COMPARISON OF THE ENVIRONMENTAL PERFORMANCE OF IPHONE FINEWOVEN MATERIAL AGAINST A LEATHER FOR IPHONE CASE

Introduction – The Customer requested the comparison of the environmental performance of two cases iPhone 15 Pro Max FineWoven (colour Burgundy and Taupe) against a sample of Leather developed for iPhone casing and supplied for this scope during many seasons.

Fig. 1 - iPhone 15 Pro Max FineWoven Case Burgundy

Fig-2 iPhone 15 Pro Max FineWoven Case Taupe

Fig – 3 Leather for iPhone Case

The analyses we have chosen are some fundamental parameters based on a series of standards that the European Commission for Standardization (CEN) has defined to regulate the information that must be contained in an informative sheet providing the ecological characteristics of the materials, in a Business-to-Business (EN 16848) view, and for objects created with them in business-to-consumer communication (EN 16935) combined with the European Eco-design Directive.

The analyses chosen are as follows:

1. Preliminary microscopic analysis
2. Bio-based carbon content
3. Carbon and Nitrogen content

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4. Greenhouse gasses generation after incineration
5. Durability towards Martindale abrasion test.

The Samples analysed were the following:

- ***iPhone 15 Pro Max FineWoven Case Burgundy***
- ***iPhone 15 Pro Max FineWoven Case Taupe***
- **Leather for iPhone Case**

1- Preliminary microscopic analysis

Fig. 4 – iPhone FineWoven Taupe Top view

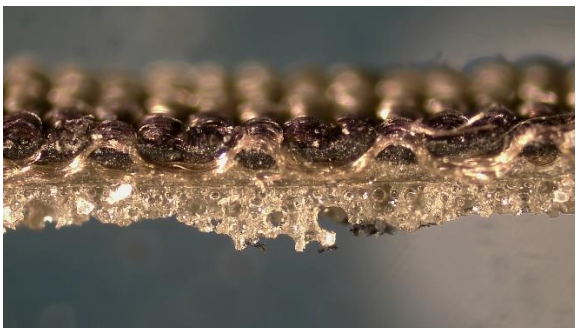

Fig. 5 – iPhone FineWoven Taupe Transversal cut

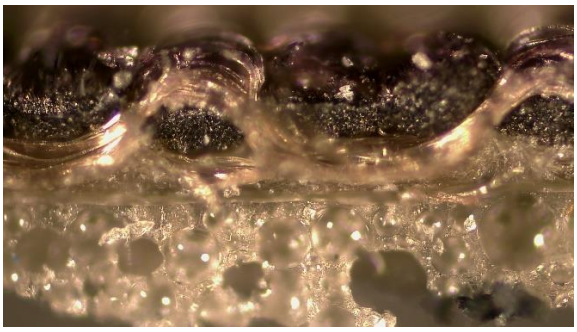

Fig.6 – iPhone FineWoven Taupe Transversal cut detail

iPhone FineWoven presents a tight weave of polymeric fibres on a polymeric foam bed.

The intimate fusion of the components of the composite material makes difficult an eventual recycling attempt.

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Fig. 7 - Leather for iPhone Case

