

Statistical analysis of dusts taken from different areas of the Turin Shroud

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Foreword

This paper has been written in honour of the lamented Giovanni Riggi di Numana, a later STURP Member who was authorized to vacuum some dusts from the Turin Shroud in 1978 and 1988.

One of his purposes was to detect and sample linen fibers coming from the Turin Shroud from other particles, that will be useful for future studies. For this reason he freely and gratis furnished some aspired dusts “to lost fund” to the first author.

The present paper is a first result to realize hope of Giovanni Riggi di Numana who should have been very happy to see that his important contribution to the Turin Shroud was not forgotten by the scientific community.

Abstract

In 1978 and in 1988 Giovanni Riggi di Numana vacuumed some dusts from the back of the TS (Turin Shroud) and sampled them in various filters. Some analysis have been done at micrometric level on these dusts (declared by G. Riggi di Numana as coming from the TS) using SEM (Scanning Electron Microscope) and other instruments, but these analyses were principally steered for conservation problems. A description of dusts composition and a statistical analysis of their content have not yet been published.

For this reason the authors have decided to study the composition of the dusts coming from 5 different areas of the back of the TS, considering the following material relatively easy to be detected with a petrographic microscope: 1) cotton fibers; 2) TS fibers; 3) Holland Cloth fibers; 4) TS fibers coming from fire zone; 5) red fibers; 6) blue fibers; 7) other fibers; 8) red-brown particles (blood-like); 9) bright red particles; 10) yellow-red heads particles; 11) opaque particles; 12) other.

The TS fibers have been recognized from the others by using a proper cross-polarized light. A statistic analysis of dusts samples has been performed in relation to 5 filters containing dusts vacuumed from the Hands (“e”), Face (“f”), Feet (“g”), Buttocks (“h”) and ¹⁴C area (“i”).

To perform the analysis each one of the 5 samples has been subdivided in 3 or 4 sub-samples and a separate evaluation was performed: the selected fibers had diameters greater than 5 micrometers and the rounded particles a diameter greater than 3-4 micrometers.

The different distribution of the fibers in the various filters shows the relative difficulty of remixing dusts between TS and Holland cloth; in the case of more rounded particles, a greater capability of remixing is found instead.

Apart from the cotton fibers probably coming from the filters support that have been therefore excluded from the statistic analysis, about 8 fibers over 10 result from the TS.

In the sample "f" it has been found one only darker fiber similar to the TS body image, in agreement with the hypothesis of the double superficiality of the body image in correspondence of the Face (www.sindone.info/FANTI.PDF). This because it is not easy to suppose that an image fiber passes through the fabric thickness. One only fiber is not so meaningful but future analyses could confirm this fact.

This study is useful for the knowledge of the contents of the filters containing TS dusts and for future analysis on this material because it is now possible to know which material is there contained and how much is it. A future development could be addressed to the statistics of particles smaller than 3-4 micrometers.

1. Introduction

The TS^{1,2} (Turin Shroud) is an object in which it is imprinted a body image not yet explained by modern science³. For this reason many study are still open in order to better understand its characteristics.

One of them is devoted to the study of the microscopic characteristics of the TS linen fibers in order to better understand how the colored TS image could have formed without the presence of pigments.

In 1978 and in 1988 Giovanni Riggi di Numana aspired some dusts⁴ from the back of the TS and sampled them in various filters. Different analyses^{5, 6, 7} have been done at micrometric level on these dusts (declared by G. Riggi di Numana as coming from the TS), and other analyses using SEM and other instruments (made by G. Riggi di Numana but not published) were performed principally for conservation problems.

As it is shown in Figure 1, G. Riggi di Numana sampled the dusts, vacuumed from space between the TS and the Holland Cloth, in filters from "e" to "i". The dusts object of the present study were sampled from each filter by using sticky tapes of low tackiness put in contact with the dusts collected in the blue filter.

Aim of the present work is to describe the dusts composition in statistical analysis in order to differentiate and quantify the content of these filters. This work could also be useful to answer to the possibility to use the sampled TS fiber in a future radiocarbon analysis of the requested quantity will be sufficient.

2. Types of filters and particles analyzed

The dusts analyzed comes from the following 5 different areas of the back of the TS:

- filter "e" corresponding to the Hands area (1978 sampling);
- filter "f" corresponding to the area of the Face (1978 sampling);
- filter "g" corresponding to the area of the Feet (1978 sampling);
- filter "h" corresponding to the area of the Buttocks (1978 sampling);

- filter "i" corresponding to the area of the C-14 (1988 sampling).

The areas involved in the vacuuming are shown in Figure 2. Samples "e", "f", "g", "h", and "i" consist of strips of adhesive tape placed in contact with the dusts of the respective filter, previously vacuumed in the interspace among the TS and the Holland Cloth, as indicated in Figures 2. From each sample, 3 or 4 secondary samples were removed and consisted in little adhesive tape strips named:

- Sample "x - a";
- Sample "x - b";
- Sample "x - c".

being x = e, f, g, h or i.



Figure 1a. Giovanni Riggi di Numana showing Filter "i" that contains dusts vacuumed from the ^{14}C -1988 area.

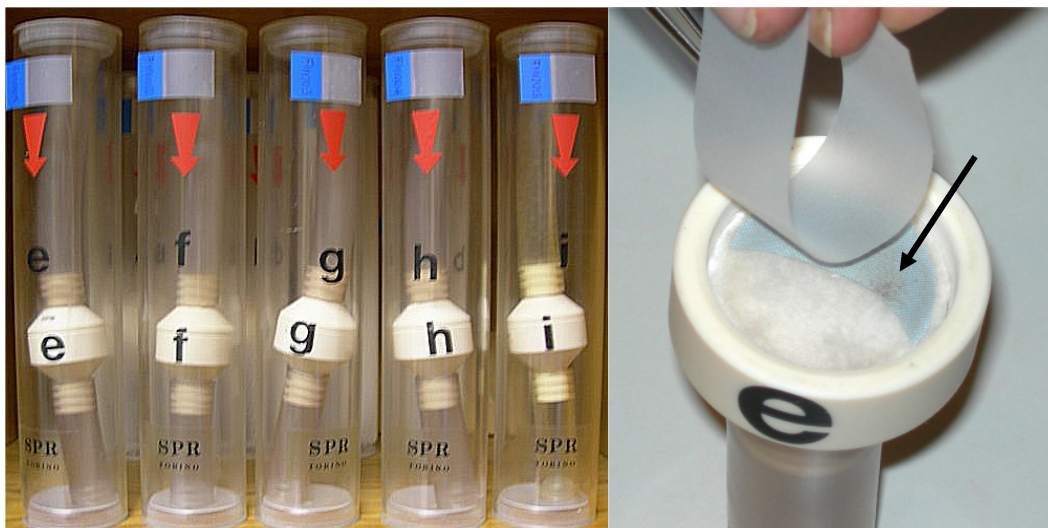


Figure 1b. Filters "e" to "i" that contains dusts vacuumed from the ^{14}C -1988 area on the left. Filter "e" from the Hands area while some dusts were sampled on a sticky tape on the right; the arrow shows the most prominent area of dusts.

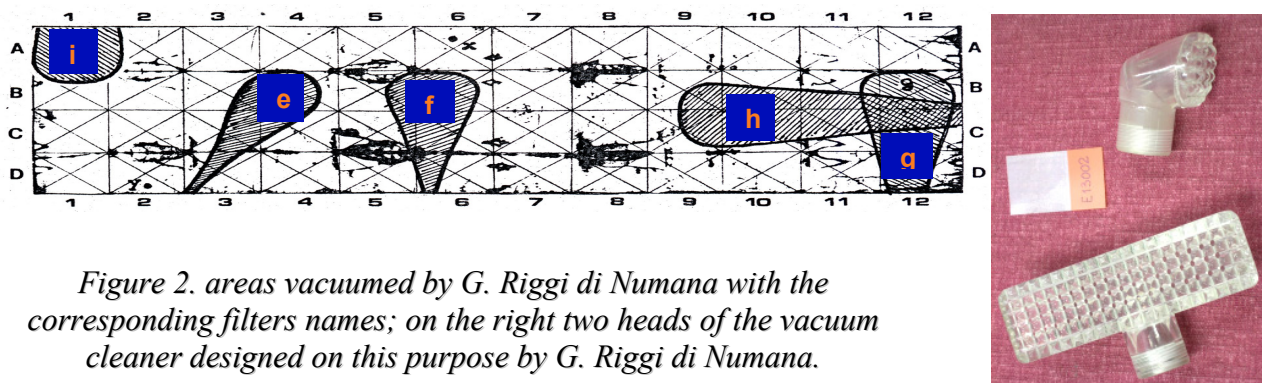


Figure 2. areas vacuumed by G. Riggi di Numana with the corresponding filters names; on the right two heads of the vacuum cleaner designed on this purpose by G. Riggi di Numana.

The content of each strip has been analyzed using a petrographic microscope in visible and cross-polarized light; with this last type of light it has turned out quite easy to distinguish the TS linen fibers (characterized by more evident coloring changes and by presence of discontinuities shown by segments inclined of about 45° with respect to the fiber axis, the so called “kink bands” or “dislocations” by plant researchers) from other fibers such as those probably coming from the adjacent Holland Cloth (of generally greater diameter, with minor changes of color in polarized light and a smoother surface) or coming from the colored silk placed to the TS borders or sampled from the cotton placed under the vacuuming filter which has been obviously sampled together with the dusts.

A statistic analysis of dusts samples has been performed after having recognized and subdivided the particles in 12 types, see Table 1.

Table 1. List of fibers and particles analyzed.

N.	TYPE	FIGURE
1	cotton fibers	3
2	TS fibers	4
3	Holland Cloth fibers	5
4	TS fibers - fire zone,	6
5	red fibers	7
6	blue fibers	8
7	other fibers	9
8	blood-like particles	10
9	bright red particles	11
10	yellow-red particles	12
11	opaque particles	13
12	other	14

The cotton fibers (easily recognizable because characterized by a section not as circular as that of the line fibers and often twisted) have not been considered in the statistical analysis even if for completeness also these were counted.

It has not always possible to perform an exact fiber count because frequently some of them were one above the other and various fragments were not considered.

The “other particles” in the dusts were quite numerous and were only counted those of diameter higher than 3-4 micrometers. Also in this case the count has not been easy because there were some agglomerates of different particles.

Based on preliminary observations, the dusts were classified into the elements shown in Table 1, easily distinguishable at the optic microscope with magnifications up to 500x in visible, polarized and ultraviolet light. The fibers have been separately considered from the other particles because much numerous. Given the presence of not easy identifiable particles, these have been classified as "other fibers".

