Optimized smart inkjet printing of fashion garments and shoes, their characterization and validation in relevant environment

Deliverable 4.4

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List of Abbreviations

Acronyms	Description
2D	Two dimensions
3D	Three dimensions
AC	Acetate
c	chroma
CIE	International Commission on Illumination
CO	Cotton
CV	Viscose
D	Deliverable
EA	Elastane
GA	Grant Agreement
h	hue angle
ISO	International Organization for Standardization
L	lightness
MS	Milestone
n/a	Not applicable
PA	Polyamide
PAN	Acrylic
PES	Polyester
PHA	Polyhydroxyalkanoate
RH	Relative humidity
T	Task
VC	Value chain
W2BC	**Wast2BioComp**
WO	Wool
WP	Work package
ΔE	Colour difference

1. Introduction

This report shows the production of the demonstrator's inkjet printed within the project, and their characterization. Both the 2D and 3D equipment developed in **W2BC** were employed to produce the demonstrators, all using the 1% indigo bio-based ink developed within WP1.

The 2D equipment was used to print:

- Different textile substrates, cellulose and PES based, with the pre-treatments developed in WP1;
- Show foams used for the insoles production in T4.1;
- Textile fabrics spray coated with polyhydroxyalkanoate (PHA), from T4.3;
- Leather patterns, used for the production of fashion vests;
- Packaging paper from PROPAGROUP;
- Fashion garments (cellulose and polyester based), direct to garment.

The 3D equipment was used to print:

- Textile based sports shoes;
- Leather based sports shoes.

This is part of WP4 – Use cases and validation of bio-based products and processes. This report, together with D4.1, D4.2 and D4.3, show the accomplishment of MS5 (Bio-based demonstrators for each VC), by showing the production of inkjet printed substrates, garments and shoes with bio-based inks and their validation in relevant environments (simulated usage conditions) displaying properties promising, although requiring improvement.

2. Optimized smart inkjet printing of fashion garments and shoes, their characterization and validation in relevant environment

This section describes the main results of the printing applications on different substrates and products, using the inkjet equipment developed in the project (see Deliverable 2.1) and the 1% bio-based indigo ink (see Deliverables 1.4 and 2.2).

In Table 1 is a summary of the substrates printed within this task, and their composition.

Table 1 Substrates used on the printing demonstrators developed in ***W2BC***

Provider	Reference	Composition	Properties	Colour
RIOPELE	TRUE	99% CO + 1% EA	369g/m^2, ready to print	White
RIOPELE	DORSET	100% PES	295g/m^2, ready to print	White
RIOPELE	KRYSS (fabric used in the jacket prototype)	97% CO + 3% EA	ready to print	White
RIOPELE	PowerMax (fabric used in the shorts prototype)	66% PES + 28% CV + 6% EA	ready to print	White
PROPAGROUP	Kraft paper	Plane kraft paper	65 g/m^2	Brown
N/A	N/A	Leather	Wet-white	White

2.1. Printing on 2D equipment

To evaluate the applicability of the developed smart inkjet printing system and its integration into final products, several demonstrators were produced using 2D printing equipment. These demonstrators include textile substrates and fully manufactured garments, as well as printed leather components, paper-based packaging, and foams. The printing process aimed to validate the performance of the bio-based indigo ink formulation in real-world scenarios, covering various material types and end-use cases.

Textile substrates

For cotton (CO) and polyester (PES) substrates, printing was performed both on individual fabric pieces and directly on fully manufactured garments, such as a jacket and a pair of shorts. All textile samples received pre-treatment with Biopolymer 2 and Binder A, whereas the finished garments were pre-treated exclusively with Biopolymer 2. This direct-to-garment printing approach, as outlined in the project proposal, highlights the system's advanced capability to handle complex, ready-made textile items without compromising print quality or process efficiency, therefore allowing a custom personalization of the garment. As to the PES and CO substrates, different references were printed and tested, to further validate the versatility of the ink.

