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RECYCLING OF WASTE ACRYLIC TEXTILES

D1.3: REPORT ON ACRYLIC TEXTILE WASTE CHARACTERIZATION

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Abstract	Report on characterization of acrylic textile waste with different kind of techniques, in order to evaluate which kinds of chemical products must be removed

Keywords	

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V0.2	26/11/2020	Review	Roberto Vannucci, Claudio Brugnoni (Centrocot)

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Acknowledgment

** REPORT: Document, report (excluding the periodic and final reports)*

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc

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CI	Classified, information as referred to in Commission Decision 2001/844/EC	
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EXECUTIVE SUMMARY

This deliverable has been created in the context of the WP 1 (Recollection, sorting and analysis of waste acrylic textiles; back logistic implementation) of the H2020-funded project REACT (Grant No. 820869).

The document provides a report of the characterizations performed on industrial and post-consumer waste of acrylic fabrics used for the manufacture of awnings and outdoor furniture. These characterizations are necessary for the development of the focus of the project to remove undesirable substances applied or resulting from use.

In this report the characterizations performed on various types of waste will be discussed according to the classification decided and published in D1.2 (Classification system: methodology for waste classification) with different techniques and experimental procedures. The document will be divided into two sections, the first dedicated to the characterizations carried out on waste and the second dedicated to the development of the predictive method using chemometrics applied to NIR spectroscopy.

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ABBREVIATIONS

NIR	Near Infrared Reflectance
FT-IR	Fourier-Transform Infrared
LC-MS/MS	Liquid Chromatography with mass spectroscopy
ATR	Attenuated Total Reflectance
PCA	Principal Component Analysis
SIMCA	Soft Independent Models of Class Analogy
WP	Work Package

1 INTRODUCTION

Before the removal of finishing and contaminants, the project will focus on their characterization to confirm which kinds of chemical products have to be removed. Soxhlet extractions, Fourier-transform infrared (FTIR) and Liquid Chromatography with Mass Spectrometer (LC-MS/MS) analysis are useful to define the coatings substances present on the textile substrate. At the same time, Near-Infrared Reflectance analysis (NIR) of acrylic fabric is used to create database and identify the main categories of finishing, in order to fix the standard products and to evaluate their presence and characteristics. NIR analysis is a fast and not destructive method that allows with the implementation of chemometric approach the determination of effective material characteristics and define evaluation parameters, such as kind of finishing and concentration. The goal is to implement in the developed system a NIR automatic forecasting method and models to identify and subsequently classify collected waste, in comparison with original textile, with an error lower than 25%. The database created will allow for the identification of chemicals or other contaminants on treated fibres and chose, for each waste, the best treatment developed for their removal. In this way, it could be possible to set the more appropriate scouring treatment corresponding to the impurities on the acrylic surfaces.

The collection and separation system designed in D1.2 identifies 3 different types of finishing according to the final use of the fabric, as shown below:

Figure 1: Types of finishing.

The materials according to the methodology described on D1.2 are further divided into various categories as outlined below:

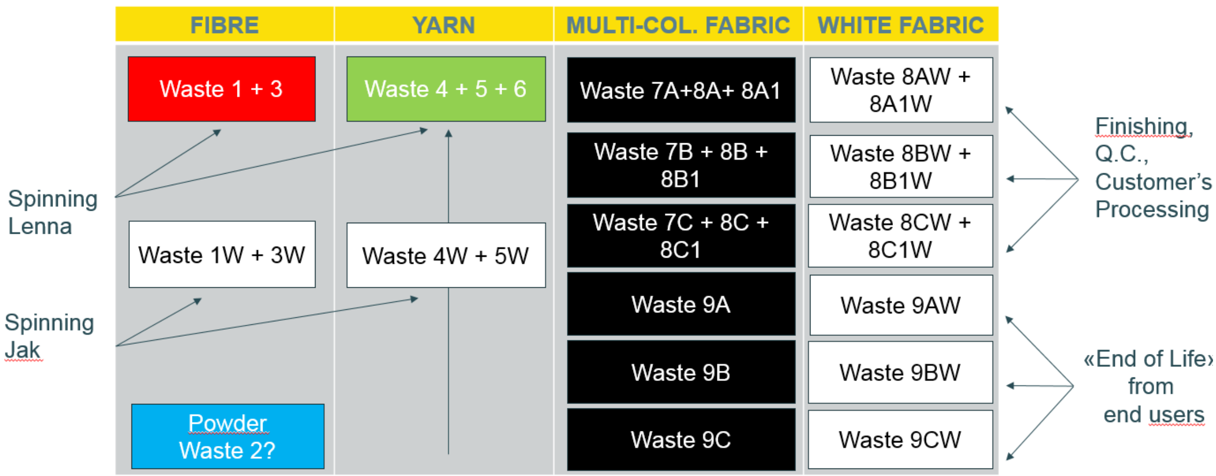

Figure 2: Plan design of waste storage.

Among these types of waste identified for the purposes of the project results, the characterization took place on those identified as Waste 7X, 8X, 8X1 and 9X, which present the application of the finishing to be removed in WP 2 (Elimination of finishing chemical products).

2 CHARACTERIZATION ANALYSIS

This part of the document deals with the analyses related to the characterization of acrylic fabrics in order to identify the chemicals present and added to increase their performance. This characterization is of fundamental importance for the subsequent removal operations developed in WP 2, indeed the knowledge of the type of chemicals present on the fabric allows to choose the most effective removal treatment. The analyses described below are the IR spectroscopy by ATR, useful for identifying the type of chemical groups present on the fabric and the LC technique, which allows, through standards, to identify the compounds present on the fabric, after extraction, according to the protocol described in the UNI CEN / TS 15968: 2010 standard.

2.1 Infrared spectroscopy

Infrared spectroscopy is a qualitative analysis and allows identifying the type of compounds present on the fabric through the vibration signals of the excited chemical bonds. The comparison between the infrared spectrum of the fabric without treatments and with treatments made it possible to identify certain substances or the class of chemicals present on them.