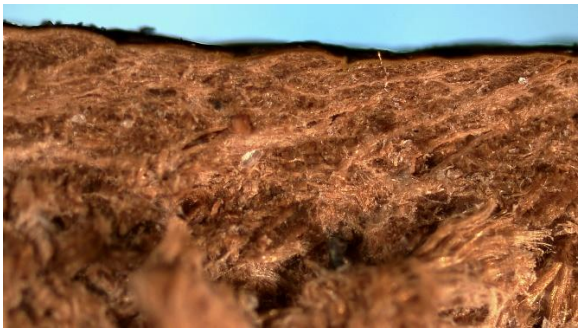

Fig. 8 - Leather for iPhone Case – papillary layer and finishing

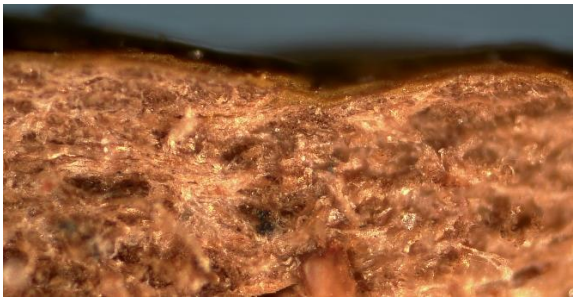

Fig. 9 - Leather for iPhone Case – papillary layer and finishing – detail

Leather for iPhone Case (Gruppo Dani) shows a compact structure with apparent absence of interfibrillar polymers, and a fine finishing coating of a media 16,4 μm. Natural pores are evident and not covered after finishing.

2 – Bio-based / fossil carbon content

The Bio-based carbon content was analysed by means of a SCAR ^{14}C Analyser with a method based in EN 16640 allowing to quantify the Bio-based / Fossil carbon proportion of a material, as a measure of circularity (being Bio-based the renewable carbon proportion). The result also defines the possibility to apply to different end-of-life options, such as Biochar production, Biofertilizers, etc. The carbon content derived from biomass is expressed in pMC units (parts of Modern Carbon). This technique also makes possible to compare different types of materials. The N/C ratio shows the proportion of nitrogen to carbon to be considered as a fundamental parameter before hypothesizing the transformation of materials into fertilizers/biofertilizers as an end-of-life option.

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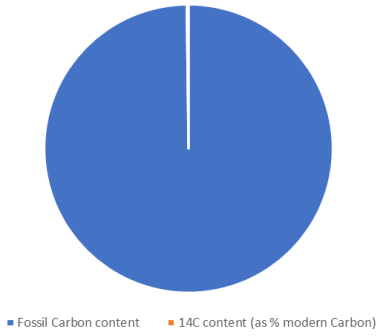

Fig. 10 - iPhone 15 Pro Max FineWoven Case Burgundy

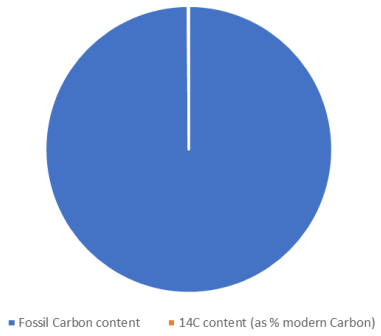

Fig. 11 - iPhone 15 Pro Max FineWoven Case Taupe

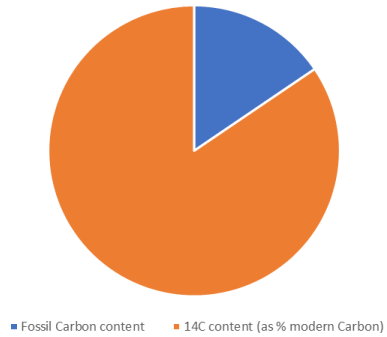

Fig. 12 - Leather for iPhone Case

	iPhone 15 Pro Max FineWoven Case Burgundy	***iPhone 15 Pro Max FineWoven Case Taupe***	***Leather for iPhone Case***
C %	60,9 %	60,5 %	41,8 %
N %	3,4 %	3,2 %	11,8 %
N/C	0,055	0,053	0,282
^{14}C (pMC)	**0,2 pMC**	**0,1 pMC**	**84,5 pMC**
Fossil carbon	**99,8 %**	**99,9 %**	**15,5 %**

Table 1 – Bio-based / fossil content on the materials analysed

3- Greenhouse gasses generation after incineration

The volume of Greenhouse gasses generated after incineration represents the worst emission scenario being important to achieve limited emissions of fossil carbon to make it viable. For this evaluation we analysed the samples towards elemental analysis to verify the generation of greenhouse gases after incineration (CO_2 and NO_2), and calculated the fossil CO_2 emission, based in the radiocarbon analysis in # 2. Results are shown in table 2.

