Material biobased carbon studies

Ars Tinctoria CEO **Gustavo Defeo** presents the results of the company's recent study, published in MDPI's Coatings journal, and discusses its methodology and some results.

Table 1. Ars Tinctoria's SCAR material study results.

Sample	% N	% C	pMC % Biobased
EVA "vegan" sole	4.6	61.6	0.2
Pod Leaf	1.1	71.3	17.7
Desserto	3.1	52.5	24.1
Appleskin	2.0	59.6	25.4
Volar Bio Ultraleather	0.9	56.9	27.8
Ultraleather fusion	1.4	53.1	44.8
Coated patent leather	8.4	53.5	47.1
Noani	0.2	47.1	58.2
Mix synthetic-natural fabric	7.8	50.2	61.0
Fully syntan tanned leather	10.7	58.8	65.6
Vegea	2.6	64.6	67.9
SnapPap	1.1	46.7	75.9
Salmon skin	13.5	49.0	82.4
Goatskin suede	12.4	41.8	83.7
Ecotan shoe upper leather	10.9	51.7	85.7
Sueded split leather	11.4	47.4	87.2
"Parma" baby calf leather	9.2	48.8	89.9
Soft milled leather "Rave"	11.8	58.2	92.6
Vachetta leather "Toiano"	8.9	50.9	94.8
Minerva box veg tan	8.5	55.3	95.9
Nebraska article veg tan	11.5	47.3	100.3
Kombucha	0.03	41.6	102.2
Chestnut traditional tanning	8.9	49.1	103.3

Ars Tinctoria CEO Gustavo Defeo.

Ars Tinctoria initiated this research on radiocarbon quantification on leather and other fashion materials during 2018 while studying the latest European regulatory trends on circularity and sustainability in a Green Deal policy context. The concept of bioeconomy proposed by Europe justified the need to evolve all sectors of materials towards a new analytical point of view, creating a new paradigm on materials development. All materials sectors should address their future developments not only considering the technical achievements required in terms of resistance, fastness properties and durability, but bearing in mind the ability to close the lifecycle with all possible end-of-life options which may result in zero waste and at the same time achieve carbon neutrality.

Considering that, with such limitations, it is easy to fall into greenwashing temptations, the choice for this research was to begin with an understanding of the intrinsic circularity of the materials and related processes, with the awareness that a true circular material must be originated from a series of circular events. This keeps eventual CO_2 compensations as a last resort when recognising that all possible variables aiming for carbon neutrality were meticulously considered and adopted. The separation of each circular event involved in a process allows the attribution of impacts originating in the materials' components themselves, managing electricity, water treatment, heat, transport, etc. separately and providing a clearer scene of each single environmental contribution.

From scientific experiences in textile, bioplastics and alternative fashionable materials developments, it is possible to recognise that the discrimination of biobased/fossil carbon proportions, although of capital importance, is a necessary but not sufficient condition in the understanding of the environmental performance of materials.

To be precise in calculations and cover the complete lifecycle of a material, we also need to understand the biomass content (which is part of Ars Tinctoria's new research, but not easy due to the complexity of leather processing). Last but not least, we must comprehend all end-of-life options such as material recycling, organic recycling, energy recovery (and consequent greenhouse gas generation) and biodegradability (and the impact of the degradation products).

Radiocarbon quantification of materials

Reasoning in circular economy terms makes understanding the intrinsic contribution of fossil and biomass origin carbon fundamental and, for this scope, CEN commission TC 411

developed the norm CEN/TS 16640 – Bio-based products — Determination of the bio-based carbon content of products using the radiocarbon method. Searching for support on the Accelerator Mass Spectrometry (AMS) and Liquid Scintillation (LS), Ars Tinctoria came across the research team of the National Institute of Optics of Florence and their new development, known as Saturated-Absorption Cavity Ring-Down Spectrometry (SCAR). This new radiocarbon analyser allows the quick determination of fossil/bio-based carbon proportions, avoiding the many drawbacks of other techniques.