The spectrum of the untreated fabrics show the typical signals of polyacrylonitrile characterized by the stretching of the cyano group to about 2240 cm^{-1} and the bending of the CH_2 to about 1450 cm^{-1}. In addition to these signals, there are other non-identifiers of polyacrylonitrile, but of another constituent, in fact by definition the acrylic fibre is a fibre consisting of at least 85% polyacrylonitrile. The most indicative signal of the presence of another component is that at about 1730 cm^{-1}, this area of the spectrum is characterized by the stretching of the C = O bond, accompanied by the signals at 1230 and 1030 cm^{-1} of the stretching of a single C – O bond, which identifies the component as an acid or derivative of an acid. Furthermore, there is a signal at 1370 cm^{-1} related to the bending of a methyl group. From the analysis of these signals, polyvinyl acetate was identified as the second component of the fibre, for which the fibre of which the fabrics are made is formed by a copolymer of polyacrylonitrile and polyvinyl acetate.

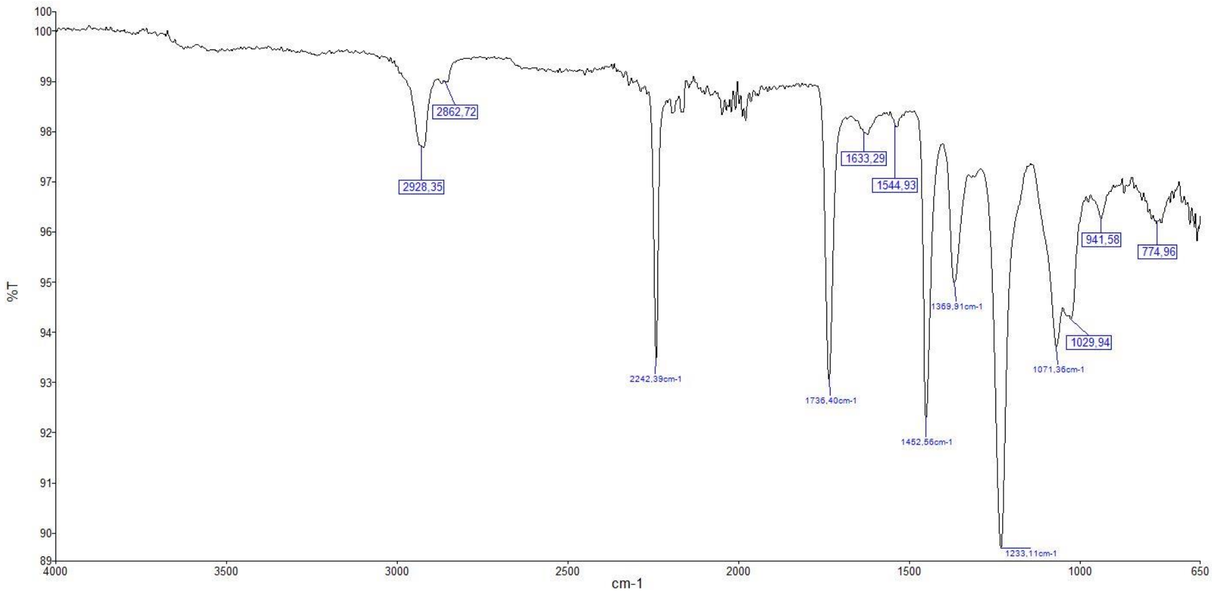

Figure 3. IR spectrum of pure acrylic fabric.

Subsequently, the fabrics were analysed by dividing them into the three types of use present in the sorting system developed in Task 1.1. The spectra for each type of use of the fabric are analysed below, for each category the spectra of fabrics deriving from the various production / use phases have been analysed.

2.1.1 Fabrics for awnings and umbrellas – finishing A

The comparison between the fabrics used for awnings and umbrellas and the fabric without finishing denotes the presence of further signals to be attributed to the substances added to the fabric to increase its properties. Analysing the spectra of the fabrics that present the type A finishing, we note the presence of absorption peaks between 1400 and 1600 cm^{-1} two signals appear that are not present on the starting fabric, respectively at about 1550 and 1480 cm^{-1}, these two signals are to be attributed to the presence of an aromatic cycle, which associated with the signal present at 814 cm^{-1} is attributable to the stretching and bending of a triazine ring. The comparison between the two spectra also shows the appearance of a low intensity signal at about 1140 cm^{-1} in this zone of the infrared spectrum the stretching signals of the C – F bonds are present, indicating the presence of fluorinated compounds on the acrylic fabric.

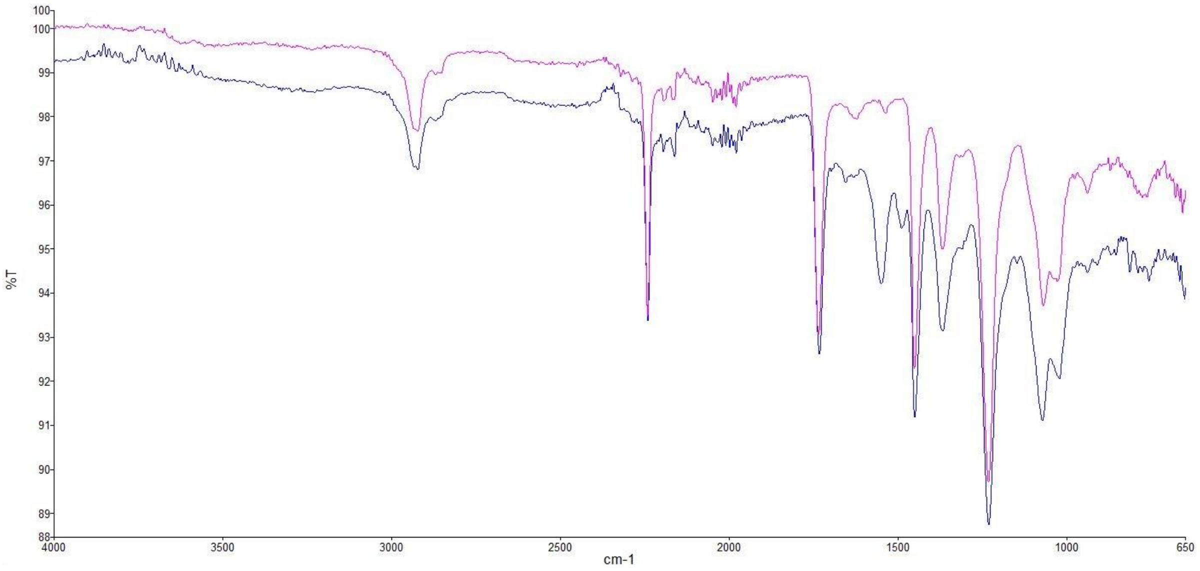

Figure 4. IR spectra of pure acrylic fabric (pink line) and acrylic fabric with finishing A (black line)

The IR spectra of fabrics identified with type A finishing denote the presence of a finishing on the fabric consisting of the mixture of a melamine resins with a fluorocarbon resins.