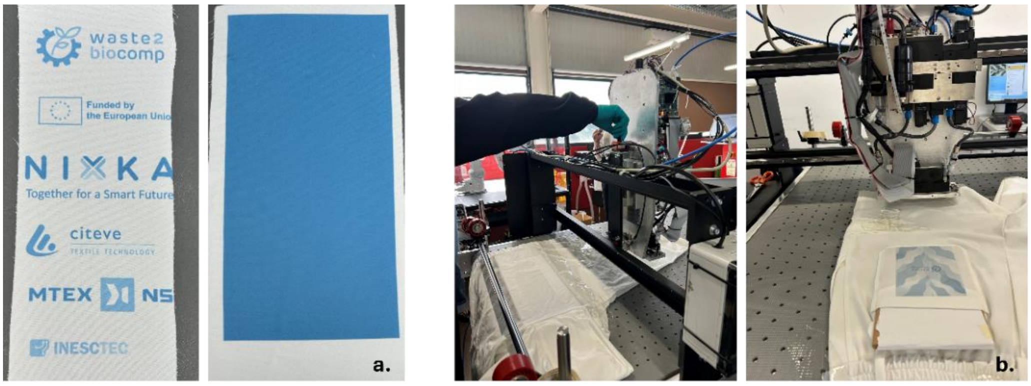


Figure 1 a. Polyester fabric printed with the bio-based ink using 2D inkjet equipment; b. On-garment printing process applied directly to finished textile products.

Figure 2 Demonstrator garments, including a jacket and a pair of shorts, printed using the 2D inkjet system developed within the project.

Leather substrate

In the case of leather, the printing was carried out on pre-cut components, which were subsequently assembled into a sleeveless vest. This approach allowed for precise ink deposition on defined pattern pieces, followed by validation of the printed material's behaviour during the garment confection process, including sewing and finishing steps.

Figure 3 Printed leather pieces prior to assembly into a sleeveless vest.

Paper substrate

Paper substrates were printed in flat format and later transformed into customized packaging solutions, such as boxes, showcasing the versatility of the ink in terms of media compatibility and surface interaction, while also highlighting potential applications beyond textiles.

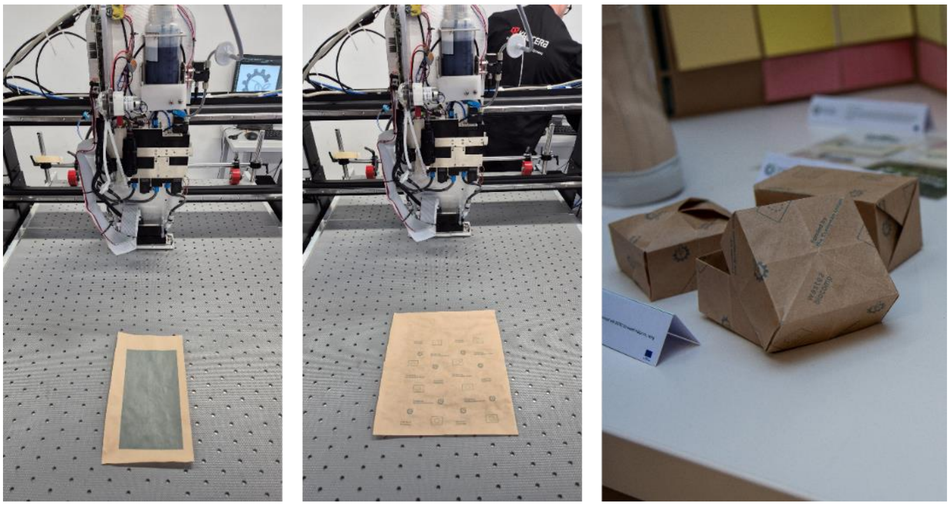


Figure 4 Customized packaging prototypes made from paper substrates printed with indigo ink.

Other materials

Foam materials made from PHAs (from T4.1) and textile substrates coated with PHA using a spray-coating technique (from T4.3) were also printed with this ink. This approach aimed to evaluate the compatibility of the bio-based indigo ink with non-traditional, coated surfaces and to assess the adhesion and visual performance of the printed patterns on flexible, irregular substrates.

Figure 5 Foam (left) and PHA-coated textile (right) samples printed using the bio-based ink formulation.

2.2. Printing on 3D equipment

The 3D printing equipment follows the strategy of keeping the printing engine in a fixed position (ensuring that the ink jets are always fired vertically) and it is the object that moves under the printing head. This movement is carried out by a robotic arm that holds the object and ensures that the optimal printing distance is respected. More details about the equipment can be consulted in Deliverable D2.1.

