	Antibacterial effect, moisture-regulating Must be combined with textile backer/waxes to increase resistance	Performance depending on processing + coating / backing Little data available today	Still under development, little data available today Modern Meadow similar / better performance than animal leather (synthetic components)	Quality and properties can be configured almost freely	Similar to the visual and haptic properties of leather Performance dependent on processing + coating + backing (usually higher performance with synthetic backers or higher percentage of synthetics in coatings)	Haptic and visual properties comparable to animal leather Meets performance requirements of automotive (used by BMW)	External tests lead to results that make it comparable to leather in most tests
Sustainability of raw material extraction	- High environmental impact in the rearing and	+ Mycelium growth low requirements (grows on waste products, no light required)	+ Mushroom is harvested in nature	+ Grows on agricultural waste with little resources	+ Strength of collagen without the ethical and environmental impact of animal leather	- Resource-intensive crude oil production	+ Part of fossil raw materials replaced by agricultural waste	+ Raw materials partly waste materials from other industries (e.g. cork)	+ Treekind partly uses waste materials (leaves) + Uncaged uses partly waste

* Disclaimer for table: Partially no values available for comparison, as there are rarely reliable studies.

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	slaughter of animals		+ cannot be cultivated according to the manufacturer		- Mixture with synthetic inputs depending on technology				materials (coffee cherry)
Sustainability of the manufacturing process	<ul style="list-style-type: none"> - Enormous consumption of resources in production (chemicals, water, CO2) - Harmful waste products (e.g. chromium) - In developing countries (approx. 70% of production volume) insufficient waste management 	<ul style="list-style-type: none"> - Processing into leather consumes resources depending on manufacturing process (currently too less information available) 	<ul style="list-style-type: none"> + Treated without toxic substances + plastic-free - Processing into leather consumes resources depending on manufacturing process 	<ul style="list-style-type: none"> + Bioreactors require little land and water - Energy uptake - Processing into leather consumes resources depending on manufacturing process (currently too less information available) 	<ul style="list-style-type: none"> - Processing into leather consumes resources depending on manufacturing process (currently too less information available) 	<ul style="list-style-type: none"> - Depending on textile carrier (polyester / cotton / ...) + type of coating. + Production on average more resource-efficient than animal leather production 	<ul style="list-style-type: none"> - Depending on textile carrier (polyester / cotton / ...) + type of coating 	<ul style="list-style-type: none"> + CO2 emissions and energy consumption lower than animal and synthetic leather (manufacturer's specification) + No water consumption during production 	<ul style="list-style-type: none"> + CO2 emissions and water uptake significantly lower than animal leather (according to innovators)
Environmental impact based on LCA data?	<ul style="list-style-type: none"> - According to HIGG Index approx. 5x as high environmental impact as synthetic leather; third most damaging textile material ever - Other scientific studies: 2-5x as high environmental impact as synthetic leather 	<ul style="list-style-type: none"> Insufficient data on the overall process to date 	<ul style="list-style-type: none"> Insufficient data on the overall process to date 	<ul style="list-style-type: none"> Insufficient data on the overall process to date 	<ul style="list-style-type: none"> Insufficient data on the overall process to date 	<ul style="list-style-type: none"> + According to HIGG index approx. 5x lower environmental impact as animal leather - Other scientific studies: 2-5x lower environmental impact as animal leather 	<ul style="list-style-type: none"> Insufficient data on the overall process to date 	<ul style="list-style-type: none"> + CO2 emissions 10 times lower than animal leather Insufficient data on other impact categories 	<ul style="list-style-type: none"> + Treekind uses <0.1% of water animal leather processing needs + CO2 emissions significantly lower than animal leather
Disposal	<ul style="list-style-type: none"> - Limited biodegradability - Enormous waste volume, partly difficult / not biologically degradable - Recycling not technically / economically feasible 	<ul style="list-style-type: none"> Biodegradability and recyclability depend on the processes, dyes and coatings used Hardly any information from the Manufacturers 	<ul style="list-style-type: none"> Biodegradability and recyclability depend on the processes, dyes and coatings used 	<ul style="list-style-type: none"> Biodegradability and recyclability depend on the processes, dyes and coatings used Hardly any information from the manufacturers 	<ul style="list-style-type: none"> Biodegradability and recyclability depend on the other input factors, processes, dyes and coatings used Hardly any information from the manufacturers 	<ul style="list-style-type: none"> Limited biodegradability. No recycling in practice. 	<ul style="list-style-type: none"> Limited biodegradability. No recycling in practice, recycling of mixed materials (plant + PU) generally more difficult. 	<ul style="list-style-type: none"> Developed for the circular economy: biodegradable and recyclable 	<ul style="list-style-type: none"> Treekind is certified home-compostable according to ISO and recyclable at lab scale. Uncaged uses a spray coating of 1%, that is partially synthetic (33% synthetic and 67% biobased), how that influences the biodegradation process is not yet clear

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									NUVI is biobased, biodegradation should be possible (not yet officially tested)
Deployment in the Fashion industry	Commercially available	Scaling still an issue due to inconsistencies in growing mycelium; first capsule collections available	Currently not applicable for industrial purposes	Currently still under development	Currently still under development	Commercially available	Commercially available	Commercially available	<p>Treekind: first capsule collections available</p> <p>Uncaged: Currently still under development</p> <p>NUVI: Currently still under development</p>

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