During the analysis other particular element were detected that must not forgotten in the present analysis even if they were not so frequent to allow a statistic analysis. They are:

- possible image fiber, Figure 15;
- the so called "Sub-micron particles" by W. McCrone⁹, Figure 16;
- an acarus, Figure 17.



Figure 3. Cotton fibers in polarized light: the twisted ribbon shape is evident.

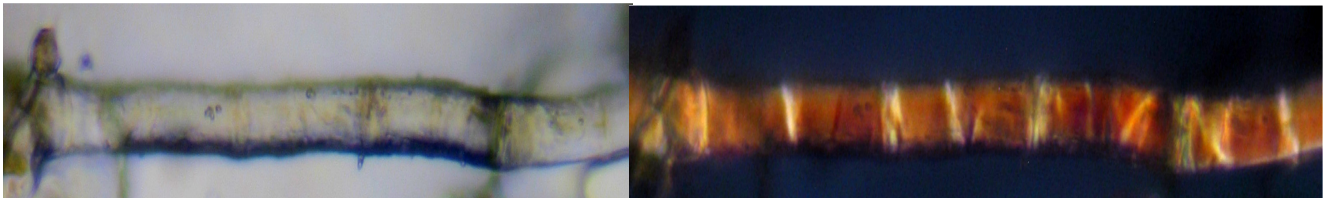


Figure 4a. TS fibers in visible light on the left and in polarized light on the right. The TS fibers have been easily recognized from the others by using to proper cross-polarized light because of their characteristic shape in correspondence of the so called "kink-bands"⁸.

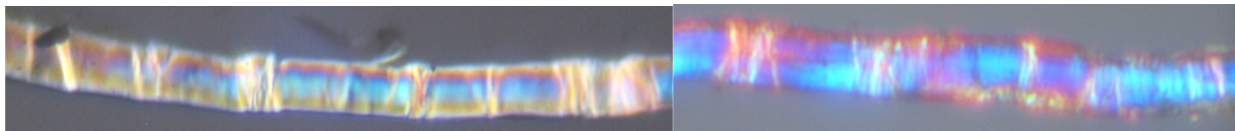


Figure 4b. TS fibers in polarized light. On the right sample F15001 yarn TS fiber from Raggi di Numana; on the left TS fiber STURP-1EB.

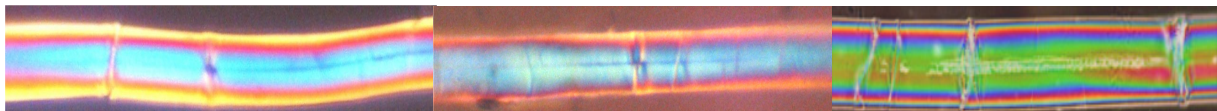


Figure 4c. Recent linen fibers in polarized light for comparison.

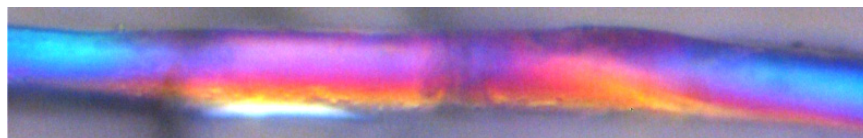


Figure 5. Holland Cloth fibers in polarized light.

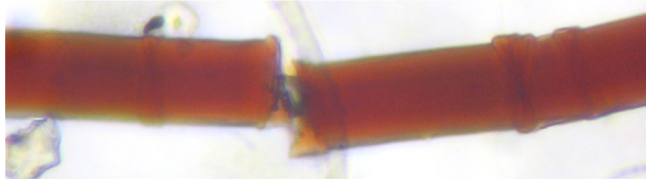


Figure 6. TS-fire-area fibers in visible light (polarization shows no effects in these fibers).

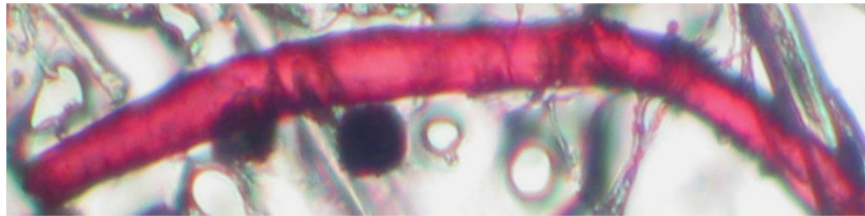


Figure 7. Red fibers in visible light from Sample "g-d", fiber thickness of about 15 micrometers.

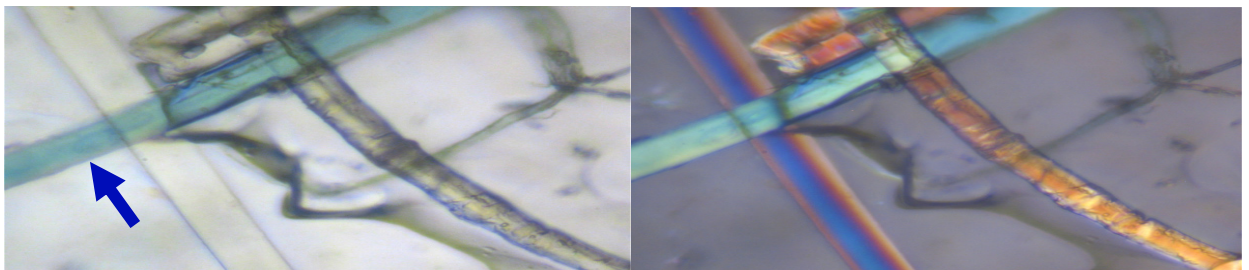


Figure 8. Blue fibers in visible light from Sample "i-b", fiber thickness of about 15 micrometers; the blue fibers crosses a TS fiber and a Holland cloth fiber (Transmitted visible light on the left and cross-polarized light on the right).

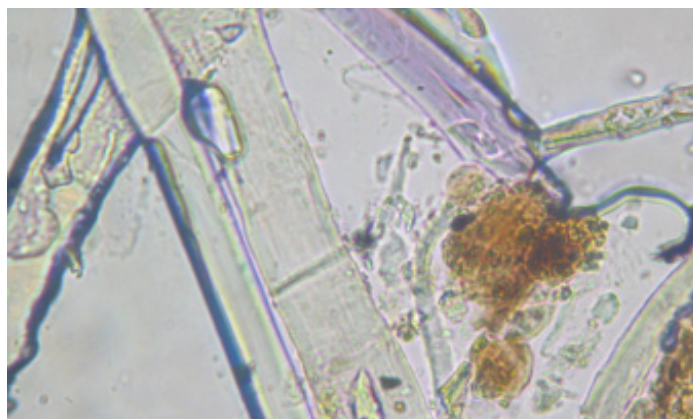


Figure 9. Other fibers (and particles) visible in the filters.

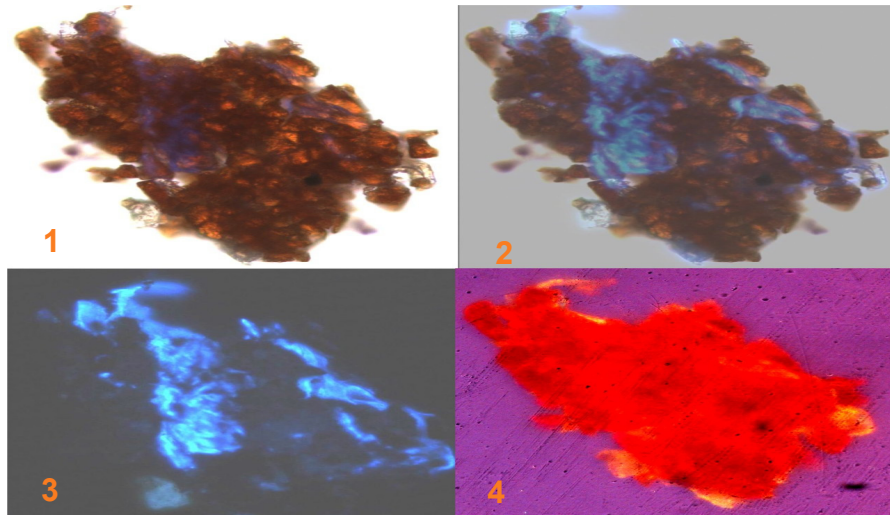


Figure 10. Blood-like particles having dimensions of about 10 micrometers; they are possible crust of blood and serum. 1) Visible transmitted light; 2) 50% visible superimposed to 50% UV light; 3) Ultraviolet light (blood appears black but the serum fluoresces); 4) Cross-polarized light (blood appears light red on a dark background).

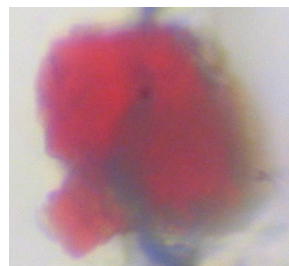


Figure 11. Bright red particles from Sample "e-b", particle size of about 20 micrometers.

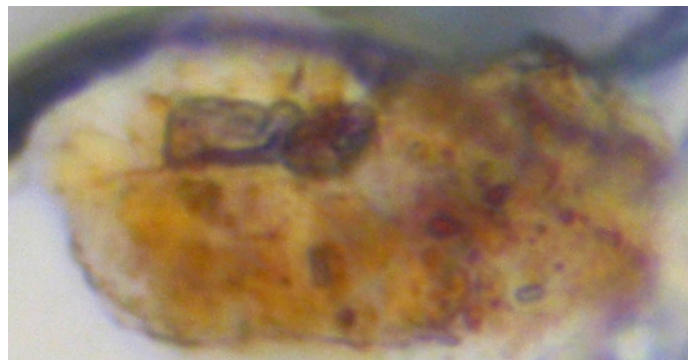


Figure 12. Yellow-red particles in agglomerated an about 30 micrometers long Sample "e-a".

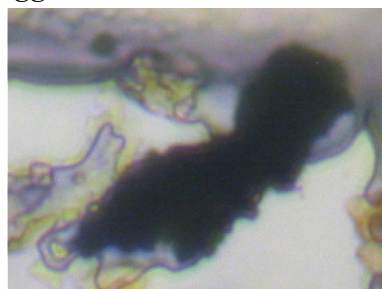


Figure 13. Opaque particles from Sample "h-a", particle of about 25 micrometers long in transmitted light.