2.1.2 Fabrics for waterproof awnings (coated) – finishing B

The spectra acquired from fabrics with type B finishing show signals similar to those of finishing A, a peculiarity is the increase in intensity of the signals when compared to the signal at 2240 cm-1 relative to the cyano group. This increase in intensity denotes the presence of a greater amount of finishing; indeed the surfaces of the fabric are different. This is due to the coating that is spread over the fabric to make it waterproof. Probably this coating has a chemistry very similar to acrylic fibre.

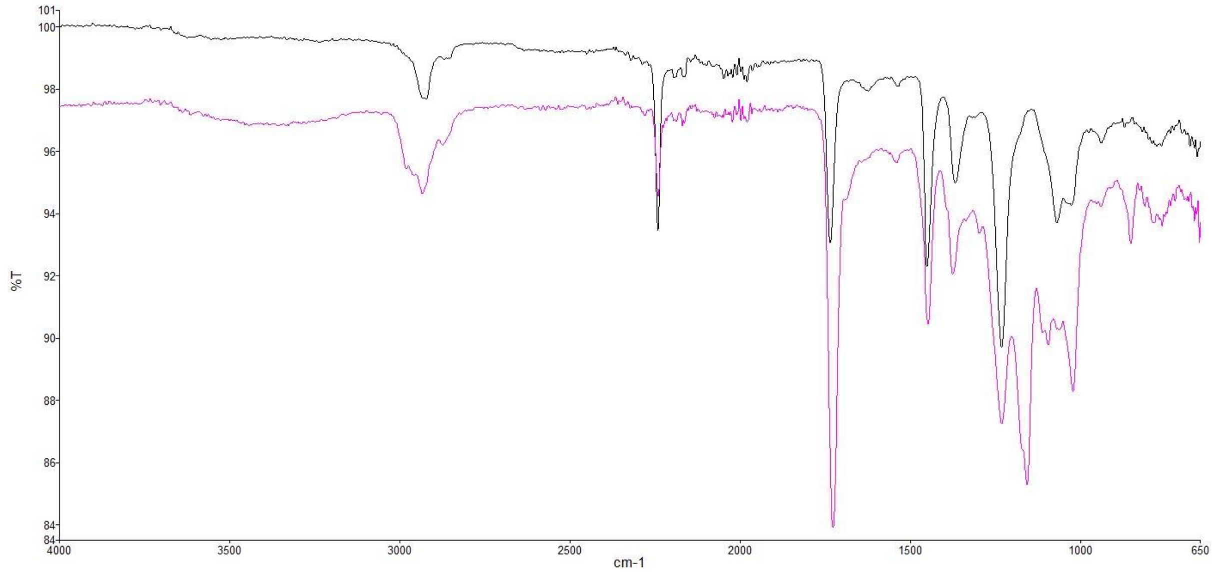

Figure 5. IR spectra of pure acrylic fabric (black line) and acrylic fabric with finishing B (pink line).

The interpretation of the IR spectra of fabrics with finishing B denotes the presence of a finishing similar to fabrics with finishing A, therefore a mixture of melamine resin with a fluorocarbon resin, with the addition of a surface coating, formed by an acrylic-based resin.

2.1.3 Fabrics for outdoor furniture – finishing C

The comparison of the spectra between fabrics with type C finishing and fabric without finishing does not show any particular difference. The finished fabric has a single additional peak around 1150 cm-1 indicating the presence of compounds containing C – F bonds and consequently of perfluorinated compounds on the fabric.

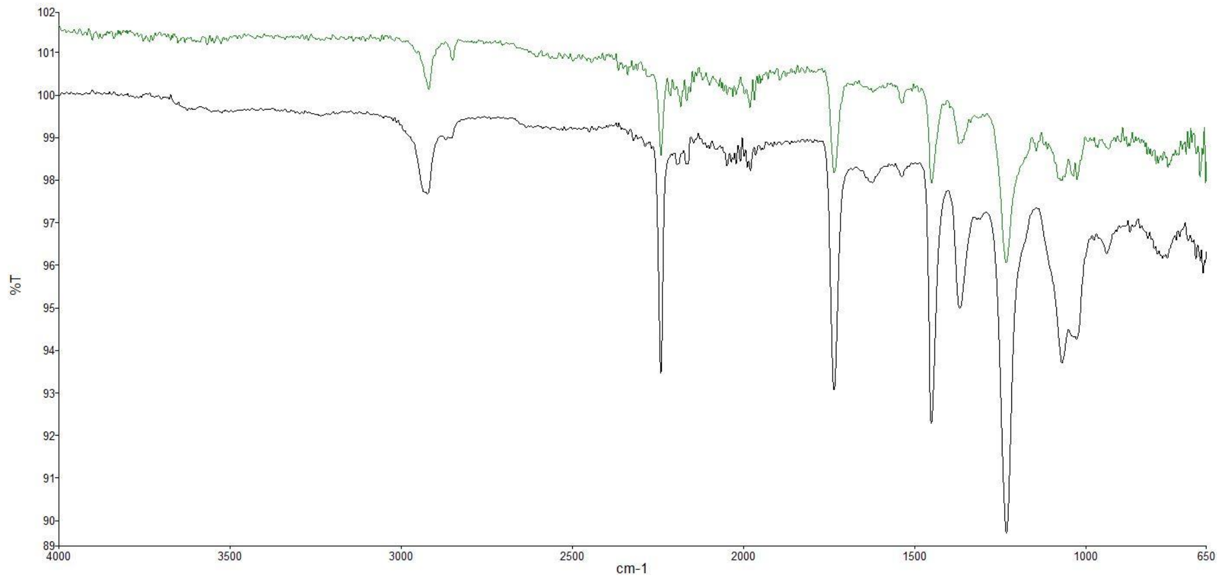

Figure 6. IR spectra of pure acrylic fabric (black line) and acrylic fabric with finishing C (green line).

