WHITEPAPER

Renewability of materials in the leather value chain

SMIT & ZOON

Renewability as a building block for sustainability

Sustainability is here to stay. Increasingly, it is becoming a driving choice in fashion, automotive, furniture and other industries which use materials such as leather. Improving sustainability by implementing measures such as those promoted by Tannery of the Future is one way. Certifications like LWG, ZDHC and others are another good means to increase sustainability in the production process. Furthermore attention is being paid to responsible use of chemicals and designing processes for the creation of materials for fashion, seating and other leather goods. We fully support these market developments.

Renewability is one of the building blocks of sustainability. But what does renewability mean? How can it be measured and how can it contribute to lowering your environmental impact as a brand or tannery? The purpose of this paper is to (a) provide an understanding of the concept of renewability, (b) zoom in on the renewability of leather, also in comparison to alternative materials and (c) give an insight in how we at Royal Smit & Zoon, implement renewability through innovation with bio-based ingredients, to avoid resource depletion and lower CO_2 emissions.

When it comes to renewability, there are multiple interpretations and explanations. In this paper we share ours. This paper is meant to create an insight into the importance of renewability, thus using bio-based chemicals, and in the processes and chemistry of leather specifically. Moving towards bio-based ingredients, instead of fossil-based ones, is part of that goal.

We should be smart about the use of raw materials. Let's celebrate the diversity and resources that Mother Nature has to offer, rather than depleting the planet.

Definitions

What are renewable materials?

According to EN ISO 14021:2016, renewable materials are materials composed of biomass and can be rapidly replenished. This definition is largely overlapping with the definition of bio-based materials. Similarly, the renewability concept can also be seen as an alternative way of expressing the bio-based content of a material.
Bio-based solutions are a way to achieve higher renewability and improve sustainability. Bio-based materials help to keep the earth's CO_2 balance, whereas petroleum-based materials do the opposite.

According to definitions from the European Committee of Standardization, 'Renewable material' means a material that is composed of biomass and can be continually replenished. Related to this, a material can be called 'rapidly renewable' if it has a harvest cycle of ten years or less.

(Materials – Sustainability (williams.edu))

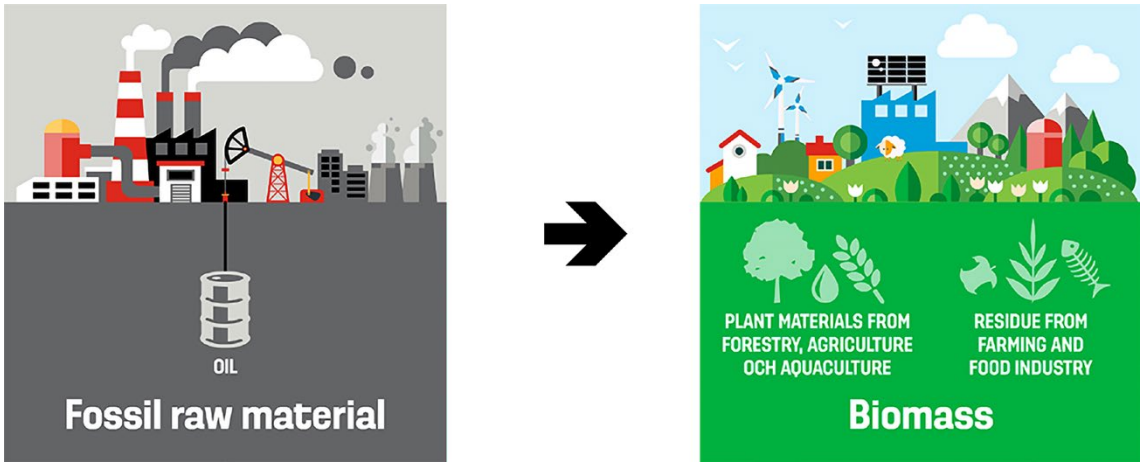
What is biomass?

Biomass refers to materials of biological origin, excluding materials embedded in geological formation and/or fossilized ones (i.e. fossil fuels). It may refer to renewable organic materials from both plant or animal origin and can be continuously replenished. Biomass contributes to CO_2 capture and is part of a continuous CO_2 renewable cycle.

What is fossil-based or petroleum-based?

Fossil-based materials refer to materials made from fossil fuels, including petroleum (crude oil), coal and natural gas. Fossil fuels are carbon-based and are continually formed by natural processes of dead organisms over a period of millions of years. They are generally classified as non-renewable resources due to two reasons:

(1) It takes a very long period to form them,
(2) Currently known viable reserves are depleted much faster than the speed at which they are being re-generated.



Improving the renewability of materials means shifting from fossil materials to biomass as a resource.