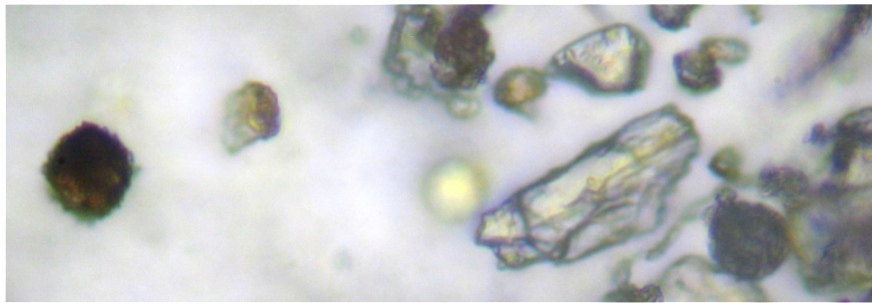


Figure 14. example of other particles having sizes of 5-40 micrometers (not analyzed) coming from

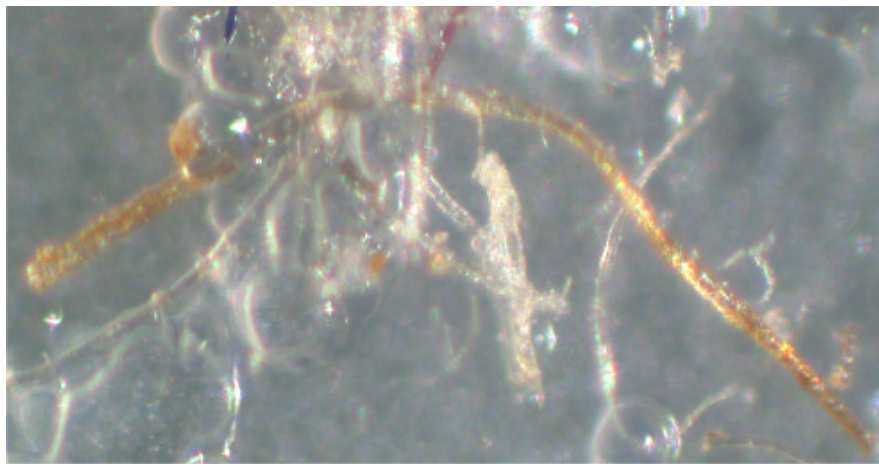


Figure 15. Possible image TS fiber perhaps coming from the second superficial body image in correspondence of Face.

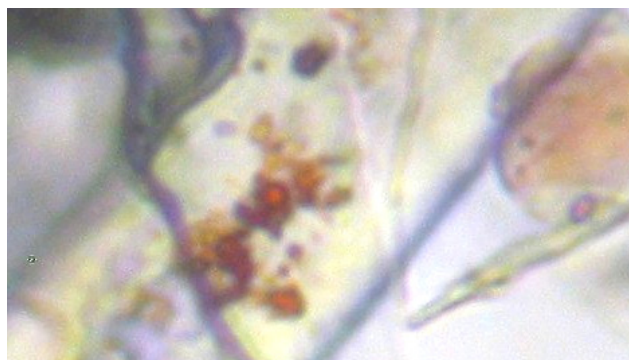


Figure 16. Brown-red particles similar to the so called "sub-micron particles" by W. McCrone (fiber diameter of about 15 micrometers) coming from Filter "i", Riggi di Numana, Fondazione 3M.

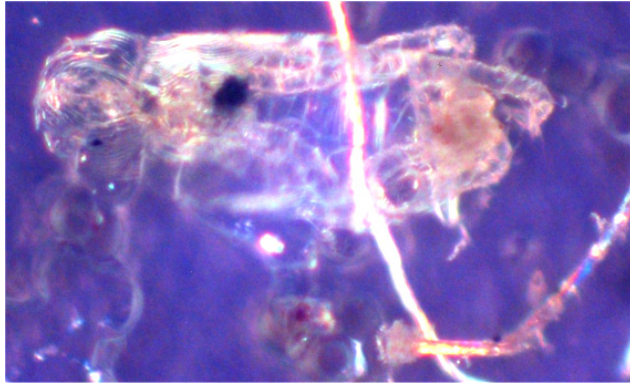


Figure 17. Acarus coming from Sample "g-a", Riggi di Numana, Fondazione 3M (about 250 micrometers long) in cross-polarized light with a TS fiber on the right bottom.

Sample "e", area Hands

From Sample "e", area corresponding to dusts vacuumed from the Hands, see figures 18, three secondary samples named "e-a", "e-b", "e-c" were extracted.

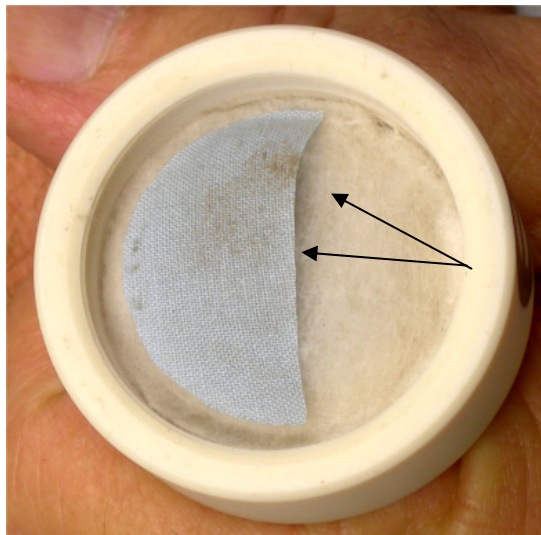
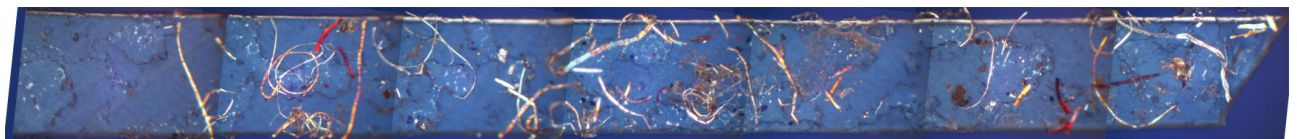


Figure 18. Filter "e": the arrows show the brownish particles of dust.

Sample "e-a"

Sample "e-a" shown in Fig. 19 has maximum length and width of 9.0 and 0.65 mm respectively Table 2 reports its content.



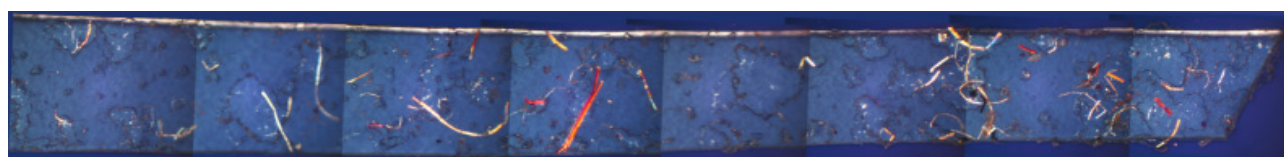
Figures 19. Sample "e-a" (in cross-polarized light) area containing dusts coming from the Hands.

Table 2. Elements analyzed in sample "e-a".

SAMPLE "e-a" TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	1	
SHROUD FIBERS	32	62.7
HOLLAND CLOTH FIBERS	0	0
SHROUD FIBERS -- AREA FIRE	8	15.7
RED FIBERS	1	2.0
BLUE FIBERS	0	0
OTHER FIBERS	10	19.6
TOTAL FIBERS (cotton excluded)	51	100
PARTICLES		
BLOOD-LIKE PARTICLES	7	53.8
BRIGHT RED PARTICLES	1	7.7
YELLOW-RED PARTICLES	4	30.8
OPAQUE PARTICLES	1	7.7
TOTAL PARTICLES	13	100
OTHER		
ACARI	-	-

Sample "e-b"

Sample "e-b" shown in Fig. 20 has maximum length and width of 11.55 and 0.70 mm respectively. Table 3 reports its content.



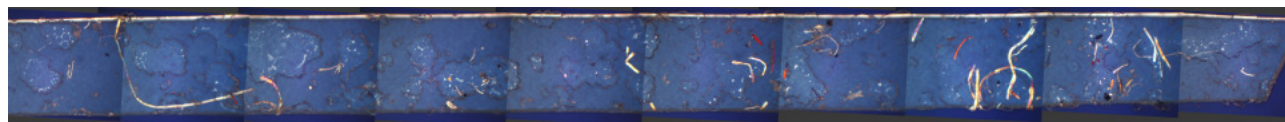
Figures 20. Sample "e-b" (in cross-polarized light) area containing dusts coming from the Hands.

Table 3. Elements analyzed in Sample "e-b".

SAMPLE "e-b" TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	1	
SHROUD FIBERS	22	44.9
HOLLAND CLOTH FIBERS	2	4.1
SHROUD FIBERS -- AREA FIRE	9	18.4
RED FIBERS	3	6.1
BLUE FIBERS	0	0
OTHER FIBERS	13	26.5
TOTAL FIBERS (cotton excluded)	49	100
PARTICLES		
BLOOD-LIKE PARTICLES	6	35.3
BRIGHT RED PARTICLES	1	5.9
YELLOW-RED PARTICLES	9	52.9
OPAQUE PARTICLES	1	5.9
TOTAL PARTICLES	17	100
OTHER		
ACARI	-	-

Sample "e-c"

Sample "e-c" shown in Fig. 21 has maximum length and width of 11.25 and 0.60 mm respectively. Table 4 reports its content.



Figures 21. Sample "e-c" (in cross-Polarized light) area containing dusts coming from Hands.

Table 4. Elements analyzed in Sample "e-c".

SAMPLE "e-c" TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	3	
SHROUD FIBERS	10	40
HOLLAND CLOTH FIBERS	7	28
SHROUD FIBERS -- AREA FIRE	8	32
RED FIBERS	0	0
BLUE FIBERS	0	0
OTHER FIBERS	0	0
TOTAL FIBERS (cotton excluded)	25	100
PARTICLES		
BLOOD-LIKE PARTICLES	2	20
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	7	70
OPAQUE PARTICLES	1	10
TOTAL PARTICLES	10	100
OTHER		
ACARI	-	-

Statistical analysis of Sample "e"

Basing on the dates obtained from Samples "e-a", "e-b" and "e-c", the following percentages shown in Table 5 result.

Table 5. Statistical results of Sample "e" area corresponding to the Hands.

SAMPLE "e" TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	-	-
SHROUD FIBERS	49.2	12.0
HOLLAND CLOTH FIBERS	10.7	15.1
SHROUD FIBERS -- AREA FIRE	22.0	8.7
RED FIBERS	2.7	3.1
BLUE FIBERS	0	0
OTHER FIBERS	15.4	13.8
PARTICLES		
BLOOD-LIKE PARTICLES	36.4	17.0
BRIGHT RED PARTICLES	4.5	4.0
YELLOW-RED PARTICLES	51.2	20.0
OPAQUE PARTICLES	7.9	2.1

Sample “f” Face area

From Sample “f”, corresponding to dusts vacuumed from the Face area, see Figure 22, three secondary samples named “f-a”, “f-b”, “f-c” were extracted.

