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Elevating the Passenger Experience

Title: **Demystifying Sustainable Fabrics: The Future of Aircraft Interiors**

Theme: Given the emergence of changing consumer needs, an aviation marketplace being disrupted by evolving values related to the planet, updated goals to support these values, increasing competition and the continued need to create superior customer experiences, ***a new category of sustainable fabrics is developing***.

Introduction: This category is challenging materiality suppliers to "up their game" by defining their contribution to the transformation of the aviation world, driven by the need to meet the sustainability requirements of the industry.

This new category is very difficult to navigate as it is developing quickly, full of new innovations, and in some cases technically complex. Participants in the industry struggle to understand what is available, what is being developed and the differences between each.

There has been much talk about leather alternatives in recent years, as the search for a more sustainable alternative is considered. Ever since the EV market coined the phrase "vegan leather", the race has accelerated in the search for new and innovative sustainable materials to replace leather.

Leather is the second oldest industry known to mankind and is often frowned upon for its perceived lack of sustainability and negative environmental impact. David Breslauer, CTO of Bolt threads and a Cal Berkely PhD graduate in Bio Engineering, said in a recent CBS interview "The fewer cows we grow industrially, the less emissions were going to have. This is a huge impact for climate change, the fashion industries biggest contributor to greenhouse gas emissions are the cows that make their leather, then there is deforestation, biodiversity loss, ecological collapse, the list goes on and on."

Whilst cows are not raised for their hides, there is a link to some of the ideas Breslauer mentions, which fit with the current narrative of sustainability at any cost and a move away from fossil fuel-based polymers and circularity of materials to ensure a renewable future. Recent innovations have seen all manner of products touted as the future of sustainable materials from products such as Desserto's Cactus leather to Barcelona based Pinatex Pineapple leather and Bolt threads Mylo mushroom-based leather. It seems that most fruits and vegetables have been trialed as leather replacement, but are they genuinely innovative and solving a problem, or is this an attempt to reuse every type of fruit and vegetable for merit points without genuinely being useful? What is the materials science industry doing about it and are they evolving with the increasing demands of tomorrows consumer?

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Genuine Leather

First let's take a look at genuine leather and examine how bad it really is? Genuine leather is one of the world's oldest products and full disclosure, this author is a leather purist at heart. As mammalian hunter gathers, we evolved as humans to protect ourselves and our families and not soon after we had worked out fire and cooking, the discarded hides left in leaf filled puddles soon caught our ancestors' attention. The natural tanning effects of water and leaves of plants like Mimosa and Quebracho soon increased the value of the discarded animal hide to a protective covering. Animal hides were naturally engineered for similar purposes, to protect, insulate and waterproof, so it made sense if the decay could be stopped to use it for an additional covering layer. Over the years, we learned to manipulate the product with natural oils and products until synthetic polymers and oils increased the haptic and durability of leather tenfold.

Today, leather remains as a cached, luxurious product used for shoes, accessories, apparel, upholstery and of course seating for vehicles. Leather is a byproduct of the meat industry, no cows (despite some contrary beliefs) are raised for their hides, the economics simply don't allow it to happen. If leather was not made, it would be discarded and landfilled, so in many ways, leather is a great example of an upcycled product. Naysayers would have you believe that the leather industry is one of the most polluting industries in history. Desserto proclaim on their website that large amounts of toxic chemicals and acidic effluents concentrated with heavy metal chromium, lead, arsenic, cobalt, copper, iron, zinc and manganese are leached into water supplies. They also claim that over 70% of untreated hide is discarded as solid waste and into landfills and that wastewater pollution is primarily a byproduct of the preparation stage where flesh, hair, mold and excrement are mixed in wash water and discarded into the water system.

The truth is fortunately a lot less dramatic, animal waste and mold for example are strictly controlled in food processing plants where the hide is removed from the carcass. The flesh and meat are carefully controlled and kept on the carcass, anything left on the hide would be an enormous waste and fiscal loss to the meat packer and modern methods are used worldwide to ensure maximum efficiency.

Lead and other heavy metals apart from chromium have not been present in leather processing chemicals for over 30 years as the industry moved to water based and sustainable chemical products a very long time ago. Trivalent chromium is an abundant and reasonably inert chemical found throughout nature and should not be confused with the similar but chemically different hexavalent chromium, which is not used in the leather industry and is not easily converted from its trivalent cousin.

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However, cows do produce methane, which is quickly broken down to biogenic carbon based CO^2. Large areas of the world have been deforested to allow for increased cow raising to support the beef industry and whilst not directly caused by, they are a byproduct of that industry.