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	iPhone 15 Pro Max FineWoven Case Burgundy	*iPhone 15 Pro Max FineWoven Case Taupe*	*Leather for iPhone Case*
C %	60,9 %	60,5 %	41,8 %
N %	3,4 %	3,2 %	11,8 %
g CO_2 / Kg	**2233,0**	**2218,3**	**1532,7**
g fossil CO_2 / Kg	**2228,5**	**2216,1**	**237,6**
g NO_2 / Kg	**111,7**	**105,1**	**387,7**

Table 2 – Emissions calculated on the materials analysed

4 – Durability: Martindale abrasion test

Martindale abrasion test was chosen to reproduce the effect caused by the continuous scuff against a textile fibre (like in the act of stowing and removing the mobile phone from a pocket). The tests were done following EN 13520:2006 standard in dry conditions applying a weight of 12 kPa and evaluating the eventual damage visually under ISO 7906 conditions.

800 cycles *1600 cycles* *3200 cycles* *6400 cycles*

Fig. 13 - iPhone 15 Pro Max FineWoven Case Burgundy Martindale abrasion test

The test results in Fig. 13 shows for iPhone 15 Pro Max FineWoven Case Burgundy evident damage after 800 cycles and the complete deterioration of after 6400 cycles with rating of 2 at the greyscale.

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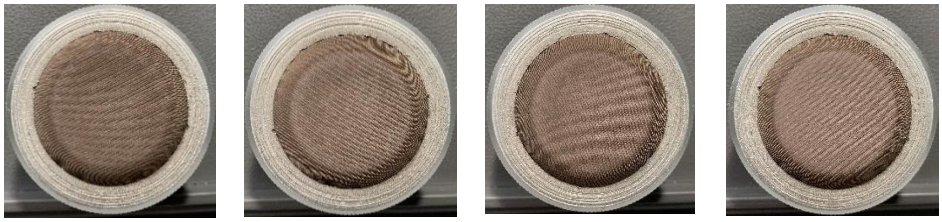

800 cycles *1600 cycles* *800 cycles* *1600 cycles*

Fig. 14 - iPhone 15 Pro Max FineWoven Case Taupe Martindale abrasion test

The test results in Fig. 14 shows for iPhone 15 Pro Max FineWoven Case Taupe evident damage after 800 cycles and the complete deterioration of after 6400 cycles with rating of 2 at the greyscale. We have evaluated the sample at the microscope (fig. 15) to verify the damage in detail.

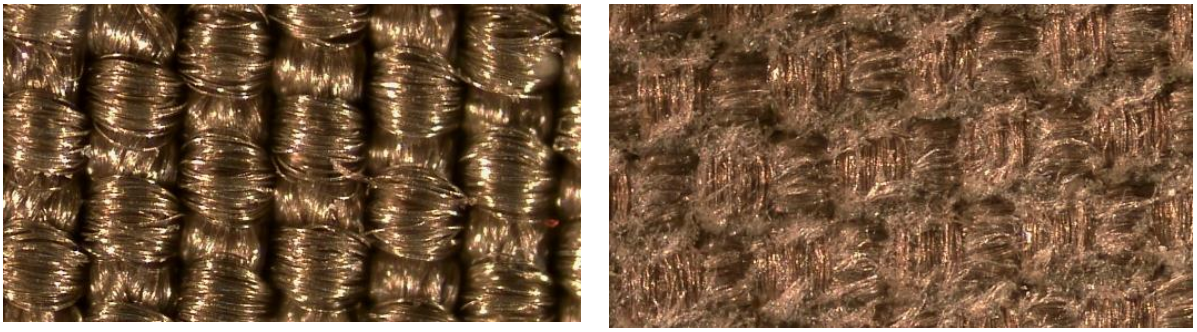

Fig. 15 - iPhone 15 Pro Max FineWoven Case Taupe abrasion test under the microscope

At the microscope we can verify the deterioration of the fibres with potential microfibres release.