2.2.1. Printing engine

The print engines developed by NIXKA (used for both the 2D and 3D equipment) are composed by the print head drive (the electronics that make the control of the print head from the commands it receives from the computer), the ink reservoir and ink supply system that guarantees the continuous recirculation of the ink) and finally the print head (a Kyocera KJ4B-1200 that allows a high print resolution of 1200dpi).

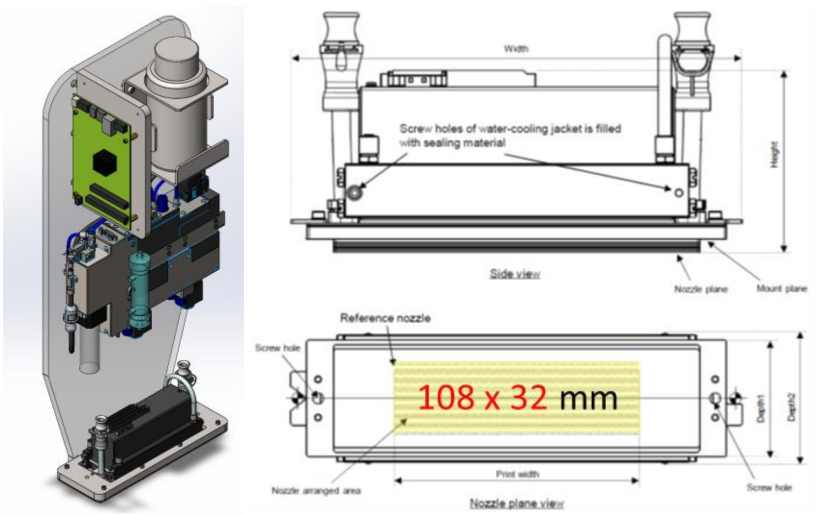


*Figure 6 **W2BC** print engine (left), developed by NIXKA, and Kyocera KJ4B-1200 print head (right).*

Table 2 Additional characteristics of the Kyocera KJ4B-1200 print head

Parameter	Value
Total nozzles number	5116
Resolution	1200 dpi
Print width	108,27 mm

The print engine was fixed in a structure along with the IRB1300 ABB 6-axis robotic arm, and both were enclosed inside a print cell (for safety reasons). The robot controller was also mounted in a lower compartment in the print cell (Figure 7).

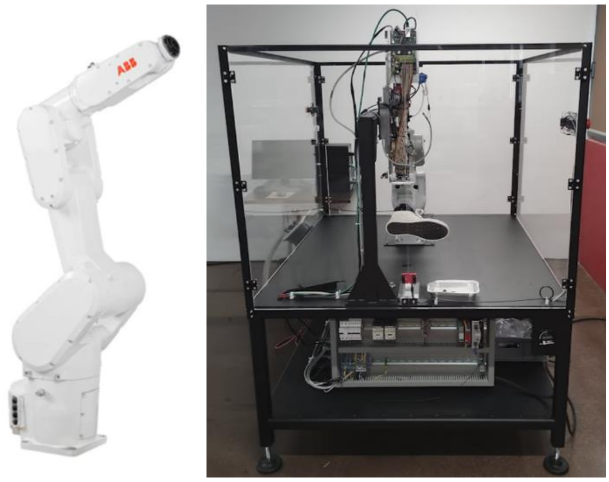


Figure 7 IRB1300 ABB 6-axis robotic arm (left) and print cell (right).

2.2.2. 3D Printing process

The steps required for printing are as follows: first, a 3D scan of the object (a sports shoe, in this case) was performed to obtain a point cloud that incorporates its three-dimensional shape. Then, using custom graphical user interface software, the image we want to print is positioned in the desired location on the shoe. The next step generates the 3D path that ensures the alignment and distance (1 to 2 mm) of the print head to the surface to be printed. Finally, the joints of the robotic arm are controlled to execute the calculated trajectory without collisions and synchronize the movement of the arm with the firing of the print head nozzles.