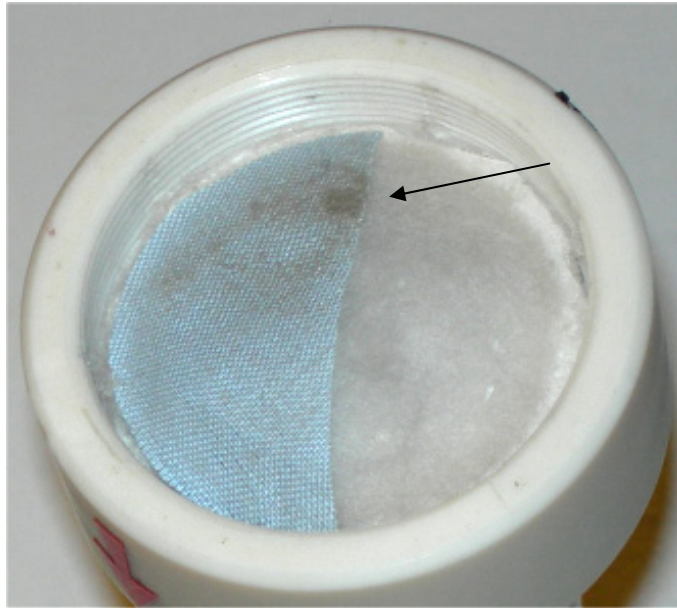


Figure 22. Filter “f”: the arrow shows the brownish particles of dust.

Sample “f-a”

“f-a” sample shown in Fig. 23 has maximum length and width of 12.35 and 0.70 mm respectively. Table 6 reports its content.

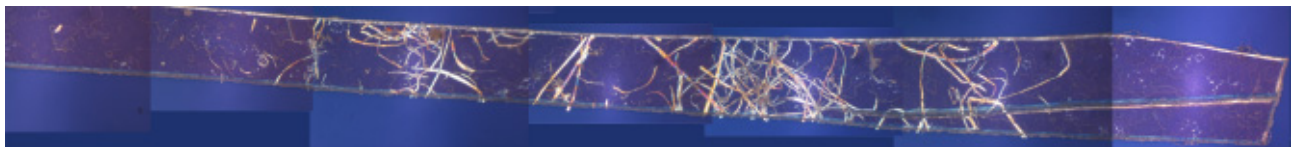


Figure 23. Sample “f-a” (in cross-polarized light) containing dusts coming from the Face area.

Table 6. Elements analyzed in Sample “f-a”.

SAMPLE “f-a” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	0	
SHROUD FIBERS	97	85.0
HOLLAND CLOTH FIBERS	7	6.1
SHROUD FIBERS – FIRE AREA	4	3.5
RED FIBERS	0	0
BLUE FIBERS	0	0
OTHER FIBERS	6	5.3
TOTAL FIBERS (cotton excluded)	114	100
PARTICLES		
BLOOD-LIKE PARTICLES	1	20
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	4	80
OPAQUE PARTICLES	0	0
TOTAL PARTICLES	5	100
OTHER		
ACARI	-	-

Sample “f-b”

“f-b” sample shown in Fig. 24 has maximum length and width of 12.55 and 0.80 mm respectively. Table 7 reports its content.

It must be observed the presence of a darker Shroud fiber that may be an image fiber coming from the Face image. see Fig. 25.



Figure 24. Sample “f-b” (in cross-polarized light) containing dusts coming from the Face area.

Table 7. Elements analyzed in Sample “f-b”.

SAMPLE “f-b” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	0	
SHROUD FIBERS	106	80.9
HOLLAND CLOTH FIBERS	6	4.6
SHROUD FIBERS – FIRE AREA	2	1.5
RED FIBERS	2	1.5
BLUE FIBERS	0	0
OTHER FIBERS	15	11.4
TOTAL FIBERS (cotton excluded)	131	100
PARTICLES		
BLOOD-LIKE PARTICLES	3	50
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	3	50
OPAQUE PARTICLES	0	0
TOTAL PARTICLES	6	100
OTHER		
ACARI	1	-

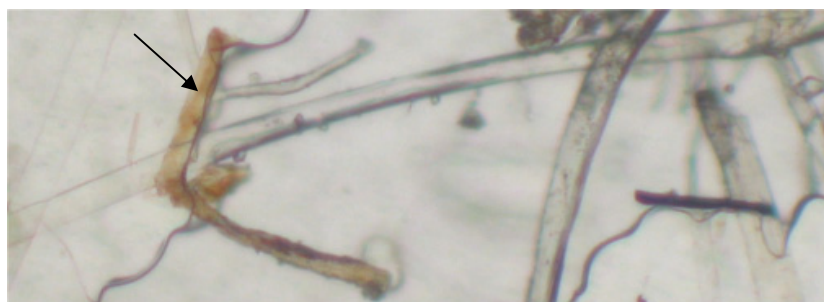


Figure 25. On the left possible TS image fiber, having a diameter of about 10 micrometers, coming from the Face area on the back side of the TS.

Sample “f-c”

“f-c” sample shown in Fig. 26 has maximum length and width of 11.25 and 0.60 mm respectively. Table 8 reports its content.



Figure 26. Sample “f-c” (in cross-polarized light) containing dusts coming from the Face area.

Table 8. Elements analyzed in Sample “f-c”.

SAMPLE “f-c” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	0	
SHROUD FIBERS	50	84.7
HOLLAND CLOTH FIBERS	4	6.8
SHROUD FIBERS – FIRE AREA	1	1.7
RED FIBERS	1	1.7
BLUE FIBERS	0	0
OTHER FIBERS	3	5.1
TOTAL FIBERS (cotton excluded)	59	100
PARTICLES		
BLOOD-LIKE PARTICLES	2	40
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	1	20
OPAQUE PARTICLES	2	40
TOTAL PARTICLES	5	100
OTHER		
ACARI	-	-

Statistical analysis of Sample “f”

Basing on the data obtained from Samples “f-a”, “f-b” and “f-c”, the following percentages shown in Table 9 result.

Table 9. Statistical results of Sample “f” corresponding to the Face area.

SAMPLE “f” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	-	-
SHROUD FIBERS	83.6	2.3
HOLLAND CLOTH FIBERS	5.8	1.1
SHROUD FIBERS – FIRE AREA	2.2	1.1
RED FIBERS	1.1	0.9
BLUE FIBERS	0	0
OTHER FIBERS	7.3	3.6
PARTICLES		
BLOOD-LIKE PARTICLES	36.7	15.3
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	50	30
OPAQUE PARTICLES	13.3	23.1

Sample “g” Feet area

From Sample “g”, corresponding to dusts vacuumed from the Feet area, see Figure 27, three secondary samples named “g-a”, “g-b”, “g-c” were extracted; a fourth sample named “g-d” was included in the analysis due to the great variety of dusts detected.



Figure 27. Filter “g”.

Sample “g-a”

“g-a” sample shown in Fig. 28 has maximum length and width of 15.20 and 1.02 mm respectively. Table 10 reports its content.

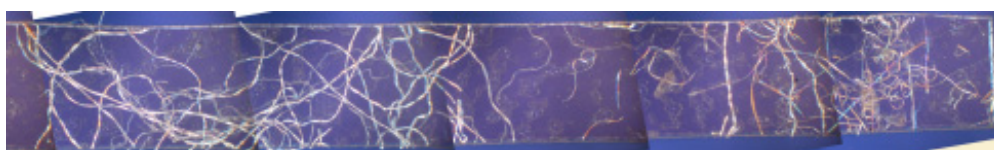


Figure 28. Sample “g-a” (in cross-polarized light) containing dusts coming from the Feet area.

Table 10. Elements analyzed in Sample “g-a”.

SAMPLE “g-a” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	50	
SHROUD FIBERS	70	83.3
HOLLAND CLOTH FIBERS	8	9.5
SHROUD FIBERS – FIRE AREA	2	2.4
RED FIBERS	0	0
BLUE FIBERS	1	1.2
OTHER FIBERS	3	3.6
TOTAL FIBERS (cotton excluded)	84	100
PARTICLES		
BLOOD-LIKE PARTICLES	2	20
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	4	40
OPAQUE PARTICLES	4	40
TOTAL PARTICLES	10	100
OTHER		
ACARI	-	-

Sample “g-b”

“g-b” sample shown in Fig. 29 has maximum length and width of 14.90 and 0.80 mm respectively. Table 11 reports its content.

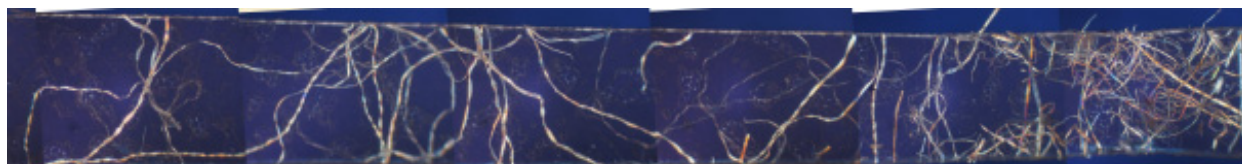


Figure 29. Sample “g-b” (in cross-polarized light) containing dusts coming from Feet area.
Table 11. Elements analyzed in Sample “g-b”.

Table 11. Elements analyzed in Sample “g-b”.

SAMPLE “g-b” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	50	
SHROUD FIBERS	100	85.5
HOLLAND CLOTH FIBERS	5	4.3
SHROUD FIBERS – FIRE AREA	1	0.8
RED FIBERS	0	0
BLUE FIBERS	0	0
OTHER FIBERS	11	9.4
TOTAL FIBERS (cotton excluded)	117	100
PARTICLES		
BLOOD-LIKE PARTICLES	13	48.2
BRIGHT RED PARTICLES	2	7.4
YELLOW-RED PARTICLES	11	40.7
OPAQUE PARTICLES	1	3.7
TOTAL PARTICLES		100
OTHER		
ACARI	-	-

Sample “g-c”

“f-a” sample shown in Fig. 30 has maximum length and width of 15.30 and 0.74 mm respectively. Table 12 reports its content.



Figure 30. Sample “g-c” (in cross-polarized light) containing dusts coming from Feet area.

Table 12. Elements analyzed in Sample “g-c”.

SAMPLE “g-c” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	0	
SHROUD FIBERS	77	82.8
HOLLAND CLOTH FIBERS	12	12.9
SHROUD FIBERS – FIRE AREA	0	0
RED FIBERS	1	1.1
BLUE FIBERS	0	0
OTHER FIBERS	3	3.2
TOTAL FIBERS (cotton excluded)	93	100
PARTICLES		
BLOOD-LIKE PARTICLES	8	80
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	2	20
OPAQUE PARTICLES	0	0
TOTAL PARTICLES	10	100
OTHER		
ACARI	-	-
VIOLET FIBER	1	-



Figure 31. Violet fiber having a diameter of about 7 micrometers found in Sample “g-c”.