The test results in Fig. 16 shows the Leather for iPhone Martindale abrasion which show no damage up to 51.200 cycles with the maximum rating of 5 at the greyscale. We have evaluated the sample at the microscope (fig. 17) to verify eventual damages not visible to the naked eye.

Minor scuffs after 51.200 cycles (circle in fig. 17) are visible under the microscope, but no other evident damages.

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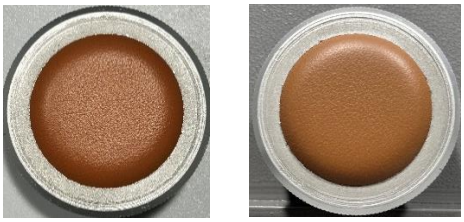
800 cycles *1600 cycles* *800 cycles* *1600 cycles* *12800 cycles*



25600 cycles *51200 cycles*

Fig. 16 – Leather for iPhone casing Martindale abrasion test

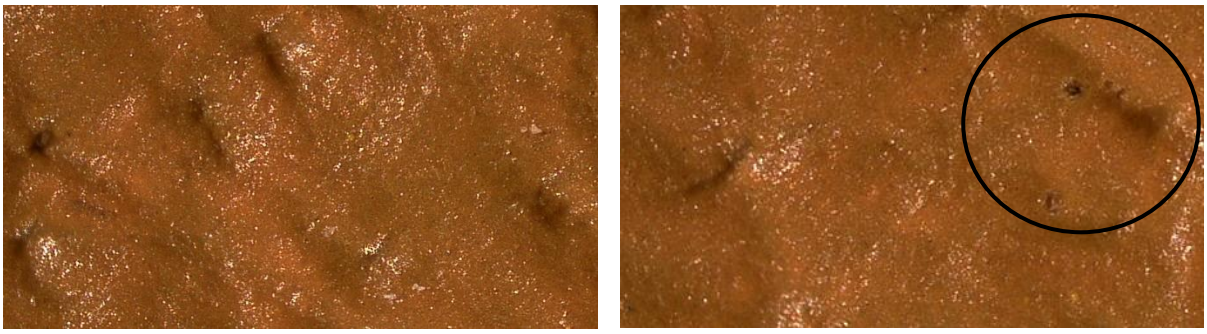


Fig. 17 - Leather for iPhone casing Martindale abrasion test under the microscope

5 – Conclusions

The microscopic analysis showed that iPhone FineWoven presents a tight weave of polymeric fibres on a polymeric foam bed, while the Leather for iPhone sample presents no evidence of interfibrillar polymers apart of a 16,4 μm finishing layer.

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Bio-based content found on iPhone FineWoven was close to 0, which means that the product in fully of fossil origin (petrol based). The intimate fusion of the components of the composite material makes difficult an eventual recycling attempt, and at the same time the null Bio-based content bans its application for Biochar. The high fossil CO_2 emission prevents its incineration, considering the ca. 2.230 g of fossil CO_2 per kg.

In terms of end-of-life options for the Leather for iPhone casing sample, the Bio-based content of 84,5 pMC allows its application for Biochar. The thin finishing layer combined with the said Bio-based content and an N/C proportion of 0,28 ca. are of good hope its use for fertilizers.

The fossil carbon emission of 237,6 g CO_2 / kg is near one tenth of the ca. 2230 CO_2 / kg of the iPhone FineWoven material.

Regarding durability, iPhone FineWoven did not reach the minimum results, while the Leather for iPhone casing analysed show no damage after ca 100 times more wearing cycles.

Gustavo Adrián Defeo PSLTC – Laboratory director

November 10th, 2023

Disclaimer-

I, Gustavo Adrián Defeo, have been instructed by the customer to take on the measurements reported herein, and to provide my expert opinion on them. I hereby declare that I am aware of my obligation give an impartial expertise and

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that there is no conflict of interest for me or Ars Tinctoria S.r.l. relating to this report and expert opinion which would affect its impartiality.

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