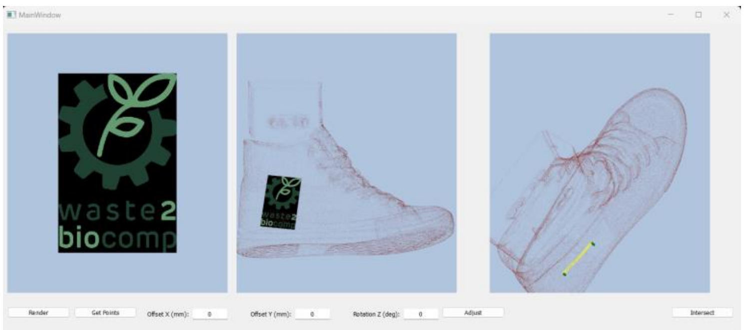


Figure 8 Custom software that allows the image to be printed (left) to be positioned on top of the Point Cloud (centre) to calculate the trajectory (right).

Due to the huge area of the print head (around 108x32mm) some special measures were taken to avoid having severe concave surfaces in the sneakers that would cause collisions during printing using the optimal distance. For that, besides the shoe last that holds the sneakers, some 3D fill objects were used to turn those concave shapes in a flatter (or at least convex) surface.

Figure 9 Shoe last (left); concave profile of the sneakers (centre); and infill object (right).

2.2.3. Printing results

The textile sneakers used for these tests were commercially available and presented hydrophilic properties (to be able to absorb some of the ink applied), while the leather sneakers were kindly produced by the RXM Shoes company, using the same leather that was tested since the start of the project (and bought by CITEVE).

In both cases (fabric and leather) the print results using the bio-based indigo ink were very good as can be seen in Figure 10, Figure 11 and Figure 12.

Figure 10 Final printing results on fabric sports shoes (left) and leather sports shoes (right).

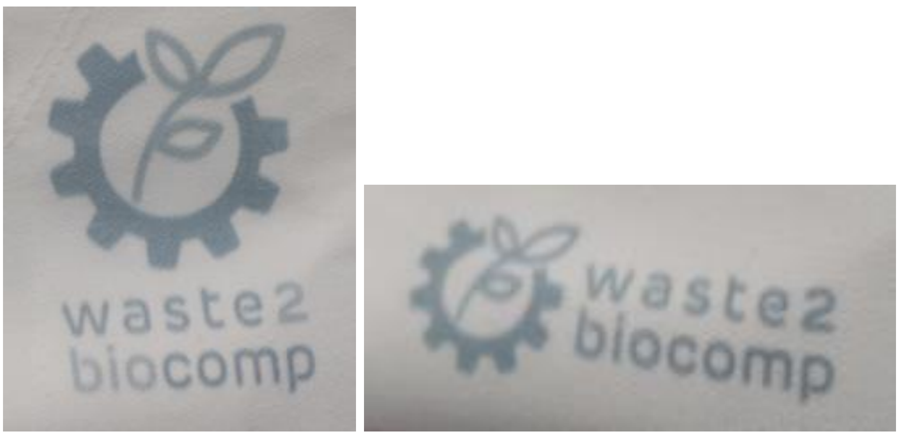


*Figure 11 Details of printing the **W2BC** logos on the fabric shoes.*

*Figure 12 Details of printing the **W2BC** logos on the leather shoes.*

2.3. Characterization of the printed samples

2.3.1. Colour fastness of textile substrates

The printed fabrics were evaluated for colour fastness according to the following most used standards for fashion textiles: domestic washing (ISO 105-C06:2010), water (ISO 105-E01:2013), perspiration (ISO 105-E04:2013), artificial light (ISO 105-B02:2014) and rubbing (ISO 105-X12:2016). For kraft paper substrates, colour fastness was assessed to water spotting (ISO 105-E07:2010) and artificial light (ISO 105-B02:2014).