What is bio-based content?

Bio-based content is the fraction of a product that is derived from biomass (EN 16575: 2014). Carbon is present in the atmosphere as CO_2. Organisms such as plants, algae and some bacteria convert this inorganic carbon to organic carbon (carbohydrates) using sunlight. Over geological time frames (>106 years) this organic matter (plant materials) becomes fossil fuels. The carbon atom C has a naturally occurring variant C14, which slowly disappears over time. As a result, the C14 of fossil-based materials that is older than 20,000 years disappears almost completely. In other words, the presence of C14 in a material must originate from recent atmospheric CO_2 and the C14 content may be used as a tracer of chemicals or materials recently synthesized from atmospheric CO_2, particularly those derived from biomass. In the context of materials and chemicals, bio-based content can also be refered to as the renewability or the renewable content of a material.

What is C14?

C14 or carbon-14 is the longest-lived radioactive isotope of carbon, whose decay allows the accurate dating of archaeological, geological and hydrogeological artifacts. C14 relates to the renewable carbon content of a material and can be directly measured using analytical tools. C14 can be used as an independently proven method to show progress on renewability as a steppingstone of eco-(re)design, based on life cycle thinking (LCA). C14 is not used as a direct environmental sustainability indicator.

How to measure bio-based content?

There are two ways of determining bio-based content:

- C14 measurement: determine the bio-based carbon (out of all carbon or all organic carbon) by direct analytical measurements
- Mass balance: determine the bio-based content by theoretical calculations.

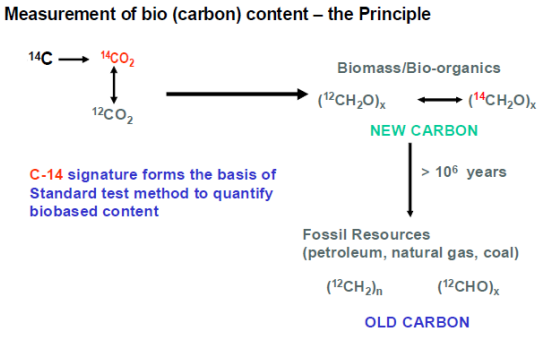
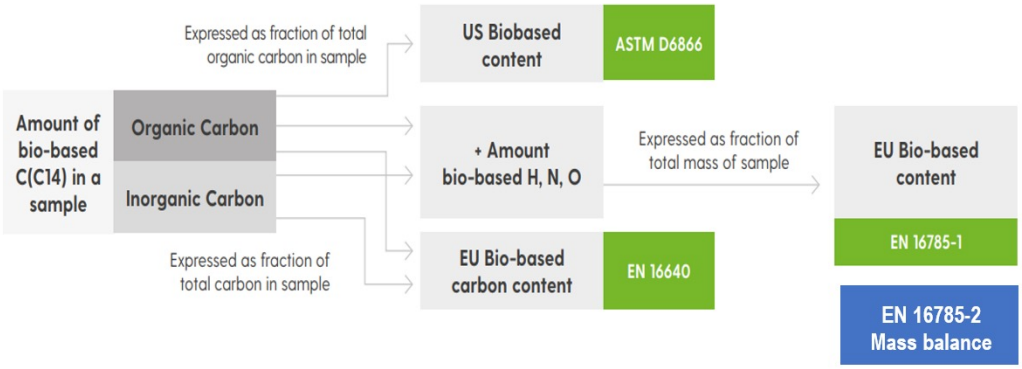


Figure 1. Basic principle of bio-based content determination by measurement on the C14 content.[1]

[1] *R. Narayan, Biobased & Biodegradable Plastics: Rationale, Drivers, and Technology Exemplars; Degradable Polymers and Materials: Principles and Practice (2nd Edition), Chapter 2, pp13-31, 2012.*

Based on the above principle, several standards are developed to determine the bio-based contents of products:[2]



Calculation bio-based statements

ASTM 6866 (US bio-based content): this standard specifies a test method to 'experimentally' measure the biobased carbon content of solids, liquids, and gaseous samples, using radiocarbon analyses. The bio-based carbon content is calculated as a fraction of the organic carbon. Thus, any inorganic (fossil) carbon present in the product is not considered in the determination. Nor are non-carbon molecules considered when determining the bio-based content.

EN 16640 (EU bio-based carbon content): the analytical test method of this standard is compatible with that of ASTM 6866. However, attention should be paid to the fact that the bio-based carbon content in EN 16640 is expressed by a fraction of sample mass or as a fraction of the total carbon content thus not excluding the inorganic carbon components.