Sample “g-d”

“g-d” sample shown in Fig. 32 has maximum length and width of 6.50 and 1.60 mm respectively. Table 13 reports its content.

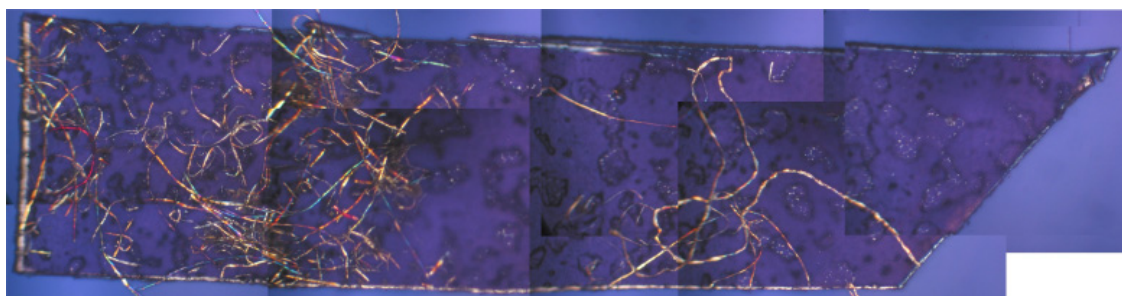


Figure 32. Sample “g-d” (in cross-polarized light) containing dusts coming from Feet area.

Table 13. elements analyzed in Sample “g-d”.

SAMPLE “g-d” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	10	
SHROUD FIBERS	70	72.9
HOLLAND CLOTH FIBERS	7	7.3
SHROUD FIBERS – FIRE AREA	4	4.2
RED FIBERS	2	2.1
BLUE FIBERS	0	0
OTHER FIBERS	13	13.5
TOTAL FIBERS (cotton excluded)	96	100
PARTICLES		
BLOOD-LIKE PARTICLES	8	80
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	2	20
OPAQUE PARTICLES	0	0
TOTAL PARTICLES	10	100
OTHER		
ACARI	-	-

Statistical analysis of Sample “g”

Basing on the data obtained from Samples “g-a”, “g-b”, “g-c” and “g-d”, the following percentages shown in Table 14 result.

Table 14. Statistical results of Sample “g” corresponding to the Feet area.

SAMPLE “g” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	-	-
SHROUD FIBERS	81.1	5.6
HOLLAND CLOTH FIBERS	8.5	3.6
SHROUD FIBERS – FIRE AREA	1.9	1.8
RED FIBERS	0.8	1.0
BLUE FIBERS	0.3	0.6
OTHER FIBERS	7.4	5.0
PARTICLES		
BLOOD-LIKE PARTICLES	57.0	28.9
BRIGHT RED PARTICLES	1.9	3.7
YELLOW-RED PARTICLES	30.2	11.8
OPAQUE PARTICLES	10.9	19.5

Sample “h” Buttocks area

From Sample “h”, corresponding to dusts vacuumed from the Buttocks area, see Figure 33, three secondary samples named “h-a”, “h-b”, “h-c” were extracted; a fourth sample named “h-d” was included in the analysis due to the scarceness of material detected.

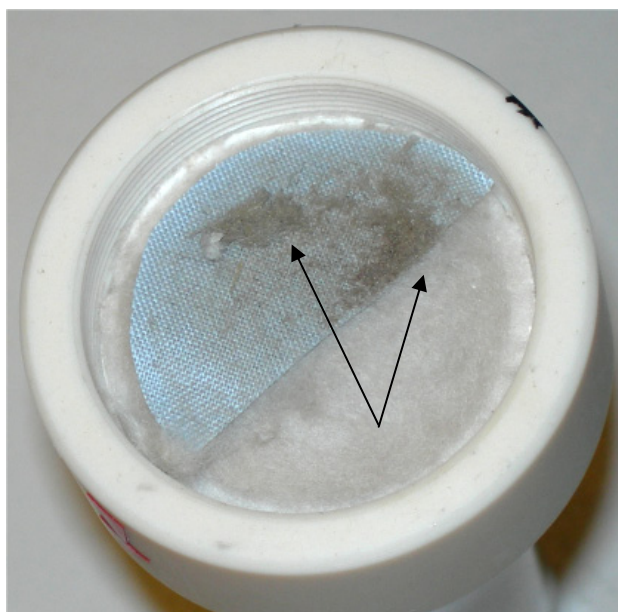


Figure 33. Filter “h” : the arrows show the brownish particles of dust.

Sample “h-a”

“h-a” sample shown in Fig. 34 has maximum length and width of 9.90 and 0.70 mm respectively. Table 15 reports its content.



Figure 34. Sample “h-a” (in cross-polarized light) containing dusts coming from the Buttocks area.

Table 15. Elements analyzed in Sample “h-a”.

SAMPLE “h-a” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	1	
SHROUD FIBERS	59	64.8
HOLLAND CLOTH FIBERS	1	1.1
SHROUD FIBERS – FIRE AREA	9	9.9
RED FIBERS	4	4.4
BLUE FIBERS	0	0
OTHER FIBERS	18	19.8
TOTAL FIBERS (cotton excluded)	91	100
PARTICLES		
BLOOD-LIKE PARTICLES	20	55.6
BRIGHT RED PARTICLES	2	5.5
YELLOW-RED PARTICLES	10	27.8
OPAQUE PARTICLES	4	11.1
TOTAL PARTICLES	36	100
OTHER		
ACARI	3	-

Sample “h-b”

“h-b” sample shown in Fig. 35 has maximum length and width of 13.50 and 0.72 mm respectively. Table 16 reports its content.



Figure 35. Sample “h-b” (in cross-polarized light) containing dusts coming from the Buttocks area.

Table 16. Elements analyzed in Sample “h-b”.

SAMPLE “h-b” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	1	
SHROUD FIBERS	84	77.1
HOLLAND CLOTH FIBERS	3	2.7
SHROUD FIBERS – FIRE AREA	10	9.2
RED FIBERS	1	0.9
BLUE FIBERS	0	0
OTHER FIBERS	11	10.1
TOTAL FIBERS (cotton excluded)	109	100
PARTICLES		
BLOOD-LIKE PARTICLES	33	46.5
BRIGHT RED PARTICLES	3	4.2
YELLOW-RED PARTICLES	32	45.1
OPAQUE PARTICLES	3	4.2
TOTAL PARTICLES	71	100
OTHER		
ACARI	2	-

Sample “h-c”

“h-c” sample shown in Fig. 36 has maximum length and width of 10.20 and 0.70 mm respectively. Table 17 reports its content.



Figure 36. Sample “h-c” (in cross-polarized light) containing dusts coming from the Buttocks area.

Table 17. Elements analysed in Sample “h-c”.

SAMPLE “h-c” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	3	
SHROUD FIBERS	10	43.5
HOLLAND CLOTH FIBERS	2	8.7
SHROUD FIBERS – FIRE AREA	1	4.3
RED FIBERS	0	0
BLUE FIBERS	0	0
OTHER FIBERS	10	43.5
TOTAL FIBERS (cotton excluded)	23	100
PARTICLES		
BLOOD-LIKE PARTICLES	2	33.3
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	3	50
OPAQUE PARTICLES	1	16.7
TOTAL PARTICLES	6	100
OTHER		
ACARI	-	-

Sample “h-d”

“h-d” sample shown in Fig. 37 has maximum length and width of 4.60 and 1.10 mm respectively. Table 18 reports its content.

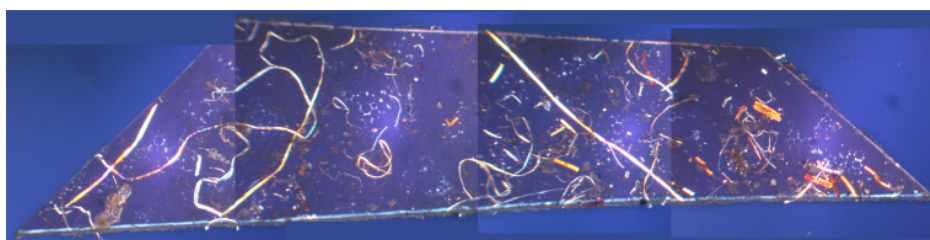


Figure 37. Sample “h-d”(in cross-polarized light) containing dusts coming from the Buttocks area.

Table 18. Elements analyzed in Sample “h-d”.

SAMPLE “h-d” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	1	
SHROUD FIBERS	60	75
HOLLAND CLOTH FIBERS	0	0
SHROUD FIBERS – FIRE AREA	14	17.5
RED FIBERS	1	1.2
BLUE FIBERS	0	0
OTHER FIBERS	5	6.3
TOTAL FIBERS (cotton excluded)	80	100
PARTICLES		
BLOOD-LIKE PARTICLES	15	36.6
BRIGHT RED PARTICLES	1	2.4
YELLOW-RED PARTICLES	22	53.7
OPAQUE PARTICLES	3	7.3
TOTAL PARTICLES	41	100
OTHER		
ACARI	1	-

Statistical analysis of Sample “h”

Basing on the data obtained from Samples “h-a”, “h-b”, “h-c” and “h-d”, the following percentages shown in Table 19 result.

Table 19. Statistical results of Sample “h” corresponding to the Buttocks area.

SAMPLE “h” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	-	-
SHROUD FIBERS	65.1	15.4
HOLLAND CLOTH FIBERS	3.1	3.9
SHROUD FIBERS – FIRE AREA	10.2	5.4
RED FIBERS	1.7	1.9
BLUE FIBERS	0	0
OTHER FIBERS	19.9	16.7
PARTICLES		
BLOOD-LIKE PARTICLES	43.0	10.1
BRIGHT RED PARTICLES	3.1	2.4
YELLOW-RED PARTICLES	44.0	11.5
OPAQUE PARTICLES	9.9	5.4

Sample “i” C-14 area

From Sample “i”, corresponding to dusts vacuumed from the area corresponding to the 1988-¹⁴C-sample withdrawal, see Figure 38, three secondary samples named “i-a”, “i-b”, “i-c” were extracted.