Table 3 Colour fastness results of CO (TRUE and KRYSS) and PES (DORSET and PowerMax) based textile substrates pre-treated with Biopolymer 2 and Binder A, and printed with 1% indigo ink

Substrate	TRUE		KRYSS	DORSET		PowerMax
Pre-treatment	**Biopolymer**	**Binder A**	**Biopolymer**	**Biopolymer**	**Binder A**	**Biopolymer**
Washing(1)	4	4	4-5	4-5	4-5	4-5
Water(1)	4	4	4-5	4-5	4-5	4-5
Perspiration: acid(1)	4	4	4-5	4-5	4-5	4-5
Perspiration: alkaline(1)	4	4	4-5	4-5	4-5	4-5
Rubbing: dry	4-5	4	4-5	4-5	4-5	4-5
Rubbing: wet	3	2-3	3-4	3-4	4	3-4
Artificial light	3-4	1	4-5	3	3-4	3

(1)Only colour change values.

As shown in Table 3, the colour fastness results revealed similar behaviours for all textiles and pre-treatments in relation to colour fastness to washing, water and perspiration (either acid or alkaline), with the thickest cotton fabric (TRUE) given the worst result (grade 4), but still excellent.

The rubbing fastness presented distinct values for each sample. Once again, TRUE fabric gave only satisfactory results, suggesting that this might not be a suitable fabric for this type of print technique / equipment. Overall, polyester exhibited more consistent performance across all test conditions, with similar fastness ratings for both Biopolymer 2 and Binder A. For cotton, Binder A resulted in lower performance in rubbing and artificial light fastness. These findings suggest that pigment fixation is more effective and stable on polyester. Consequently, Biopolymer 2 appears to be the most suitable option for natural fibres such as cotton.

As to the staining of different fibres during the colour fastness tests to washing, water, and perspiration, all samples gave quite similar results, with grade 4-5 for acetate, cotton and polyamide, and grade 5 for polyester, acrylic and wool.

2.3.2. Colour fastness of leather

The leather substrates were evaluated for colour fastness according to the same standards as used in the textiles, and water spotting (NP EN ISO 105 E07:2010).

Table 4 Colour fastness results of printed leather printed with 1% indigo ink

Test	Colour change	Staining					
		AC	CO	PA	PES	PAN	WO
Washing	4	4-5	4-5	4-5	5	5	5
Water	4	4-5	4-5	4	4-5	4-5	4-5
Perspiration: acid	4	4-5	4-5	4	4-5	4-5	4-5
Perspiration: alkaline	4-5	4	4	4	4-5	4-5	4-5
Rubbing: dry	4	n/a					
Rubbing: wet	3	n/a					
Artificial light	2	n/a					
Water spotting	After 2 min: 2 After drying: 3-4	n/a					

AC - acetate, CO - cotton, PA - polyamide, PES - polyester, PAN - acrylic, WO – wool. n/a – non applicable.

Table 4 shows the results for leather samples. Overall, leather substrates exhibited good resistance to washing, perspiration, and water exposure (ratings: 4–5). Dry rubbing resistance was good (rating: 4), but wet rubbing was lower (rating: 3), indicating some susceptibility to friction under moist conditions. On the other hand, the fastness to water spotting is good (ratings 3-4 after drying). Artificial light fastness was rated at 2, suggesting visible degradation after exposure to light.

2.3.3. Colour fastness of paper

The kraft paper substrates, were tested as to their colour fastness to water spotting (ISO 105-E07:2010) and artificial light (ISO 105-B02:2014).

Table 5 Colour fastness results of kraft paper printed with 1% indigo ink

Colour fastness to	Water spotting		Artificial light
	After 2 min.	After drying	
Colour change	2	4-5	3-4

Table 5 presents the colour fastness results for paper substrates printed with the bio-based indigo ink. After drying, the samples exhibited a rating of 4–5 for water spotting, indicating very good resistance to moisture-induced discolouration. In terms of exposure to artificial light, the samples achieved a rating of 3–4. These results demonstrate that the indigo-based ink performs well on paper substrates.

2.3.4. Colour fastness to weathering

Colour measurements were performed using the CIELab* colour space, a colorimetric system defined by the International Commission on Illumination (CIE). This system is designed to represent colour as perceived by the human eye, using three axes:

- **L*** (lightness): Ranges from 0 (black) to 100 (white), indicating the brightness of the sample.
- **a***: Represents the green–red axis, where negative values indicate green and positive values indicate red.
- **b***: Represents the blue–yellow axis, where negative values indicate blue and positive values indicate yellow.
- **C*** (*chroma*): Represents the saturation or intensity of the colour. It is calculated as the Euclidean distance from the neutral grey axis in the a*-b* plane:

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

- **h°** (*hue angle*): Describes the type of colour perceived (e.g., red, yellow, blue) and is given in degrees. It is calculated using the inverse tangent function:

$$h° = tan^{-1}(\frac{b*}{a*})$$

These parameters allow a comprehensive and quantitative description of a sample's colour.