2.2 High-performance liquid chromatography

HPLC is a technique in analytical chemistry used to separate, identify, and quantify each component in a mixture. It relies on pumps to pass a pressurized liquid solvent containing the sample mixture through a column filled with a solid adsorbent material. Each component in the sample interacts slightly differently with the adsorbent material, causing different flow rates for the different components and leading to the separation of the components as they flow out of the column. HPLC was used within the project to verify the presence on fabrics of perfluorinated compounds, comparing them with the reference standards, leading to the identification of the fluorinated compounds present, through coupling with mass spectroscopy. The analyses were performed according to the UNI CEN / TS 15968: 2010 standard, which provides for the following sample preparation procedure:

A 1 dm^2 fabric sample was cut into small pieces, to which 50 ml of methanol is added. The mixture was heated to 60 ° C for 2h. The extract was concentrated by a factor of 10 and a volume of 10 μl is transferred into a vials for LC. The sample was analysed by LC-MS / MS with negative electrospray ionization mode and with an appropriate gradient program.

The results obtained from the analysis of different fabrics have identified that perfluorinated organic compounds are present in all the indicated categories of finishing, in particular the analysis highlighted the presence of a mixture of C6 perfluorinated compounds applied as finishing on the fabric.

The comparison of the results between the quality control fabric and the end-of-life fabric with the same finish showed a significant variation in the concentration of perfluorinated compounds. Taking into consideration the quality control fabric and comparing the quantity of perfluorinated compounds on this fabric by 100%; there is a concentration of perfluorinated compounds on fabrics with use of 6-8 years of about 20% compared to the initial state of the fabric.

3 PREDICTIVE METHOD

This part of the document deals the development of a predictive method using chemometrics approach applied at NIR spectra of acrylic fabrics, in order to obtain a fast and not destructive analysis for sorting the fabrics, separating the fabrics with different finishing. Moreover, the model developed will be used in the WP2 to identify the removal process effectiveness.

3.1 Chemometrics

Chemometry is the discipline that allows facing complex experimental problems using suitable mathematical and statistical tools. Chemometric methods provide solutions for separating useful information from what else is contained in the data, minimizing time and costs. Chemometric tools can in general be applied to all complex scientific problems. For a complex analytical problem, the direct solution is impossible. The only possible approach remains a "soft model" based on the following phases:

- Exploratory data analysis: reduce the causes of complexity as much as possible. The most common and used method for this reduction is the analysis of the principal components.
- Grouping of data: look for similarity between data.
- Subdivision of data into classes: divide the data between natural classes known a priori.
- Data modelling: look for a quantitative or qualitative relationship (model) between responses and variables that can be used in place of the unknown functional relationship between responses and variables.
- Validation of models: quantify the descriptive capacity and the predictive capacity of the models.

3.1.1 Exploratory data analysis

Principal component analysis (PCA) is the most important of the data exploration techniques and consists in transforming the original variables into new variables, called principal components, obtained by linear combination of the original variables and such as to be orthogonal to each other. The PCA allows you to:

- Reduce the dimensionality of the data, representing them in an orthogonal space
- Eliminate spurious information (e.g.: instrumental noise)
- Evaluate the relative importance of the variables
- View objects and search for outliers, clusters, classes

PCA is the starting point for many multivariate techniques.

3.1.2 Grouping and subdivision of data

The analysis of clusters is a chemometric technique for the identification of clusters among the data, or for the search in the data of non-random structures. The problem of finding clusters does not have a single solution as it depends on the objectives that the operator sets himself; however, it is a procedure that has objective quantitative bases. The analysis of clusters is based on the mathematical concept of similarity between data, which in turn is linked to the concept of distance. Two objects are all the more similar the smaller their mutual distance is.

3.1.3 Data and validation modelling

A model is a mathematical relationship between responses and predictors. The models summarize the state of knowledge of a problem and allow predicting the evolutions of the studied system. The construction of a mathematical model is always preparatory to chemometric procedures such as classification and regression. The classification is based on qualitative models, the regression on quantitative models. The procedure on which the search for a model is based is divided into 4 phases:

- Identification. It consists in establishing whether the model is of a deterministic type, i.e. based on a priori knowledge of functional connections between variables, or stochastic, i.e. based on statistics.
- Construction. It consists in giving a numerical form to the model, through a fitting procedure; the latter involves the estimation of parameters that define the model and the evaluation of uncertainty.
- Validation. It consists in checking the model (testing), quantifying its descriptive capacity and predictive capacity.
- Application. The model is used to predict unknown events.

Subsequently the modelling is validated in order to evaluate the predictive capacity.

3.2 Predictive model developed

The predictive method developed in the project uses data obtained through NIR spectroscopy performed on acrylic fabrics. For the construction of the model, the data were acquired through the analysis of the acrylic fabrics from quality control, in order to have fabrics of which the substances present are known. The creation of the model took place previously using white fabrics, after which the data obtained from the analysis of coloured fabrics and finally the fabric data from the sellers were added. The data were acquired over all spectral range of the NIR, with a resolution of 8 cm-1, acquisition interval of 2 cm-1 and with 64 scans for each spectrum. 40 acquisitions were performed for each class of samples with different samplings. From these data, the main components of the system were obtained and the clusters were analysed in order to classify the data and create clusters that enclose the spectra of fabrics with the same finishing. The classification was carried out using the Soft Independent Models of Class Analogy (SIMCA) method.