Let's take a look at the competitors and new vegan innovations and examine just how sustainable they really are and if they offer a genuine solution to reducing the drain on our natural resources.

The competitors

Mylo

Mylo from Bolt Threads is a Silicon Valley startup, founded by a group of PhD bioengineering graduates. The product seeks to grow Mycelium in large self-contained farms. The mycelium grows into a foamy wispy layer. The mycelium is harvested and processed into a sheet material and then is finished by a Leather tannery using leather finishing methods, as per their website. The company has been in existence for around ten years, but commercial, revenue generating products are still not available.

Desserto

Desserto is the infamous cactus leather. Desserto uses an intermediary layer that is infused with processed cactus to create a hybrid layer. A backing layer is added and then a polyurethane based finish is applied, similar to the Mylo method above.

Eleather

Eleather was one of the original bio-based products. Using the same waste that Desserto talk about on their website, they take chrome shavings from wetblue (tanned hides) and create a paste that is then applied to a high-performance fabric layer, which is used as the base for the product. The product is then coated in a similar method to the Desserto product above using traditional polyurethane chemistry.

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Pinatex

Pinatex was invented by Carmen Hijosa, a materials scientist from Barcelona. Whilst working in the Philippines, she noticed such huge waste from the discarded exterior of the pineapple leaves. The leaf waste is collected, the fibers are extracted, washed, dried in the sun and then mechanically bonded together. The short length fibers (24 inches or so) are spun into yarn and then needle punched into a felt. The product is then coated with 40% oil-based resins, otherwise known as plastics. Today the resin is down to less than 5% petroleum-based resin. According to the founder, over 27 million tons of leaves are discarded every year as biomass, which is estimated to be enough to cover the entire annual production of shoe leather.

Modern Meadow

Modern Meadow founder Andras Forgacs started out with a company called Organovo almost 20 years ago. His father, Gabor was a renowned scientist in his native Hungary and pioneered several advances in bio-fabrication. They founded Modern Meadow with the aim of taking what they had learned about bi-fabricating organs at Organovo and producing a bio-fabricated leather product. The base layer is designed to be grown organically, bio-fabricated over a relatively short period of time and then finished using a similar method as the Pinatex above. The company has been in existence for around ten years, but commercial, revenue generating products are still not available. MM has since moved to using soy and/or collagen proteins, so has moved down a similar path to the other novel leathers discussed previously.

Ultrafabrics

Ultrafabrics, as you know, is a company I work very closely with and in the last ten years they have been working with a clear sustainable goal in mind. Our product as a synthetic leather is composed of a backcloth layer made from cellulosic materials, a Polycarbonate foam layer and is finished by, you guessed it, a similar method to the other products above. There are some subtle differences in that the topcoat is polycarbonate, not polyurethane, which has a longer lifespan, which is in itself more sustainable. In addition, we are moving away from petrochemical based products in every element of our products and by 2030, will have moved to over 70% of our products being made from bio-based, sustainable and renewable products. The backcloth is moving to a fully sustainable product called Tencel, which is made from bio-based wood pulp sourced from sustainably managed forests. The fabric base layer is made in a closed loop system and the final product is inert with very little VOC's, much lower than the other sustainable products featured above.

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Table 2. Physical properties.

Physical Properties		Thickness	Tensile Strength	Tear Res.	WVP	WVA	Flex Res.
		ISO 17186-A	ISO 3376	ISO 3377-1	ISO 14268	ISO 17229	ISO 32100
		(mm)	(N/mm^2)	(N/mm)	($mg/(cm^2 \times h)$)	mg/cm^2	Flex Cycles to Grade > 2
Naturally grown material	Leather	1.93	39.5	82.9	4.6	8.4	>200,000
	Muskin®	6.22	0.2	0.5	10.4	6.0	10,000
	Kombucha	0.29	9.7	5.1	0.1	9.2	10,000
Coated textile	PUR coat text.	1.37	10.2	17	1.1	1.4	200,000
	Desserto®	0.88	20.8	37.2	0.5	2.5	30,000
	Appleskin®	1.14	14	18.4	0.4	1.7	50,000
	Vegea®	0.95	9.4	16.6	0.6	3.0	50,000
	Teak Leaf®	0.57	12.2	30.7	0.1	0.1	100
Non-wovens of plant fibers	Pinatex®	1.43	4.5	31	2.5	3.8	150,000
	SnapPap®	0.57	24.9	7.5	10.3	3.7	5,000

(WVP: water vapor permeability; WVA: water vapor absorption; Tear Res: tear resistance).