To evaluate the colour change after environmental exposure, the *colour difference (ΔE)** was calculated between two states (typically before and after weathering) using the Euclidean distance in the L*a*b* colour space:

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

This value quantifies the perceived colour change. Common interpretation ranges are:

ΔE* < 1: Not perceptible

ΔE* 1–3: Slight, usually acceptable

ΔE* 3–6: Noticeable

ΔE* > 6: Clearly visible and potentially critical

The printed substrates were submitted to different conditions of exposure, in function of their potential application. Textile and leather substrates were exposed to artificial light (simulating optical daylight) and spray (simulate the effect of rain and dew) - exposure to light and 1 min spray, followed by light and 29 min drying. These are conditions considered suitable for functional wear and similar applications, whenever the textile is not permanently exposed to an outdoor environment.[1] Results are presented in Table 6.

Leather and paper substrates were exposed to cycles with and without light and under different temperature and humidity conditions to simulate their use e.g., during packaging transport or inside a car. They were exposed to 3.8 h "light on" under 63 °C and 50% RH, followed by 1 h "light off" under 38 °C and 95% RH. Results are presented in Table 7.

[1] ISO 105-B04

Table 6 Results of samples tested aligned to ISO 4892-2 (Cycle B04) with colour transition 0h/16h. Printed samples were analysed in duplicate

Sample	Exposure	L*	a*	b*	C*	h°	ΔE*	Colour transition
CO A	0 h	64.32 63.88	-6.5 -7.42	-13.51 -14.17	14.99 16	244.31 242.36	N/A	
	16 h	72.44 72.15	-4.21 -4.55	-10.62 -10.91	11.42 11.82	248.38 247.36	8.92 9.35	
CO	0 h	62.29 62.33	-5.71 -5.82	-14.56 -14.39	15.64 15.52	248.59 247.98	N/A	
	16 h	65.64 66.01	-5.23 -5.3	-15.27 -15.15	16.14 16.05	251.09 250.72	3.46 3.80	
CO_control	0 h	92.17	-0.13	2.77	2.77	92.69	N/A	
	16 h	92.43	0.05	1.74	1.74	88.35	1.07	
Leather	0 h	65.72 66.44	-4.23 -4.43	1.91 2.61	4.64 5.14	155.7 149.49	N/A	
	16 h	61.55 61.25	-1.79 1.3	9.93 18.75	10.09 18.8	100.22 86.03	9.36 17.89	
Leather_control	0 h	82.66	5.01	17.96	18.65	74.41	N/A	
	16 h	73.12	10.59	32.59	34.27	72	18.33	
PES A	0 h	61.2 60.46	-10.76 -11.13	-20.56 -21.59	23.21 24.29	242.37 242.73	N/A	
	16 h	67.07 66.13	-10.63 -11.12	-18.39 -19.68	21.24 22.6	239.97 240.53	6.26 5.98	
PES	0 h	62.72 63.01	-9.19 -9.25	-18.57 -19.23	20.72 21.34	243.67 244.31	0	
	16 h	67.2 67.66	-8.99 -9.03	-16.13 -16.48	18.47 18.79	240.87 241.28	5.10 5.41	
PES_control	0 h	90.63	-0.49	2.16	2.21	102.78	0	
	16 h	90.67	-0.56	2.47	2.53	102.77	0.32	

The colorimetric evaluation revealed substrate-dependent differences in colour appearance after 16 hours of exposure, despite the application of identical pigment formulations on all printed samples described in Table 6. All samples were tested in alignment with ISO 4892-2 (Cycle B04). The measurements were carried out in the CIE Lab* colour space, and total colour differences (ΔE*) were calculated relative to the initial standard.

In all printed samples, shifts in the L*, a*, and b* values were observed after 16 hours, indicating measurable colour changes. Most samples exhibited an increase in the L* value, suggesting a lightening of the surface, potentially due to pigment diffusion, surface interaction, or changes in the binder matrix upon aging.