About the authors

Saverio Bartalini has been a senior research scientist at the Italian National Research Council - Institute of Optics (CNR-INO) since 2010. His research activity is mainly in the field of infrared molecular spectroscopy, in particular for the development of highly sensitive and/or metrological-grade laser spectroscopy techniques. In 2016, he co-founded the start-up ppqSense and has been its CEO since 2019. He is the co-author of over 70 scientific papers and co-inventor of one patent.

Davide Mazzotti has been a senior research scientist at the CNR-INO since 2003. He specialises in high-precision and high-sensitivity laser-based molecular spectroscopy in the mid-infrared for trace gas detection, particularly radiocarbon dioxide. He is a co-author of over 110 scientific publications in journals and books, co-inventor of two patents and co-founder of ppqSense.

Iacopo Galli is a senior research scientist at the CNR-INO. His main research interests include non-linear optics, high-sensitivity and high-precision infrared spectroscopy, frequency metrology and quantum cascade lasers. He is a co-founder of ppqSense.

Federico Carcione graduated in Management Engineering from the University of Siena in 2019 and is currently pursuing a Ph.D. in Industrial Engineering (Energy Engineering and Innovative Industrial Technologies) at the University of Florence. He joined ppqSense as a Production Engineer in 2020.

Gustavo Adrián Defeo studied industrial chemistry at the Otto Krause technical school (Argentina) and has been working in the leather industry since 1985. After 26 years of experience collaborating with some of the best-known multinationals in the leather chemicals field, he founded the Ars Tinctoria materials laboratory in Santa Croce sull'Arno. Currently, he is convenor of CEN TC 289 WG2 and WG3 commissions and Chairman of IULTCS' IUF and IUP commissions.

Considering the widespread practice of greenwashing under false sustainability credentials (worsening the environmental performance of the materials industries in general and inducing tanneries to a more polluting processes) and the new startups promoting alternatives to leather without considering the real environmental consequences for the end-of-life of such new materials, it was decided to validate the SCAR spectrometry technique for materials in general as a transparent parameter to quickly understand how circular a material is. The authors decided to develop a method to compare, in a transparent way, the results obtained for different types of leather, and alternative fashionable materials, following the article written by Meyer, M.; Dietrich, S; Schulz, H.; Mondschein A.: *Comparison of the technical performance of leather, artificial leather, and trendy alternatives*, published in MDPI's Coatings journal.

The paper in Coatings

The article is titled *Materials' Circularity: A Novel Method for Biobased Carbon Quantification on Leather, Artificial Leather, and Trendy Alternatives* and was written in a collaboration between Ars Tinctoria and the National Institute of Optics in Florence (CNR-INO), the European Laboratory of Non-Linear Spectroscopy (LENS), the University of Florence and ppqSense (a spin-off of CNR-INO).

The authors are Federico Carcione, Iacopo Galli, Saverio Bartalini and Davide Mazzotti, while Ars Tinctoria CEO Gustavo Adrián Defeo coordinated and supported the project.

The paper begins by focusing on environmental policies before explaining SCAR spectroscopy principles and the analytical method for miscellaneous materials developed by the authors. For the validation, they chose commercial materials covering approximately the whole 0-100 pMC (parts of modern carbons) range in regular intervals (see Table 1). A preliminary verification under the microscope allowed the authors to choose the samples to compare based on the homogeneous distribution of each microstructural component, then compare the results obtained with SCAR spectrometry and AMS. The matching between both instruments was comparable within a very narrow gap. All tests were done once and no tests were repeated during the experiments, demonstrating the robustness of the system.

In conclusion, the paper reveals the results obtained of the biobased carbon content of the materials covered in the article by Meyer et Al. as well as other leather samples ranging from heavily coated to nubuck, splits and salmon skins with miscellaneous tanning methods (metal free, chrome and pure vegetable). See the Table 1 for these results. The full paper can be found at www.mdpi.com/2079-6412/13/5/892.

The achievements obtained in this publication were also presented during the Freiberg Leather Days event in Germany, June 2023.