Source:- Comparison of the Technical Performance of Leather, Artificial Leather, and Trendy Alternatives - FILK 2021

We are moving in a similar direction to Pinatex with bio-based resin and polymer systems in the topcoat and intermediary layers.

Perhaps the greatest advantage is that Ultrafabrics products have a history in their sector and do not suffer from the lack of physical properties that the other leather alternatives have.

In the table above, courtesy of leather research center, FILK, most of the products have very low tear strength that would render it unfit for purpose in an aircraft interior. Ultraleather typically has a tensile strength in excess of 25 N/mm2 and flex resistance in excess of 100,000 cycles on a bally flex.

When we look at sustainability in products in addition to the use of bio-based materials several other questions have to be asked:

1. Is the bio component providing a use to the product?
2. Does the bio version equal or improve on the current status quo (leather or synthetic leather)?
3. Can the bio component be scaled to genuine mass production at a scale that can genuinely replace leather as a product?
4. If the bio-based component is being used to recycle, what is the sustainable impact assessment of reusing it over starting from fresh?

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5. Do the Vegan alternatives really offer any difference or sustainable improvements over existing products (genuine and synthetic)?

Using the cross-section illustrations above, we can see that almost all of the vegan replacements are essentially only replacing one element, the backcloth and even then the new base layer is either compromised physically with reduced performance or the amount added is so minimal that it could be argued it was done to tick a box, not genuinely improve or replace a product. For every cactus leather there is also an apple leather, mango leather and more or less every other type of fruit and vegetable imaginable and all made in more or less the same way, none at scale.

We must also think about the scale factor by asking can the product be grown, harvested, etc. at a scale that can support the wide implementation of a new product? Cactus for example takes approximately ten years to grow one inch. At that rate, a significant amount of land would be needed to replace leather at the amount of duplication that would be needed to keep up with supply. Mylo and Modern Meadow have not been successful in over ten years of development, if they can't scale it in ten years, can it really be scaled?

Most of the products don't really offer a tangible improvement on performance or aesthetic quality over genuine or synthetic leather, so their only tangible benefit could be said to devolve back to a recycle of waste products (cow dust, apple dust, mango dust, cactus dust, etc.). But how much energy and resources are actually used converting the waste into a new product that offers no real tangible performance improvement versus alternative means of disposable? Apple skins for example when buried decompose and biodegrade proving a circular benefit to the planet, turning them into leather requires water, power and chemical processing that arguably depletes natural resources to a much greater extent.

More research is certainly warranted in the use of bio-based base layers and I would love to see more work done on using materials like bamboo and algae for example, principally for their speed of growth. Bamboo grows so quickly that you can literally watch it grow in real-time. The pace of growth and ease of growth would support rapid scale without draining resources, the same can be said for algae. Bamboo made into either rayon or viscose are all currently available and I encourage more research into those types of areas. It is important to remember that even with all of these advances in backcloths, we need to tackle the synthetic polymers and look to replace them with bio-based polymers. Leading chemical companies are making huge advances in these sectors and work from the likes of Pinatex and Ultrafabrics with bio-based resins must be a focus going forward.

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Ultimately, we should applaud the ingenious and innovative efforts of some of the worlds pioneering scientists in creating new sustainable products. It's certainly a direction we should continue to explore, but we should not forget or discount the excellent efforts of next generation products like Ultraleather and not forget there is still a strong argument for genuine leather. Sometimes the original ideas are the best ones after all.

Product List

1. Pinatex - Pineapple Leather - https://www.ananas-anam.com/
2. Desserto - Cactus Leather
3. Vegea - Grape Leather
4. Mylo - Mushroom Leather- https://mylo-unleather.com/
5. Modern Meadow - Biofabricated Leather - /www.modernmeadow.com
6. Eleather -
7. LOVR - Hemp leather - https://www.revoltech.com/
8. Leap - Apple leather - https://www.explore-leap.com/
9. Tomtex - Bio based waste materials - https://www.tomtex.co/
10. Mirum – plant based material - https://mirum.naturalfiberwelding.com/
11. Fruitleather - fruit waste leather - https://fruitleather.nl/
12. Bio Philica - Leather from tree waste - https://www.biophilica.co.uk/
13. Lino Leather - Leather from Linoleum - https://www.donyawkwaning.com/linoleather
14. PortgualiaCork - Leather from Cork - https://www.portugaliacork.com/
15. Ohoskin - Orange and Cactus Leather - https://www.ohoskin.com/
16. Bucha Bio - Bacterial Nano cellulose - https://bucha.bio/materials

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