The reference samples (denoted as "control") were not printed but represent the original material surfaces. As expected, they showed minimal changes in colorimetric values (ΔE* ≤ 1.07), indicating negligible intrinsic colour shift of the substrate material itself over time. These references serve as baseline controls to isolate pigment-related effects from material-specific aging.

Among the printed samples, the strongest colour deviations were observed on the **leather substrates**, showing a ΔE* between 9.36 and 17.89. This was accompanied by substantial shifts in b* and C* values, and a significant change in hue angle (h°), reflecting a visible yellowing and increased colour saturation. Such behaviour is likely due to interactions between the leather surface and components in the ink, leading to pronounced colour instability.

Moderate changes were observed on **CO and PES** substrates, where ΔE* ranged between 3.5 and 9.4. These samples showed relatively uniform increases in brightness (L*) and slight reductions in *chroma* (C*), pointing to consistent but less severe changes. While these differences are visible, they may still be tolerable in applications with moderate colour accuracy requirements, such as fashion garments or other applications that do not require / require little exposure to outdoors.

Overall, the results emphasize the importance of substrate choice when consistent and stable colour appearance is required. Surface properties and chemical compatibility with the pigment system significantly influence long-term colour fidelity.

Table 7 Results of samples testes aligned to ISO 4892-2 (Cycle B06) with colour transition 0h/180h. Printed samples were analysed in duplicate

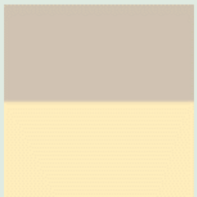
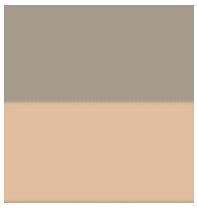
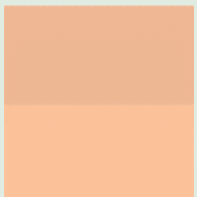
Sample	Exposure	L*	a*	b*	C*	h°	ΔE*	Colour transition
Leather	0 h	66.65 65.79	-4.36 -4.19	3.12 1.82	5.36 4.57	144.41 156.52	N/A	
	24 h	77.61 78.46	5.16 4.61	24.3 23.27	24.84 23.72	78.01 78.79	25.68 26.42	
	48 h	81.7 82.31	4.04 3.64	24.78 23.83	25.11 24.11	80.74 81.32	27.68 28.61	
	120 h	84.9 85.76	2.21 1.88	24.5 23.53	24.6 23.6	84.85 85.43	28.87 30.12	
	180 h	85.95 86.54	1.62 1.32	24.39 23.57	24.44 23.61	86.2 86.79	29.34 30.56	
Leather_control	0 h	83.17	4.85	17.61	18.27	74.6	N/A	
	24 h	80.42	6.92	25.25	26.18	74.67	8.38	
	48 h	85.18	2.69	23.84	23.99	83.56	6.89	
	120 h	86.1	2.03	23.78	23.87	85.12	7.39	
Paper	0 h	50.14 49.97	-3.75 -3.63	3.95 3.78	5.45 5.24	133.51 133.84	N/A	
	24 h	55.67 55.67	-4.08 -4.15	6.27 5.71	7.48 7.06	123.05 126.01	6.01 6.04	
	48 h	58.22 57.93	-3.67 -3.95	7.77 7.12	8.59 8.14	115.28 119.02	8.94 8.64	
	120 h	63.36 63.15	-1.93 -2.17	11.58 11.06	11.74 11.27	99.46 101.1	15.37 15.13	
	180 h	66.56 66.06	-0.17 -0.83	14.57 13.72	14.57 13.75	90.67 93.46	19.88 19.12	
Paper_control	0 h	65.58	6.99	20.62	21.77	71.27	N/A	
	24 h	68.97	6.05	22.5	23.3	74.95	3.99	
	48 h	69.26	6.14	22.97	23.78	75.03	4.45	
	120 h	69.96	6.25	23.06	23.89	74.84	5.07	
	180 h	69.95	6.31	22.99	23.84	74.65	5.02	

Table 7 presents the results of each substrate group (leather and paper) and one unprinted reference sample (control). The reference surfaces represent the unprinted base material and were included to observe any changes occurring solely in the substrate without pigment. All samples were tested in alignment with ISO 4892-2 (Cycle B06).