SIMCA is a non-parametric method based on the PCA performed on self-scaled data. It may happen that an unknown object does not belong to any considered class, with a discriminating approach it would be erroneously assigned to one of the classes. To eliminate the error, another approach must be used, therefore, a law is taken into consideration that does not discriminate between a fixed number of classes, but between belonging to a class or not. This one is possible thanks to the construction of a model for each class and the use of the same to determine the belonging of an unknown object to the various classes. This is the basis of the SIMCA method.

The SIMCA classification is based on the calculation of a PCA model for each class known a priori and on the choice of an appropriate number of principal components to be used in prediction; the unknown samples are then compared with the built models and are assigned to the classes according to the similarities with the training set. The results obtained are represented in the Cooman graph; it reports the distance of the sample from the two chosen models; this graph allows you to understand if the object belongs to a class, to neither or to both easily.

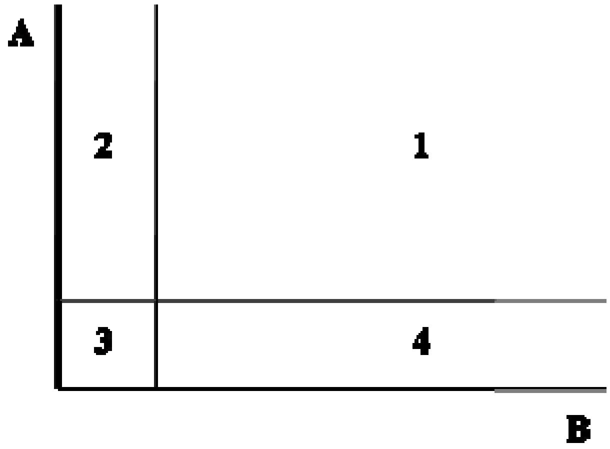

Figure 7: Example of Cooman graph.

The two lines, whose position is linked to the chosen level of significance, divide the space into four quadrants. The first places the samples assigned to none of the selected models; the second area hosts the samples assigned to model B, while in the fourth area the samples assigned to model A, finally, in the third area the samples assigned to both models.

Once the model was created, its predictive capabilities were evaluated through the validation method on test set. This method involves splitting the original data into two groups, called training sets and evaluation sets or test sets. The model is calculated on the training set. On the evaluation set, the quantification of predictive capabilities is carried out.

3.3 Results

The simplest model developed consists of 4 different categories of fabrics. A model containing clusters of identification of the fabric without finishing, of white fabrics with the respective 3 finishing described previously in paragraph 2 was created. This simplistic model was developed as a starting point to verify the predictive capacity of the type of finishing, and therefore that the clusters created are well spaced from each other in order to avoid any spatial overlaps and consequently false predictions of the model. From the results obtained, it can be seen that the 4 different fabrics are agglomerated in respective 4 families spaced appropriately and in the case of the fabric without finishing and those with finishing of type A and C with high precision, creating clusters of limited size. As regards the fabric with finishing B, the cluster generated in the model instead shows a larger size, with the respective spectra located in two precise and distant areas in the cluster. This is due to the coating, in fact, by analysing the spectra of finishing B, it can be seen that the intensity of the signals is different depending on whether the spectrum is acquired from the part where the coating is present or not. To overcome this problem, it could be indicated to always analyse these fabrics from the same side, or create two separate families for finishing B relative to the two faces of the fabric. However, given the distance between the clusters created by the model and the absence of overlaps, it was decided to keep a single cluster for finishing B. The test sets applied to this system gave a validation of the predictive model of 93%. The only sample that fails the assignment during the validation phase has a Total Distance Ratio value just over 1, the limit value for the model to assign a sample to a specific class.

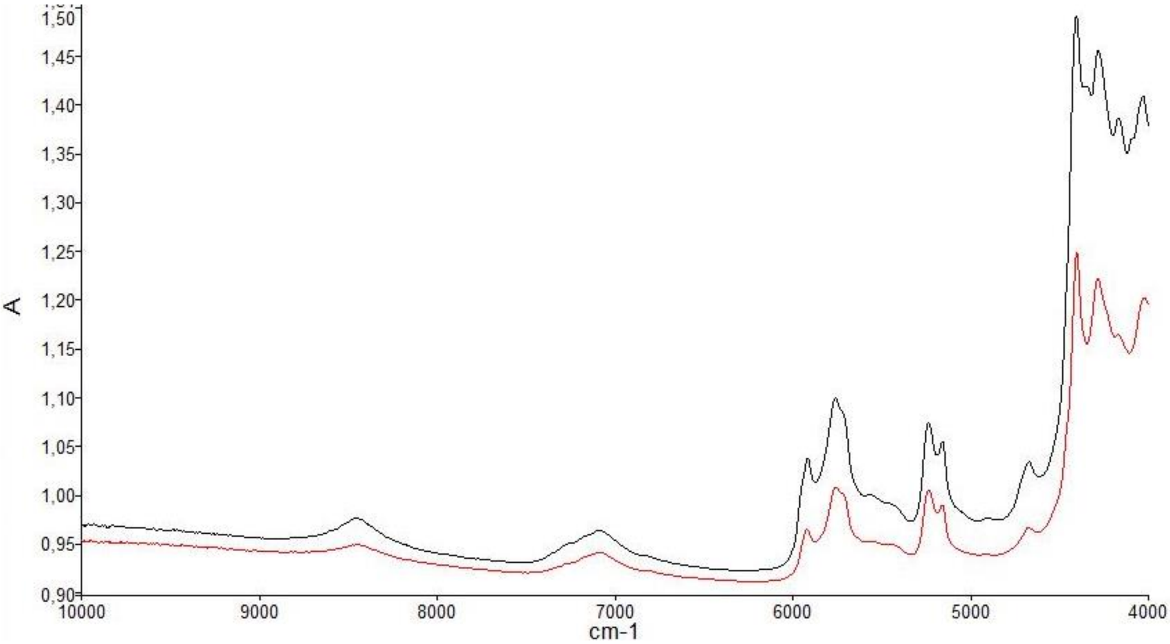

Figure 8. Comparison between the NIR spectrum of the fabric with finishing B on the face of the coating (black line) and on the face opposite the coating (red line).