EN 16785-1 (EU bio-based content part 1: Determination of the bio-based content using the radiocarbon analysis and elemental analysis): the bio-based content of a product including all major elements including carbon, hydrogen, nitrogen and oxygen as a fraction of the total mass of a material. However, isotopic measurements are only performed on carbon, the contents of other elements are obtained by calculations.

EN 16785-2 (EU bio-based content part 2: Determination of the bio-based content using the material balance method): calculating the bio-based content in products using the material balance applied to a representative product batch in a production unit when the composition of the product and the bio-based content of each input, output and loss are known and when the bio-based content of the product is verifiable by analysis.

For the chemical industry, it would be preferable if the bio-based contents of chemicals (products) is determined or verified by one of the analytical methods described above, for example ASTM 6866. However, as this is not always feasible especially during the product development process, it would be helpful to develop a calculation method that can result in an as close as possible approximation of the bio-based content of a product (following EN 16785-2).

[2] *H. Willemse, M. van der Zee, Communicating the bio-based content in the EU and in the US.*

Renewability of leather

Leather is a renewable material. Leather starts with a hide or skin, which is a natural material and 100% bio-based. By using products in the leather making process with a high level of bio-based content, the level of renewability of the material remains high. The renewability of leather can be as high as 95%.

Still, even in a case of using less sustainable chemicals or in case of leather with heavy, non-biobased, conventional finishing, the renewability level of leather will not likely go below 70%. In comparison to alternatives to leather, this is very high, since most alternatives contain a high level of fossil-based materials (e.g., plastics) and will likely not score higher than 20% renewability.

Genuine leather vs. alternative materials

The figure below shows comparisons of bio-based carbon (C14) contents measured on leathers with different wet-end and finishing recipes (bio-based vs traditional petro-based, Royal Smit & Zoon internal data) and on various types of 'bio-based alternative materials' such as 'cactus leather' and AppleSkin.

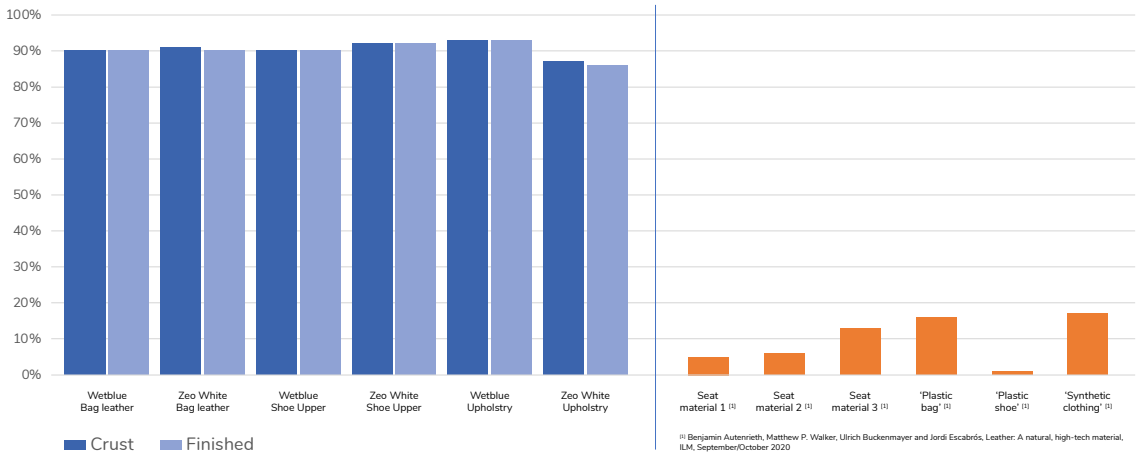
The data presented in the figure clearly demonstrates the bio-based nature of leather. Even with traditional petro-based wet-end and finishing recipes, finished leather still presents a typical bio-based carbon content between 70-80%. This can be further optimized up to a range of 85-95% using bio-based recipes, without significantly impacting the performance of the leather. By contrast, the self-proclaimed 'bio-based alternative materials' typically present bio-based carbon contents below 30%.

The effect of high bio-based content in leather

A hide is renewable in and of itself and intrinsically biodegradable. Depending on the leather making process, including the right chemicals and tanning agent, biodegradability and compostability levels can be further improved. Using the right chemicals in the leather making process is aimed at keeping the renewability level as high as possible. When the leather itself has a high renewable content, this also means the waste streams and residues (clippings, shavings) from this leather making process will have higher bio-based content and can therefore be re-used, recycled or bodegraded more easily

Bio-based in combination with good biodegradability will support full circularity of leather if, of course, the leather is also correctly processed after use.