Leather Substrates

On leather surfaces, the printed samples showed a pronounced increase in L* over time, indicating significant lightening due to weathering. The a* values shifted from negative (greenish) towards positive (reddish), and the b* values increased markedly, reflecting increased yellowing. This led to a strong increase in *chroma* (C*) and a substantial shift in hue angle (h°) from ~145–157° towards ~86°, indicating a hue transition from greenish-blue to yellow-orange. The total colour differences (ΔE*) ranged from 25.68 to 30.56 after 180 hours, confirming a strong colour change, attributed primarily to degradation of the printed pigment.

The unprinted leather reference sample showed much less changes in all parameters. L*, a*, and b* values changed only slightly, resulting in low ΔE* values (< 8). This indicates that the leather substrate itself remains comparatively colour-stable under the applied B06 weathering conditions, when comparing with the printed substrates.

Paper Substrates

The printed paper samples exhibited similar trends. The L* values increased continuously, indicating surface lightening. The a* values stayed negative but moved closer to zero (less green), while b* values increased significantly, pointing to increased yellowing. *Chroma* values more than doubled in some cases, and h° shifted from ~134° to ~93°, signifying a clear hue shift towards yellow tones. ΔE* values after 180 hours reached approximately 19–20, confirming clear and visible colour changes in the printed layer due to weathering.

The unprinted paper reference sample showed only minimal changes in colour parameters. ΔE* remained below 5 throughout the test period. This supports the conclusion that the substrate surface alone exhibits limited optical change, and that the observed differences in the printed samples are primarily due to pigment degradation.

Interpretation and summary

The analysis shows that weathering has a significant impact on the colour stability of printed pigments, regardless of the substrate. In all printed samples, both on **leather and paper**, notable increases in L*, b*, and C*, as well as significant hue shifts, were observed. The ΔE* values confirm that the colour changes are perceptible and exceed acceptable limits for visual colour stability.

In contrast, the unprinted reference samples, which represent the raw material surfaces, remained largely stable under the same conditions. This confirms that the main source of colour change is the degradation of the pigment formulation rather than the substrate itself.

3. Conclusions

Several inkjet printed demonstrators were successfully produced, using either the 2D or the 3D inkjet equipment developed in **W2BC**, namely textiles, foams, shoes, leather and garments.

While the printing on the flat substrates went smoothly, the print on final garments was more challenging, as the surface to be printed needed to me flatten out to ensure a stable distance between the printhead and the textile, an essential aspect to allow prints with good resolution. However, it was possible to achieve garments printed with very good resolution, and in different parts of the piece. The results obtained across all tested materials confirmed the versatility and effectiveness of the developed ink formulation and printing system. Notably, the process demonstrated that high-quality printing is feasible not only on flat substrates but also directly on fully manufactured garments.

As to the fastness tests, the colour fastness of the ink on both cellulose based and PES-based textiles, was validated and is comparable to fashion benchmarks, although the fastness to wet rubbing and artificial light can be further improved. As to leather, the colour fastness values obtained range from very good to acceptable, but leather presented some susceptibility to friction under moist conditions, and the colour fastness to artificial light was also low. On the other hand, the tests performed in paper revealed quite good results.

In terms of colour fastness to weathering, in the tests where the samples were submitted to light and cycles of spray and dry, leather was the one showing the strongest colour deviations (ΔE between 9.36 and 17.89), accompanied by a visible yellowing and increased colour saturation, which could be expected given the fastness results to artificial light. Moderate changes were observed on CO and PES substrates (ΔE^* between 3.5 and 9.4) with CO pre-treated with biopolymer presenting the best result, which is slightly in line with the results from the colour fastness to artificial light.

As to the samples submitted to cycles with and without light and under different temperature and humidity conditions, leather, as expected, gave the worst results. The analysis shows that weathering has a significant impact on the colour stability of printed pigments, regardless of the substrate. The ΔE^* values confirm that the colour changes are perceptible and exceed acceptable limits for visual colour stability, mainly leather.

The non-toxicity of the printed textiles is shown in Deliverable D6.1.

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