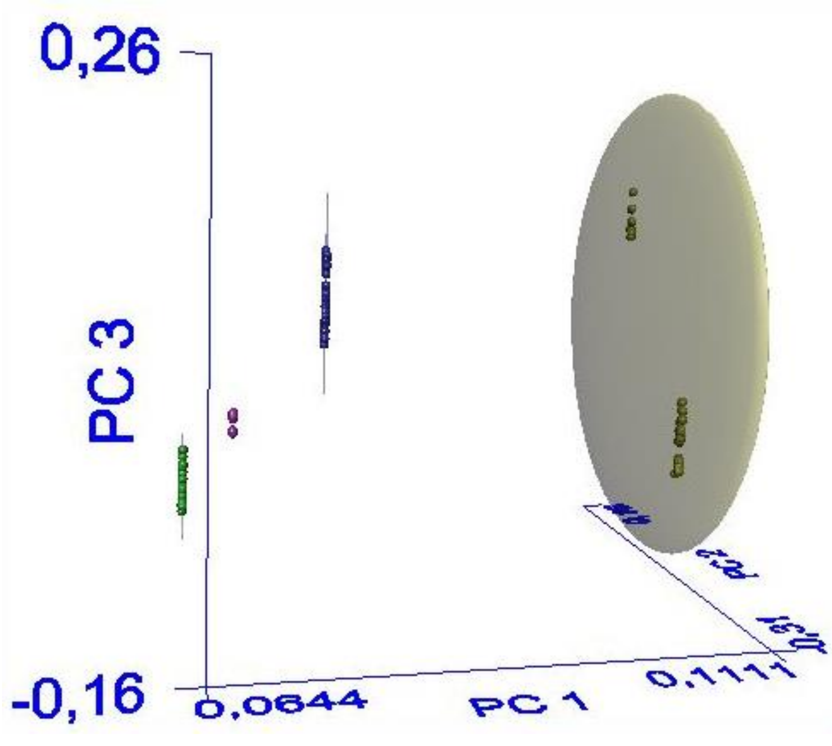

Figure 9. 3D graph of the PCA with the raw fabric (green), fabrics with finishing A (blue), fabrics with finishing B (yellow), fabrics with finishing C (pink) clusters.

Results:

	Sample I.D.	Specified Material	Identified Material	Result	Specified Material Total Distance Ratio
1	greggio_tondello_036_1	greggio	greggio	Passed	0,7610
2	greggio_tondello_037_1	greggio	greggio	Passed	0,6625
3	greggio_tondello_038_1	greggio	greggio	Passed	0,8196
4	greggio_tondello_039_1	greggio	greggio	Passed	0,9299
5	greggio_tondello_040_1	greggio	greggio	Passed	0,7032
6	8wa_036_1	8aw	8aw	Passed	0,8281
7	8wa_037_1	8aw	8aw	Passed	0,7146
8	8wa_038_1	8aw	8aw	Passed	0,6155
9	8wa_039_1	8aw	8aw	Passed	0,8534
10	8wa_040_1	8aw	8aw	Passed	0,7543
11	8bw_036_1	8bw	Other	Failed	1,0716
12	8bw_037_1	8bw	8bw	Passed	0,9010
13	8cw_036_1	8cw	8cw	Passed	0,6643
14	8cw_037_1	8cw	8cw	Passed	0,9090
15	8cw_038_1	8cw	8cw	Passed	0,8005
16	8cw_039_1	8cw	8cw	Passed	0,7966

Figure 10. Validation analysis of Test set.

Once the predictive ability and the ability to separate the white fabrics into the right categories created in the model were verified, the coloured fabrics were inserted for the construction of the model. In a first model developed, white and multicolour fabrics were divided with the same finishing. For type B finishing, two clusters were created depending on the face of the fabric on which the analysis was performed. The clusters obtained in this model have a good separation between them, an increase in the size of the clusters were noted compared to the model with white fabrics, and this is due to the different colours present that involve small variations in the NIR spectra underlined in the PCA. The validation of this predictive model has an accuracy rate of 47%. The significantly lower value is due to the presence of the colours, in fact, especially in the case of finishing A, there is a non-univocal assignment to the class belonging to the test sets, in fact, the model thus constructed identifies fabrics with finishing A both as white than like coloured fabrics. Another source of error is the separation between the front and back of finishing B, which leads to errors in the predictive capacity.