Smit & Zoon renewability bio-based collection
Difference is based on choice of wet-end products (C14 optimized or common products)



Data extracted from S. Bartalini, F. Carcione, G.A. Defeo, I. Galli, D. Mazzotti, "Leather and Alternative Materials: A Novel Method for Bio-Based Carbon Quantification through Saturated-Absorption Cavity Ring-Down (SCAR) Spectroscopy", Proceedings of the EURO IULTCS 2022, September 2022.

Examples of bio-based materials in leather manufacturing

Which bio-based materials can be used to replace petrochemicals? Royal Smit & Zoon uses a wide range of classical and new innovative, renewable/ bio-based ingredients for its products. For example:

1. Fish oil

For most of its history Royal Smit & Zoon has used fish oil already. Fish oil goes back to the start of our company in 1821 by Albert Smit, when the main trading products were dried codfish, salted herring and medicinal cod liver oil. Today, Royal Smit & Zoon uses a technical fish oil from by-products from food industry that are not suitable for use in human food or animal feed. This means that, unlike almost all other vegetable or animal oils, the use of this type of oil does not compete in any way with use for human food. The by-products originate from farmed fish. This means that the production of this oil does not have a relation with the environmental risks related to wild catch fisheries, like depletion of species, damaging of seafloors, Illegal, Unreported and Unregulated (IUU) fishing etc.

2. Vegetable oils and vegetable based products

Examples of vegetable oils or products of vegetable/ plant origin are wheat flour, lecithin, synthetic lanoline from bio-based materials, rapeseed oil, sunflower oil, soy bean oils, and molasses, just to name the main products.

3. Forestry

Forestry production delivers both classic ingredients, such as lignosulphonate, but also next generation ingredients such as lignin, for use as bio-aromatics. Royal Smit & Zoon is engaged with partners who only use certified, sustainably grown woody biomass which is not only produced sustainably and efficiently, but also preserves the biodiversity of the forests.

4. New innovative sources and processes

Innovation is at the heart of our company and we are continuously looking for new sources and ingredients to make the chemical industry more sustainable, reducing CO_2 emissions from production and reducing non-degradable and toxic substances.

Research conducted by Wageningen Food & Bio-based Research in close collaboration with Royal Smit & Zoon has shown that pectins from sugar beet pulp are suitable as bio-based ingredients for the production of leather. Royal Smit & Zoon has also developed novel production process in the LIFE BIOPOL project, where bio-based materials, including leather shavings, can be processed to make high quality performance products.

Renewability as part of sustainability

As we mentioned in the introduction, renewability is not a goal in itself. Renewability is one of the building blocks of making the leather value chain more sustainable and lowering the environmental impact of the industry.

Other elements of sustainability, with reference to leather, are:

- Biodegradability/compostability
- Emissions
- Animal welfare
- Sustainable sourcing
- Durability
- Reduced waste
- Potential for re-use, recycle, repair

It is also good to understand that materials classified as bio-based are not necessarily more sustainable. It is important to not only look at the ingredient itself, but also at the way it is being sourced, for example. Wood is a bio-based material, but if it contributes to deforestation it is not necessarily more sustainable.

Additionally, being bio-based does not indicate whether the ingredient and end product are biodegradable, which is also an important element of sustainability. Biodegradability and compostability can be measured by established methods. The overall sustainability of a product could be be evaluated by looking at its life cycle and if possible, quantitatively measured by a Life Cycle Assessment (LCA).

More information on LCA can be found in our sustainability Q&A document.
More information on Biodegradability can be found in our whitepaper on Biodegradability and disintegration of leather.

Certifications

Especially for designers and fashion, footwear, automotive, furniture and aviation brands it can pose a challenge to acquire information on how to source materials sustainably.

Every industry has its certifications, restriction lists and guidelines. For the leather supply chain we would like to highlight four certifications offering transparency in chemical use and screening of chemicals:

- LWG - Leather Working Group
- ZDHC – Roadmap to Zero Discharge of Hazardous Chemicals
- Cradle to Cradle Certified®
- ToxFMD Screened Chemistry®

Let's summarize

- Bio-based or renewable materials are very important for closing the carbon cycle and to reach full circularity.
- The main driver of using bio-based and renewables is to avoid resource depletion. Moreover, it absorbs and stores CO_2 (until its disposal) and thus lowers CO_2 emission.
- Leather is a bio-based material with a high bio-based content.
- Genuine leather outperforms alternatives for leather (such as 'vegan leather') on renewability scores.
- The chemicals used in leather manufacturing influence the renewability of leather, but also influence the biodegradability of the material.
- It's not just about the materials. The key for minimized environmental impact is to look at the entire leather making process.
- Meet your sustainability goal by (1) asking the right sourcing questions (origin, chemicals used) (2) checking certifications (3) looking at the longevity and end-of life of products.

More information

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