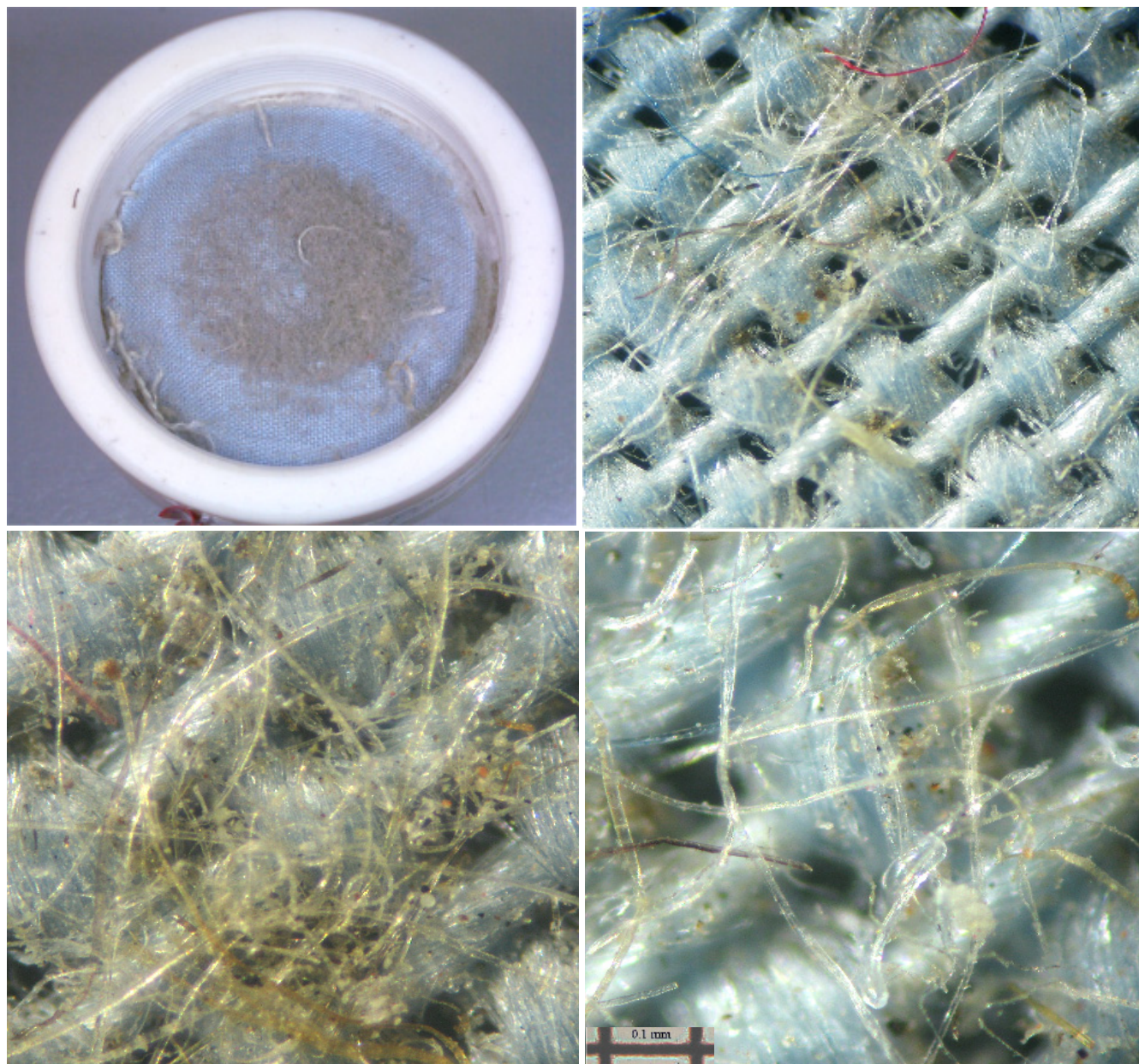


Figure 38. Filter “i” with some details.

Sample “i-a”

“i-a” sample shown in Fig. 39 has maximum length and width of 5.20 and 0.60 mm respectively. Table 20 reports its content.

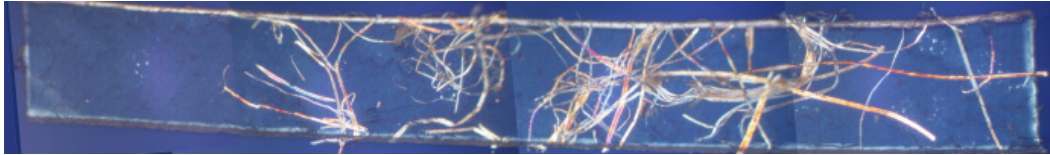


Figure 39. Sample “i-a” (in cross-polarized light) containing dusts coming from the 1988-¹⁴C area.

Table 20. Elements analyzed in Sample “i-a”.

SAMPLE “i-a” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	1	
SHROUD FIBERS	50	75.8
HOLLAND CLOTH FIBERS	3	4.5
SHROUD FIBERS – FIRE AREA	1	1.5
RED FIBERS	0	0
BLUE FIBERS	0	0
OTHER FIBERS	12	18.2
TOTAL FIBERS (cotton excluded)	66	100
PARTICLES		
BLOOD-LIKE PARTICLES	3	60
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	1	20
OPAQUE PARTICLES	1	20
TOTAL PARTICLES	5	100
OTHER		
ACARI	-	-

It must be observed the finding of a TS fiber having a group or microparticles on its surface. of a blood-like color very similar to those defined by W. McCrone as “sub-micron particles”, see Figure 16.

The characteristics (color in visible, polarized and UV light) of the particles are very similar to those of blood. The possibility that such particles are desiccated erythrocytes on the surface fiber must not be excluded; future analyses should be performed.

Sample “i-b”

“i-b” sample shown in Fig. 40 has maximum length and width of 4.10 and 0.60 mm respectively. Table 21 reports its content.

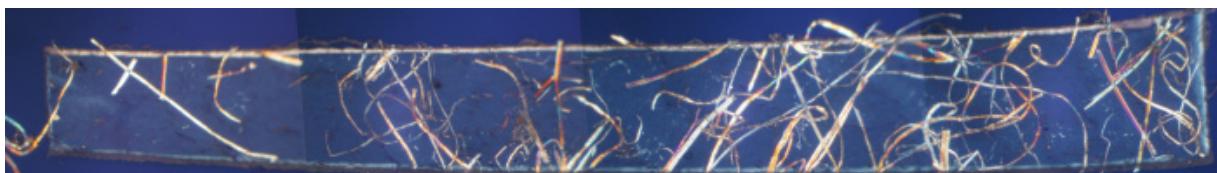


Figure 40. Sample “i-b” (in cross-polarized light) containing dusts coming from the 1988-¹⁴C area.

Table 21. Elements analyzed in Sample “i-b”.

SAMPLE “i-b” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	9	
SHROUD FIBERS	28	45.9
HOLLAND CLOTH FIBERS	9	14.8
SHROUD FIBERS – FIRE AREA	1	1.6
RED FIBERS	0	0
BLUE FIBERS	2	3.3
OTHER FIBERS	21	34.4
TOTAL FIBERS (cotton excluded)	61	100
PARTICLES		
BLOOD-LIKE PARTICLES	9	64.3
BRIGHT RED PARTICLES	0	0
YELLOW-RED PARTICLES	3	21.4
OPAQUE PARTICLES	2	14.3
TOTAL PARTICLES	14	100
OTHER		
ACARI	-	-

Sample “i-c”

“i-c” sample shown in Fig. 41 has maximum length and width of 4.20 and 0.60 mm respectively. Table 22 reports its content.

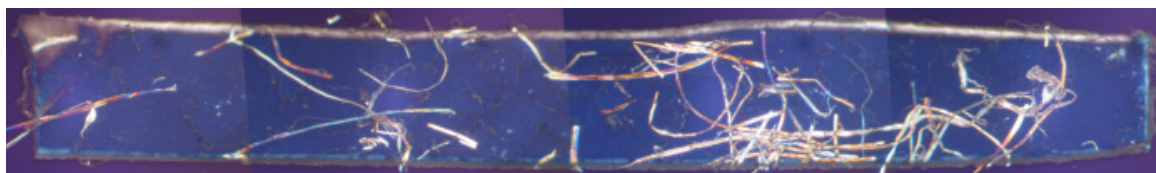


Figure 41. Sample “i-c”(in cross-polarized light) containing dusts coming from the 1988-¹⁴C area.

Table 22. Elements analyzed in Sample “i-c”.

SAMPLE “i-c” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	4	
SHROUD FIBERS	21	37.5
HOLLAND CLOTH FIBERS	12	21.4
SHROUD FIBERS – FIRE AREA	1	1.8
RED FIBERS	1	1.8
BLUE FIBERS	3	5.4
OTHER FIBERS	18	32.1
TOTAL FIBERS (cotton excluded)	56	100
PARTICLES		
BLOOD-LIKE PARTICLES	3	42.9
BRIGHT RED PARTICLES	1	14.2
YELLOW-RED PARTICLES	3	42.9
OPAQUE PARTICLES	0	0
TOTAL PARTICLES	7	100
OTHER		
ACARI	-	-

Statistical analysis of Sample “i”

Basing on the data obtained from Samples “i-a”, “i-b” and “i-c”, the following percentages shown in Table 23 result.

Table 23. Statistical results of Sample “i” corresponding to 1988-¹⁴C-sample area.

SAMPLE “i” TYPE	ELEMENTS NUMBER	PERCENTAGE ELEMENTS [%]
FIBERS		
COTTON FIBERS	-	-
SHROUD FIBERS	53.1	20.1
HOLLAND CLOTH FIBERS	13.6	8.5
SHROUD FIBERS – FIRE AREA	1.6	0.1
RED FIBERS	0.6	1.0
BLUE FIBERS	2.9	2.7
OTHER FIBERS	28.2	8.8
PARTICLES		
BLOOD-LIKE PARTICLES	55.7	11.3
BRIGHT RED PARTICLES	4.8	8.2
YELLOW-RED PARTICLES	28.1	12.8
OPAQUE PARTICLES	11.4	10.3

SYNTHESIS OF THE SAMPLES STATISTICAL ANALYSIS AND COMMENTS

From the statistical analysis of Samples “e”, “f”, “g”, “h”, “i” the distribution of fibers and particles reposted in Table 24 results.

Table 24. Fibers and particles distribution in Samples “e”, “f”, “g”, “h”, “i”. The values correspond to the mean value \pm standard deviation.