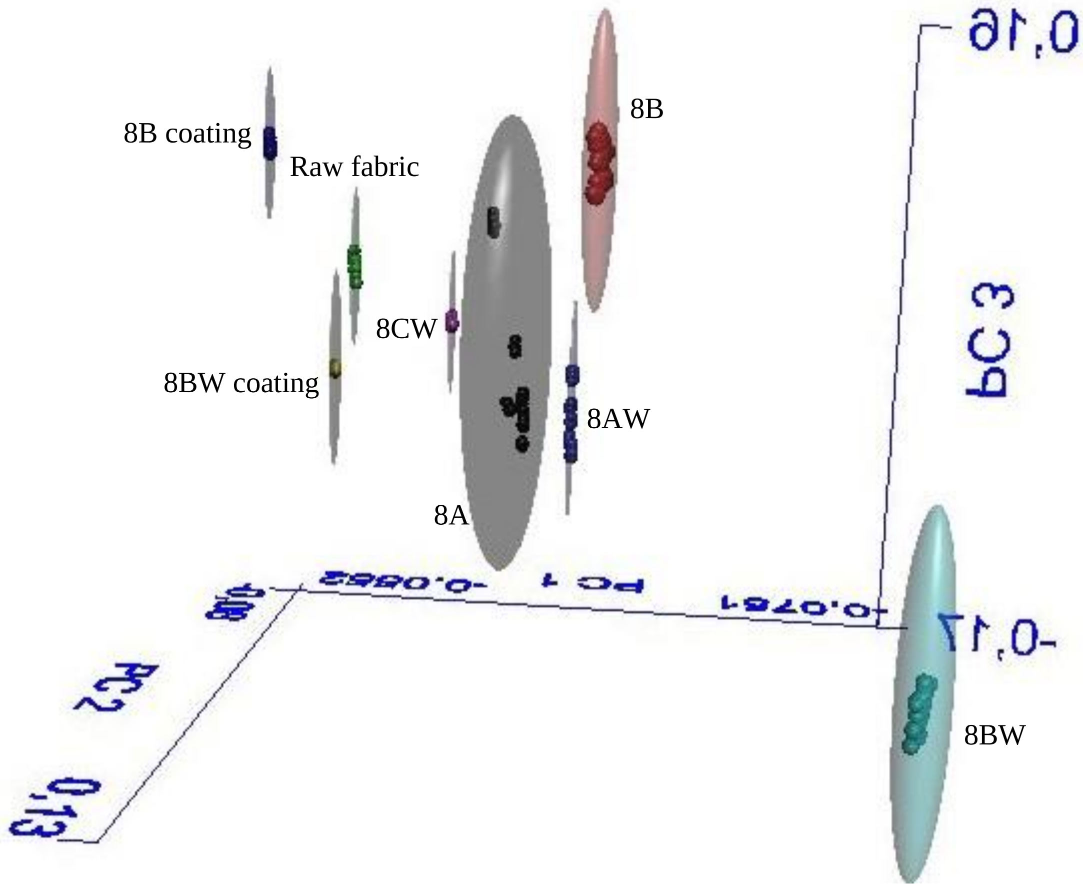

Figure 11. 3D graph of the PCA with the raw fabric, white fabrics with finishing A (8AW), white fabrics with finishing B coating face (8BW coating), white fabrics with finishing B opposite coating face (8BW), white fabrics with finishing C (8CW), multicolour fabrics with finishing A (8A), multicolour fabrics with finishing B coating face (8B coating), multicolour fabrics with finishing B opposite coating face (8B).

Results:

	Sample I.D.	Specified Material	Identified Material	Result	Specified Material Total Distance Ratio
1	8a_arancio_019_1	8a	Not Unique	Failed	0,4955
2	8a_arancio_020_1	8a	Not Unique	Failed	0,5011
3	8a_arancio_bianco_008_1	8a	Not Unique	Failed	0,5295
4	8a_arancio_bianco_009_1	8a	8a	Passed	0,7685
5	8a_blu_012_1	8a	Not Unique	Failed	0,4910
6	8a_blu_013_1	8a	Not Unique	Failed	0,5383
7	8a_blu_bianco_009_1	8a	8a	Passed	0,6608
8	8a_blu_bianco_010_1	8a	8a	Passed	0,5554
9	8a_rosa_009_1	8a	8a	Passed	0,6798
10	8a_rosa_010_1	8a	8a	Passed	0,7151
11	8a_verde_003_1	8a	Not Unique	Failed	0,6004
12	8a_verde_004_1	8a	8a	Passed	0,7731
13	greggio_tondello_046_1	greggio	greggio	Passed	0,4284
14	greggio_tondello_047_1	greggio	greggio	Passed	0,4432
15	greggio_tondello_048_1	greggio	greggio	Passed	0,4002
16	greggio_tondello_049_1	greggio	greggio	Passed	0,4424
17	greggio_tondello_050_1	greggio	greggio	Passed	0,5221
18	greggio_tondello_051_1	greggio	greggio	Passed	0,4422
19	8b_fronte035_1	8b fronte	Other	Failed	1,6689
20	8b_fronte036_1	8b fronte	Other	Failed	1,8393
21	8b_fronte037_1	8b fronte	Other	Failed	1,6335
22	8b_fronte038_1	8b fronte	Other	Failed	2,0245
23	8b_fronte039_1	8b fronte	Other	Failed	1,5703
24	8b_fronte040_1	8b fronte	Other	Failed	1,3802
25	8b_fronte041_1	8b fronte	8b fronte	Passed	0,8681
26	8b_retro_035_1	8b retro	8b retro	Passed	0,8714
27	8b_retro_036_1	8b retro	8b retro	Passed	0,8828
28	8b_retro_037_1	8b retro	8b retro	Passed	0,7332
29	8b_retro_038_1	8b retro	8b retro	Passed	0,7330
30	8b_retro_039_1	8b retro	8b retro	Passed	0,9559
31	8b_retro_040_1	8b retro	8b retro	Passed	0,9822
32	8bw_035_1	8bw fronte	8bw fronte	Passed	0,4415
33	8bw_037_1	8bw fronte	8bw retro	Failed	80,3185
34	8bw_038_1	8bw fronte	8bw retro	Failed	82,0624
35	8bw_039_1	8bw fronte	8bw retro	Failed	77,7152
36	8bw_040_1	8bw fronte	8bw retro	Failed	80,6249
37	8bw_041_1	8bw fronte	8bw retro	Failed	80,6588
38	8cw_034_1	8cw	8cw	Passed	0,5176
39	8cw_035_1	8cw	8cw	Passed	0,4849
40	8cw_036_1	8cw	8cw	Passed	0,4902
41	8cw_037_1	8cw	8cw	Passed	0,4888
42	8cw_038_1	8cw	8cw	Passed	0,4337
43	8cw_039_1	8cw	8cw	Passed	0,4024
44	8wa_035_1	8aw	Not Unique	Failed	0,5781
45	8wa_036_1	8aw	Not Unique	Failed	0,6986
46	8wa_037_1	8aw	Not Unique	Failed	0,6097
47	8wa_038_1	8aw	Not Unique	Failed	0,6098
48	8wa_039_1	8aw	Not Unique	Failed	0,6208
49	8wa_040_1	8aw	Not Unique	Failed	0,7182

Figure 12. Validation analysis of Test set.

