LOTEX

Water- and dirt repellent car interior textiles by plasma treatment

Final report

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LOTEX 1 year report

Introduction

Textile finishing of car interiors (e.g. car seats) for achieving water- and dirt repellence is today extremely water- chemical and energy consuming and in large based on wet chemical processing using bio-accumulating fluorocarbon (FC) chemistry. In this project, a prototype textile for end-use testing will be developed using methods and processes that substantially decrease water- and energy consumption and minimize the use of FCs. This will be done by the replacement of traditional wet chemistry processing with plasma treatment and spraying techniques, efficient ways to concentrate added chemicals to the material surface, thus “making more of less”. Also, plasma treatment will act to better bind added compounds to the material surface, thereby improving abrasion resistance and increasing the life-span of the end-product.

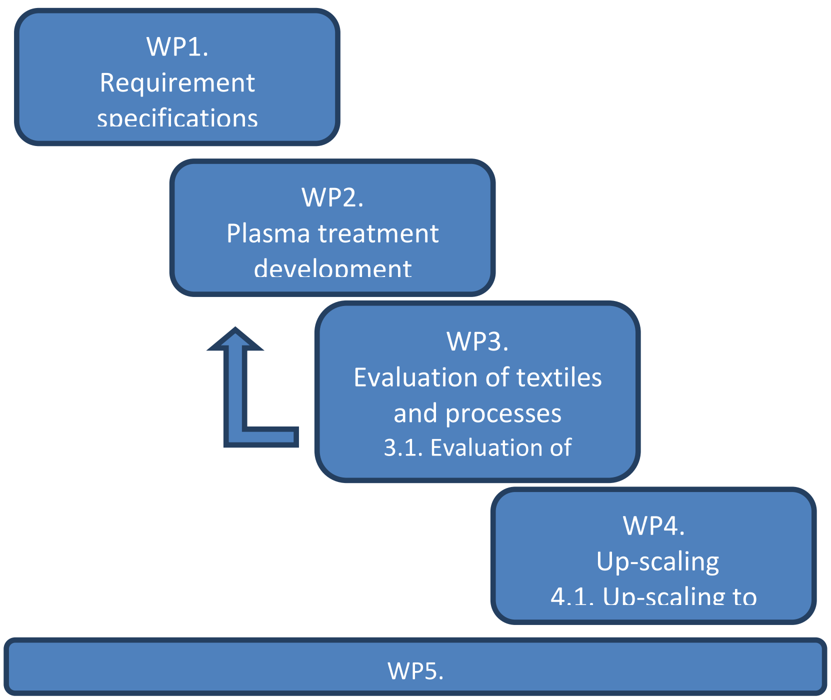


Figure 1. Work flow of the LOTEX project

The time plan of the different WP:s are as seen in Table 1. It can be seen that 1 year into the project, WP1 has been completed, as have WP2, whereas WP3 is on-going. WP5 is the continuous management WP, hence also on-going.

Table 1 Work packages

WP	WP title	WP leader	Other participants	Start month	End month
1	Requirement specifications	VCC	All	1	4
2	Plasma treatment	IVF	All	1	12

	development				
3	Evaluation of textiles and processes	IVF	All	2	13
4	Up-scaling	Borgstena	All	12	24
5	Management	IVF	All	1	24

The milestones to be reported herein are specified in Table 2 below.

Table 2 Milestones

Mile stones			Month
WP2	M2.2	Definition of plasma parameters	12
	M2.3	Definition of spraying parameters	10
WP5	M5.2	12^{th} month report	12

The results of this report are part of Deliverable D2, Report on defined plasma- and spraying parameters with evaluation of treated textiles and developed processes, which will be completed according to schedule after completion of WP3.

WP2, Plasma treatment development

Task 2.1 Selection of precursors/particles and
Task 2.2 Defining plasma and spray parameters

WP leader: Anna Thorvaldsson, Swerea IVF

Mile stone: M2.1 Selection of precursors/particles
M2.2 Definition of plasma parameters
M2.3 Definition of spraying parameters
Deliverable: D1 Report on material specifications and suitable precursors/particles
D2. Report on defined plasma- and spraying parameters with evaluation of treated textiles and developed processes

Introduction

WP2 is divided into two tasks, Task 2.1 Selection of precursors/particles and Task 2.2 Defining plasma and spray parameters. Task 2.1 was reported in the 6 month report

In task 2.1 a selection of precursors/particles and other chemicals will be done to best meet the specifications set in WP1. Silica particles and monomers, dendrimers and shorter chain FCs are all of interest. The aim is to create bio-mimicking surfaces that combine high surface roughness with low surface energy. Surface roughness at a nano/sub-micron scale is to be created using silica particles and dendrimers, both which are found in a variety of sizes and functionalities. At an even smaller scale, the etching of the plasma treatment will serve to create nano structure. The plasma will also serve to increase the bonding of particles and dendrimers to the material surface, thus increasing its wear resistance. Together with small amounts of FCs to lower the surface energy, it is expected that the combinatory effect of topography and chemistry will make it possible to greatly reduce the amount of FC compared to when relying on chemistry and wet chemical processing only. The aim is to minimize the use of FCs, while still maintaining the effect of the treatment.