TYPE	SAMPLE “e” [%]	SAMPLE “f” [%]	SAMPLE “g” [%]	SAMPLE “h” [%]	SAMPLE “i” [%]
FIBERS					
SHROUD	49.2 \pm 12.0	83.6 \pm 2.3	81.1 \pm 5.6	65.1 \pm 15.4	53.1 \pm 20.1
HOLLAND CLOTH	10.7 \pm 15.1	5.8 \pm 1.1	8.5 \pm 3.6	3.1 \pm 3.9	13.6 \pm 8.5
SHROUD – FIRE ZONE	22.0 \pm 8.7	2.2 \pm 1.1	1.9 \pm 1.8	10.2 \pm 5.4	1.6 \pm 0.1
RED	2.7 \pm 3.1	1.1 \pm 0.9	0.8 \pm 1.0	1.7 \pm 1.9	0.6 \pm 1.0
BLUE	0 \pm 0	0 \pm 0	0.3 \pm 0.6	0 \pm 0	2.9 \pm 2.7
OTHER	15.4 \pm 13.8	7.3 \pm 3.6	7.4 \pm 5.0	19.9 \pm 16.7	28.2 \pm 8.8
PARTICLES					
BLOOD-LIKE	36.4 \pm 17.0	36.7 \pm 15.3	57.0 \pm 28.9	43.0 \pm 10.1	55.7 \pm 11.3
BRIGHT RED	4.5 \pm 4.0	0 \pm 0	1.9 \pm 3.7	3.1 \pm 2.4	4.8 \pm 8.2
YELLOW-RED	51.2 \pm 20.0	50 \pm 30	30.2 \pm 11.8	44.0 \pm 11.5	28.1 \pm 12.8
OPAQUE	7.9 \pm 2.1	13.3 \pm 23.1	10.9 \pm 19.5	9.9 \pm 5.4	11.4 \pm 10.3

The dusts distributions of the various filters are reported in Figures 42-51. The histogram ordinate shows the percentage values relative to the total counting of fibers and of particles; the corresponding standard deviations values are also reported.

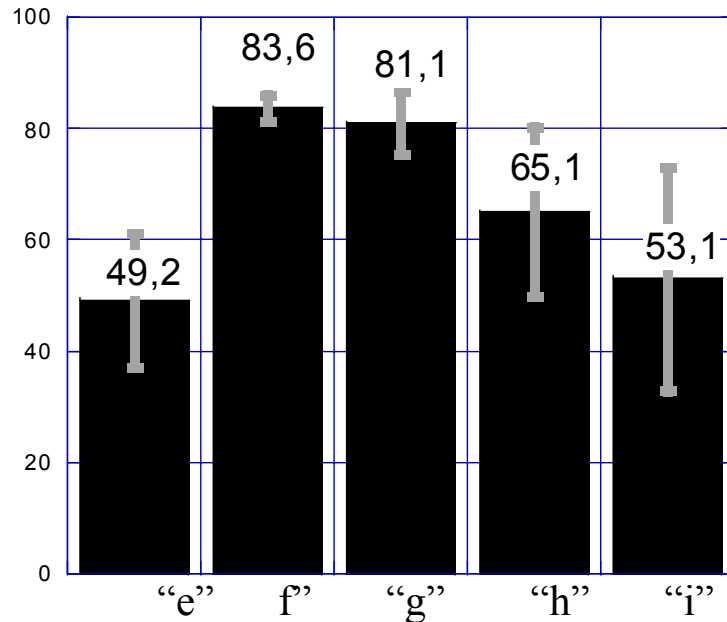


Figure 42. Histogram of fibers coming from the TS.

From the histogram of Figure 42 it results that the great part of fibers contained in the filters comes from the TS. In particular, in reference to Filter "f" (Face area) and "g" (feet area) , almost 4 fibers over 5 come from the TS.

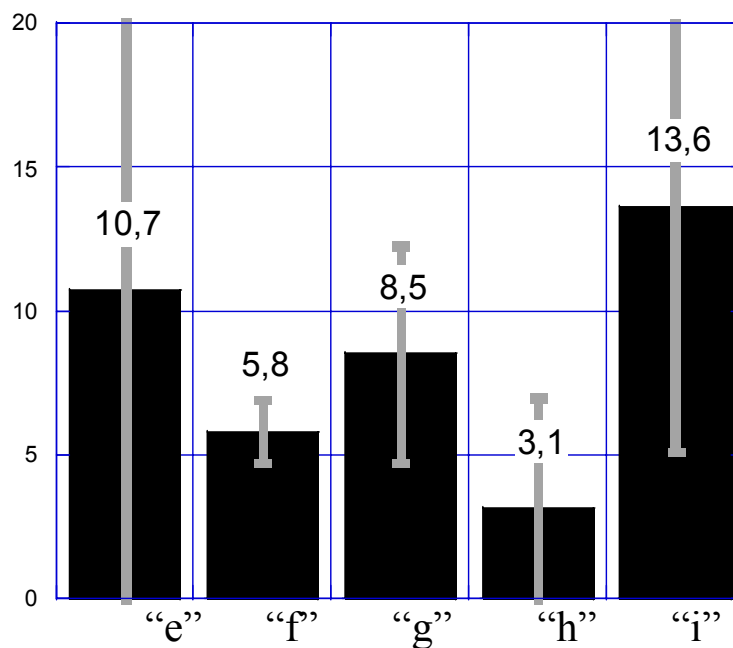


Figure 43. Histogram of fibers coming from the Holland Cloth.

From the histogram of Figure 43 it results that about only one fiber over 10 comes from the Holland Cloth, probably because these fibers are more resistant and then less easy to break or scatter and because the vacuum-head was addressed to the TS.

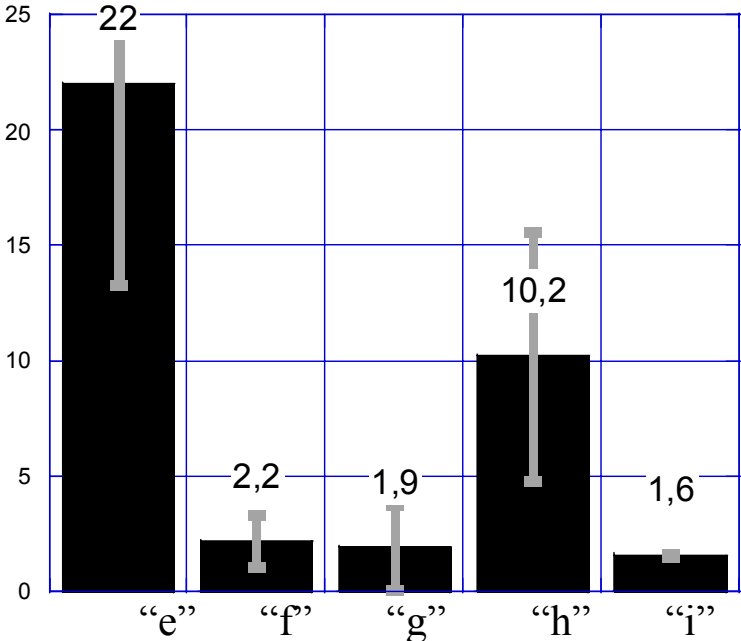


Figure 44. Histogram of fibers coming from the TS, fire area.

From the histogram of Figure 44 it results that the fibers coming from the Chambéry fire are more numerous in Filter "e" (Hands area, 22%), less numerous in Filter "h" (Buttocks area 10%) and almost absent (2%) in the other filters, showing that the possible remixing of fibers on the back of the TS is not easy also due to the sewing present.

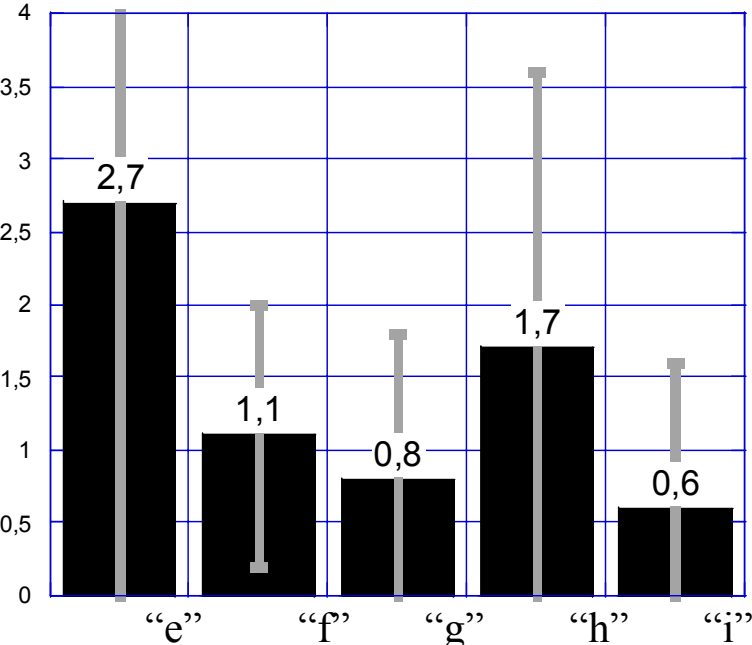


Figure 45. Histogram of red fibers.

From the histogram of Figure 45 it results the scarce presence of red fibers (about 2%).

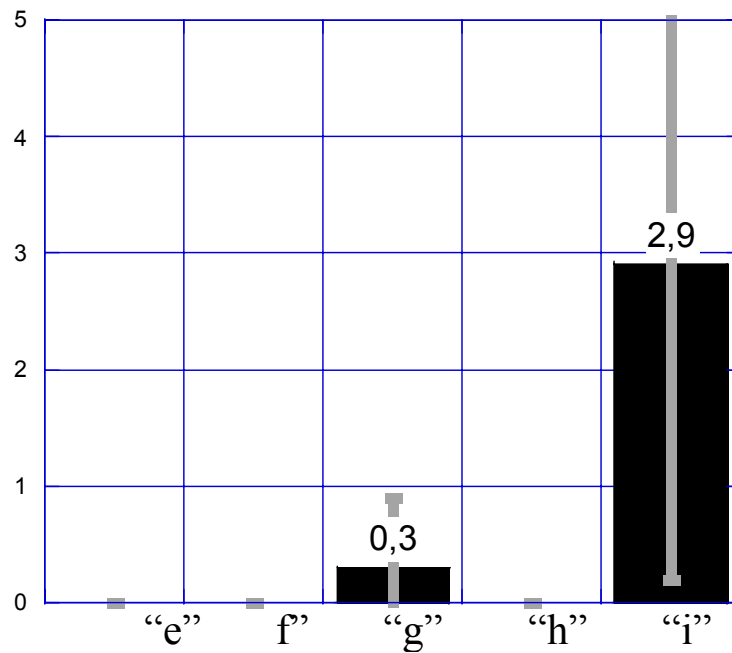


Figure 46. Histogram of blue fibers.

From the histogram of Figure 46 it results that the blue fibers are rare and are present only in Filters "i" (^{14}C area, 3%) and "g" (Feet area, 0.3%).