To overcome this problem and create a more performing predictive method, another model was created where clusters were created by inserting fabrics with the same type of finishing, whether coloured or white, within the family. This model presents 5 families consisting of fabrics without finishing, with finishing A, with finishing B on the coating side, with finishing B on the opposite side of coating and with finishing C. This model denotes a good separation of the classes, which were grouped in different spaces of the space of the principal components, this separation allows in the validation and prediction phase to avoid non-univocal assignments phenomena. The validation of the method through the test set fabrics has an accuracy index of 94%, failing the assignment on 2 samples. By evaluating the Total Distance Ratio of the two, it was noted that the assignment fails slightly, in fact the value is just above 1, and the maximum limit for assigning this fabric to the class it belongs to. To overcome this problem, we can think of creating a model by slightly increasing the distance between the limits of the cluster and its centroid, in order to include these two fabrics and obtain a model with a validation index of 100%. This is possible thanks to the distance between the clusters in the space of the principal components.

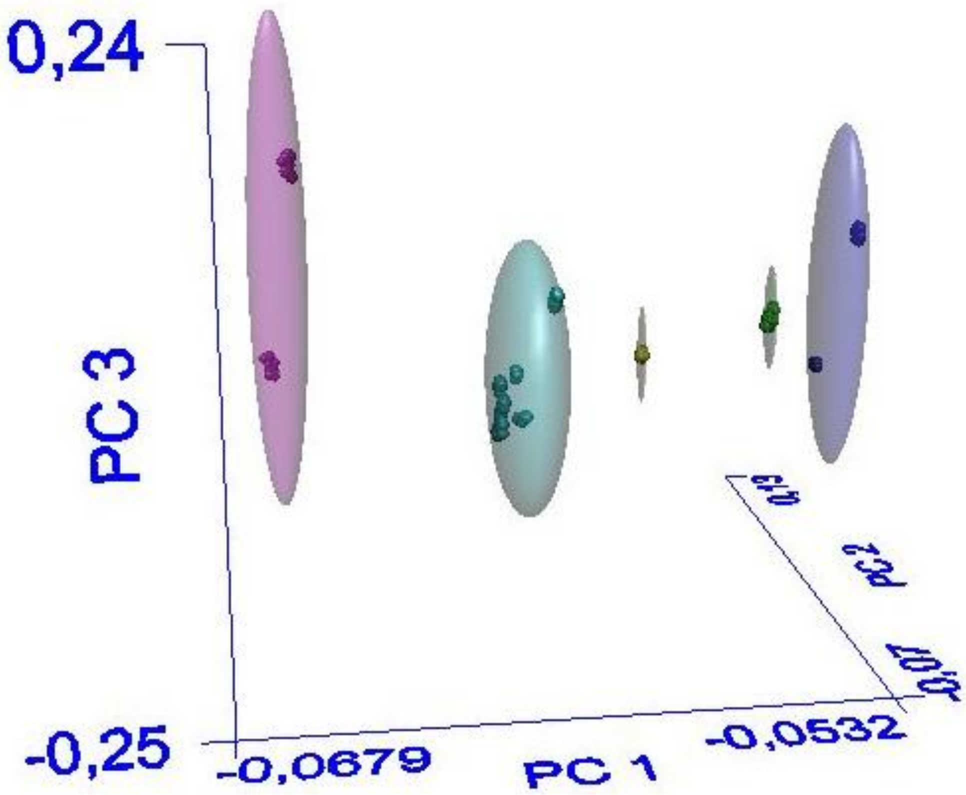

Figure 13. 3D graph of the PCA with the raw fabric (dark green), fabrics with finishing A (light green), fabrics with finishing B coating face (pink), fabrics with finishing B opposite coating face (blue), fabrics with finishing C (yellow).

Results:

	Sample I.D.	Specified Material	Identified Material	Result	Specified Material Total Distance Ratio
1	8a_arancio_019_1	8a	8a	Passed	0,7230
2	8a_arancio_020_1	8a	8a	Passed	0,6993
3	8a_arancio_bianco_008_1	8a	8a	Passed	0,7748
4	8a_arancio_bianco_009_1	8a	Other	Failed	1,0229
5	8a_blu_012_1	8a	8a	Passed	0,7578
6	8a_blu_013_1	8a	8a	Passed	0,7590
7	8a_blu_bianco_009_1	8a	8a	Passed	0,7860
8	8a_blu_bianco_010_1	8a	8a	Passed	0,7409
9	8a_rosa_009_1	8a	8a	Passed	0,7463
10	8a_rosa_010_1	8a	8a	Passed	0,8710
11	8a_verde_003_1	8a	8a	Passed	0,8017
12	8a_verde_004_1	8a	Other	Failed	1,0667
13	8b_retro_033_1	8bw retro	8bw retro	Passed	0,8137
14	8b_retro_034_1	8bw retro	8bw retro	Passed	0,8896
15	8b_retro_035_1	8bw retro	8bw retro	Passed	0,9101
16	8b_retro_036_1	8bw retro	8bw retro	Passed	0,8844
17	8b_retro_037_1	8bw retro	8bw retro	Passed	0,7852
18	8b_retro_038_1	8bw retro	8bw retro	Passed	0,8225
19	8b_retro_039_1	8bw retro	8bw retro	Passed	0,7755
20	8b_retro_040_1	8bw retro	8bw retro	Passed	0,8604
21	8b_fronte034_1	8bw fronte	8bw fronte	Passed	0,8648
22	8b_fronte035_1	8bw fronte	8bw fronte	Passed	0,7588
23	8b_fronte036_1	8bw fronte	8bw fronte	Passed	0,7157
24	8b_fronte037_1	8bw fronte	8bw fronte	Passed	0,7834
25	8b_fronte038_1	8bw fronte	8bw fronte	Passed	0,8624
26	8b_fronte039_1	8bw fronte	8bw fronte	Passed	0,8420
27	8b_fronte040_1	8bw fronte	8bw fronte	Passed	0,8312
28	8b_fronte041_1	8bw fronte	8bw fronte	Passed	0,7224
29	8cw_030_1	8cw	8cw	Passed	0,3942
30	8cw_031_1	8cw	8cw	Passed	0,4894
31	8cw_032_1	8cw	8cw	Passed	0,4232
32	8cw_033_1	8cw	8cw	Passed	0,3775
33	8cw_034_1	8cw	8cw	Passed	0,5176
34	8cw_035_1	8cw	8cw	Passed	0,4849
35	8cw_036_1	8cw	8cw	Passed	0,4902

Figure 14. Validation analysis of Test set.