An assessment of how to best apply the different chemicals will also be done in Task 2.1 to start defining the processing needed. Monomers and completely soluble compounds are possible to apply in the plasma, whereas particles and dispersions are best applied in an external spraying process.
In WP2, Task 2.2 the work will be conducted on finding suitable plasma and spray process parameters. As an alternative to foulard process, spraying techniques are to be used in this project to apply chemicals. Using spraying techniques is expected to decrease the amount of chemicals and water needed since what is applied is better concentrated to the material surface where its effect may be asserted. Plasma treatment will be evaluated mainly as a pre-treatment for better adhesion of added components and will add to the abrasion resistance of the material, an expected result based on results in previous projects.

Task 2.1 Selection of precursors/particles

A combination of He/O_2 has been found to be of best use in the processes developed herein. He as an inert gas acts to substitute the air between the electrodes in the plasma, thus allowing better control of the process, whereas O_2 is a highly reactive gas acting to modify both surface and added chemical by introduction of carboxyl groups, alcohols etc into the chemical structure.

Monomers may be added in the plasma to facilitate binding of other molecules to the substrate surface, i.e. act as binders or cross-linkers, or be added to allow for *in situ* polymerization on the material surface. Hexamethyldisiloxane (HDMSO) and 3-(aminopropyl)trimethoxysilane (APTMS) have both been evaluated alone and in combination with the three chosen fluorocarbons (Tubiguard, Bayguard and Luguard). Addition of these monomers did not significantly improve the performance of the material, as reported in the 6 month report, and was therefore discarded in this project.

In order to create a surface structure, and enhance the water repellency further, RUCO-DRY (Rudolph Chemie) has been evaluated both alone and in combination with the different fluorocarbons. It is a FC-free product commercially available and known to have a good abrasion resistance and provide good water repellent properties. It is found the mixing FC:s and dendrimers and spraying those on the fabric before plasma treatment results in both high water repellency and high oil repellency. The concentrations of the two components can also be adjusted to optimize the properties of the material surface depending on what is desired.

Beside the silica-based monomers discussed, there are possibilities of using fluorinated silanes or siloxanes. Preliminary tests using such commercial products have been done recently in other projects at Swerea IVF with good results on water- and oil repellency. This is however not included in this project, but may well be a continuation for a future project investigating alternatives to FC:s.

Task 2.2 Defining plasma and spray parameters

Introduction

Within Task 2.2 the plasma and spray parameters will be defined. Thus, tests will be carried out to evaluate important plasma parameters such as treatment time and power and also combinations of these parameters with the chosen gases and other chemicals. Likewise, the spray parameters will be optimized to allow for even distribution and a minimal usage of chemicals. Plasma as both pre- and post treatment will be evaluated, i.e. before and after spray application of chemicals. Plasma as pre-treatment allow for surface activation, whereas post-treatment allow also for polymerization and cross-linking events to occur. Treatment efficiency will be considered, as well as environmental- and health aspects. The treated samples will in this task be evaluated and screened using contact angle/surface free energy measurements, before a more thorough evaluation in Task 3.1.

Materials and methods

<u>Materials</u>
100% polyester fabric, Sportsuni Blonde, was used for treatment and analysis, and was provided by Borgstena. Three different fluorocarbon dispersion (FC) were used to treat textile surfaces by spraying processes; Tubiguard (CHT-Germany), Luguard (CTF 2000-Belgium) and Baygard (Tanatex-Netherland). In addition to the fluorocarbon compounds, Hexamethyldisiloxane (HDMSO, 98.5%, Sigma-Aldrich) and 3-Aminopropyltrimethoxysilane (APTMS, 97%, Sigma-Aldrich) precursors have been used to investigate effects of combinatorial polymeric structure. This process aimed at creating hydrophobic and durable coatings of siloxane alone or in combination of FC compounds. Also fluorocarbon-free dendrimer-based material (RUCO-DRY ECO, Rudolf Chemie) was used alone, or with combination of fluorocarbon chemical.

<u>Plasma treatment</u>
Two different routes were designed to treat fabrics with chemicals and plasma (Figure 2.2.1). The key difference between these two arrangements is in plasma function: when plasma is used as a pre-treatment before applying chemicals (Figure 2.2.1A), its function is etching, cleaning and surface activation by introduction of active functional groups, whereas when used after applying chemicals (Figure 2.2.1B) the plasma acts as a reactor for polymerization and grafting of chemicals to the material surface.