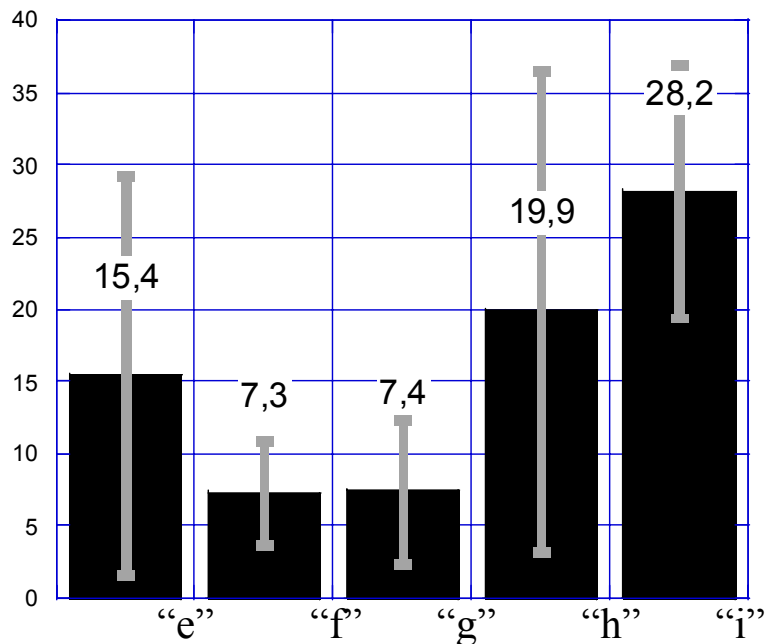


Figure 47. Histogram of other fibers.

From the histogram of Figure 47 it results that the not well identified fibers are more numerous in Filter "i" (^{14}C area) probably more subjected to the external contamination.

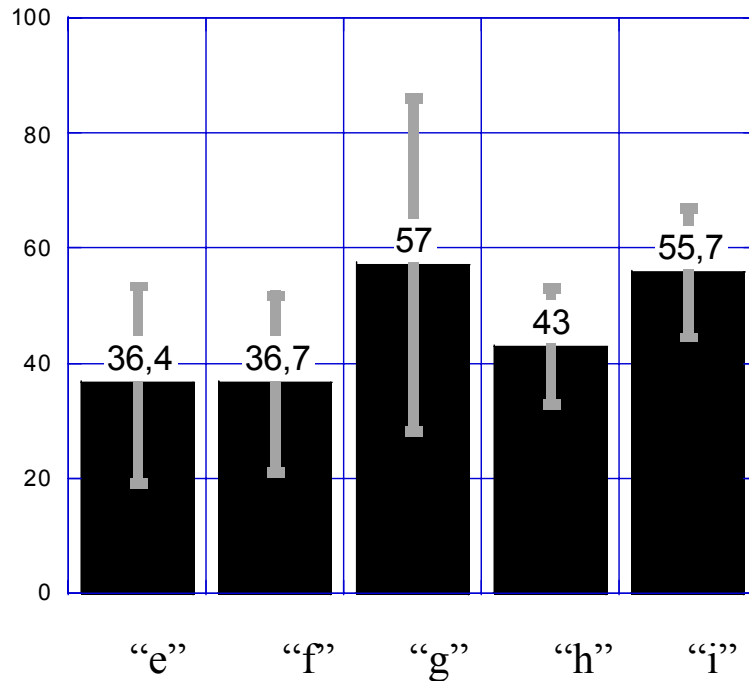


Figure 48. Histogram of blood-like particles.

From the histogram of Figure 48 it is to observe the high percentage of blood-like particles present in all the filters (36-57%): almost one particle over two analyzed is of this type.

The relatively high percentage of blood-like particles detected in Filter “i” can lead to think that the remixing of particles is easier than that of fibers also due to the particle shape that is more rounded.

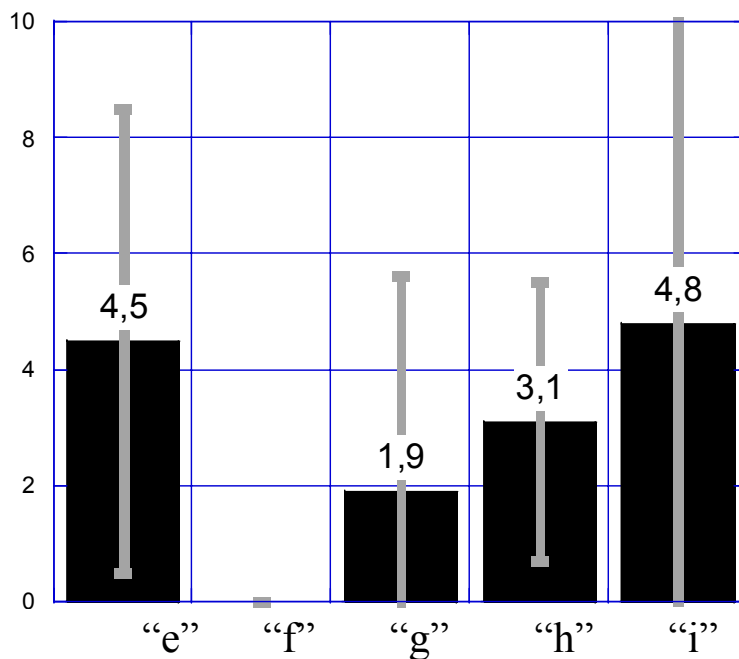


Figure 49. Histogram of bright red particles.

From the histogram of Figure 49 it results that the bright red particles, absent in Filter “f” (Face area), are present in all the other filters with percentages of about 3%.

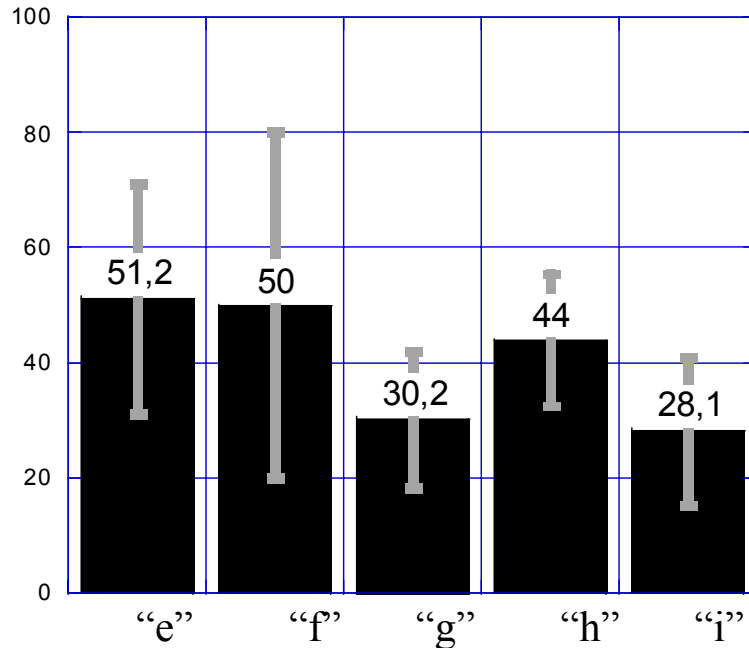


Figure 50. Histogram of yellow-red particles.

From the histogram of Figure 50 it results that the yellow-red particles are present in all the filters with percentages relatively high (28% - 51%). It should be interesting a detailed analysis of these particles to know their characteristics, probably of biological nature and perhaps deriving from body fluids.

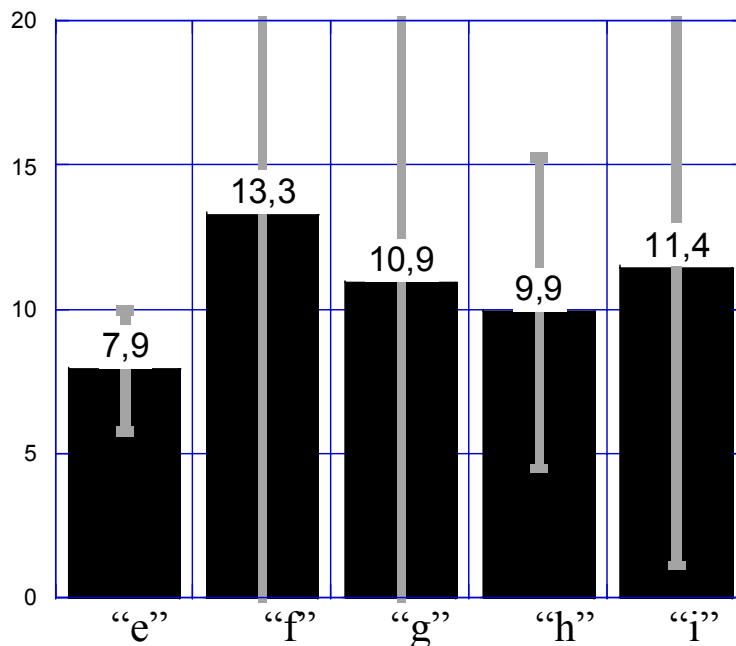


Figure 51. Histogram of opaque particles in transmitted light.

From the histogram of Figure 51 it results the non negligible presence (about 10%) of particles opaque in transmitted light that could also be of metallic origin or simply thicker than the other analyzed with the microscope.

CONCLUSION

A statistical analysis of dusts relative to the filters used to vacuum the TS areas relative to Hands (“e”), Face (“f”), Feet (“g”), Buttocks (“h”) and ¹⁴C area (“i”) (as declared by G. Riggi di Numana) has been performed.

Each of 5 Samples has been divided into 3 or 4 sub-samples and of these separated counts both of fiber with diameter greater than 5 micrometers and of particles with diameters greater than 3-4 micrometers has been performed; the results of the relative statistical analysis are shown in the Table 24. From this table and the histograms of figures 43-51 it can be concluded what follows.

The distribution variety of the fibers contained in the samples confirms the dust mixing up difficulty in the interspace between TS and Holland Cloth maybe also caused by the lengthened form of fibers; instead in case of particles having a more spherical form, a greater mixing has been detected.

The cotton fibers, probably coming from the filter supports, have been excluded by the statistical analysis; on average almost 8 fibers on 10 have turned out coming from the TS while the ones coming from the Holland Cloth have turned out about 1 on 10 because probably more resisting and then less easy to be broken and be dispersed. Other fibers have been also identified in less percent; among these, there are the TS fibers coming from the fire area and the red and blue fibers probably coming from the satin red and the blue silk times ago sewn to the TS.

In the Sample "f-b" a darker TS fiber, probably of the body image has been found. A single fiber does not have statistical meaning, but this finding is important because he strengthens the hypothesis of the double superficiality of the body image at of the face (<http://www.sindone.info/FANTI.PDF>), not yet recognized by all the scholars.

Since it is not easy for an image fiber placed on the frontal surface of the TS to come through the fabric, the hypothetical image fiber is very likely to come from the not visible TS surface, thus confirming the presence of a second superficial body image on back TS side.

A further finding in the sample "f" of a second probable image fiber, see figures 15, in an area not interested in the statistical analysis, still strengthens such hypothesis.

This study is useful for the knowledge of the contents of TS dusts in the filters for future analysis on this material. In the next future it could be interesting to address the statistics to particles smaller than about 4 micrometers and pollen.

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