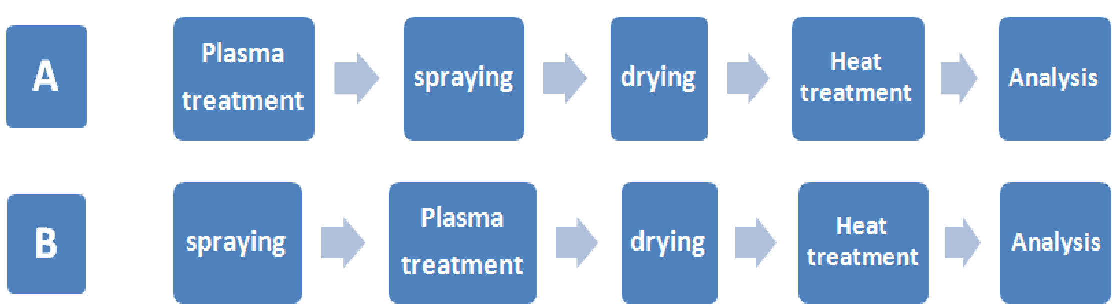


Figure 2.2.1. Processing routes A: plasma as a pre treatment (top image), B: plasma as polymer induces (below image)

The atmospheric pressure plasma processing was performed using a PLATEX600 LAB dielectric barrier discharge (DBD) plasma, GRINP SRL (Turin, Italy). This plasma device has two electrodes which enable double sided treatment. The parameter setting were as defined in Table 2.2.1.

Table 2.2.1 Plasma parameter settings

Parameter	Setting
Plasma power	680 – 720 W
Electrode distance	3 mm
Frame speed	1 (machine setting)
Cycles through plasma	4
Process gas	N_2/He (0.5:5 l/min) O_2/He (0.2:5 l/min)
Electrode temperature	30° C (no precursor) 95° C (with precursor)
Evaporator temperature	25° C (no precursor) 125° C (with precursor)

Spraying

The chemical dispersions were distributed on the fabrics by spraying process before or after the plasma treatment. Small air brushes purchased from Biltema were used. Surface density of chemicals on the fabrics was approximately 0.8 g/dm^2, as determined by weighing.

Curing

For curing in small scale, samples of 0.3 m x 0.5 m were cut out and heat treated in a lab-scale stenter. The temperature and time for different chemical treated fabrics were different which are shown in Table 2.2.2.

Table 2.2.2. Heat treatment parameters for different chemicals

Chemical	Heat treatment temperature (C)	Heat treatment time (s)
Tubiguard	160°	60
Luguard	170°	45
Beygard	170°	180

Contact angel and surface free energy test

Water contact angel and surface free energy of fabrics were measured using equipment from Krüss (DS4). Briefly, a high contact angel and low free energy indicate hydrophobicity. A water droplet was placed on the fabric surface and a camera captured an image of the drop. The droplet profile was analyzed and static contact angles calculated using image analysis software. For determining surface free energy, both water and diiodomethane were used. Surface free energy and water contact angel results are averages of at least three independent measurements.

Electron spectroscopy for chemical analysis

One of most powerful technique to study chemistry of different surfaces is electron spectroscopy for chemical analysis (ESCA). ESCA is a surface analysing technique based on irradiating the sample with low energy X-ray and determining the bonding energy of the electrons leaving the surface. Simply, the amount of bonding energy together with the intensity of the peaks, allows quantitative analysis of elements present on the surface as well as elemental identity and chemical state of surface components. In this project, chemistry of textile surfaces treated under different processes has been studied by this method. All ESCA analysis has been done in polymer group, chemistry department, at Chalmers University of technology.

Results and discussion

<u>Plasma: prior or after chemical spraying</u>

Figure 2.2.2 shows the difference in surface free energy (SFE) for textiles treated under different processes. The reference sample, polyester treated with C8 under wet chemical process and used in industry today, was evaluated for comparative reason. Basically, lower SFE means higher water and oil repelling properties.

According to this figure, the samples which were plasma-treated after exposure to the FC dispersion appear to give the best hydrophobic properties (i.e. lowest SFE) in comparison with reference or when plasma is used before FC spraying. This difference can be resulted from different dominant reactions caused by plasma; as it was described, when plasma is used before spraying, the function of the plasma process is mostly etching, cleaning and surface activation. When helium and oxygen are used as processing gases, meaning activation by introduction of oxygen-containing groups, the surface is rendered hydrophilic. Often, that results in an increased absorption of liquid, in turn resulting in a more even treatment and higher concentration of active substance in the material. The textile that is used in this project however, has enough hydrophilicity to absorb sufficient level of FC dispersion also without plasma, which means plasma cannot alter the level of final absorbed dispersion significantly. On the other hand, when plasma is used after spraying on the wet surface, great improvement in surface free energy has been registered.

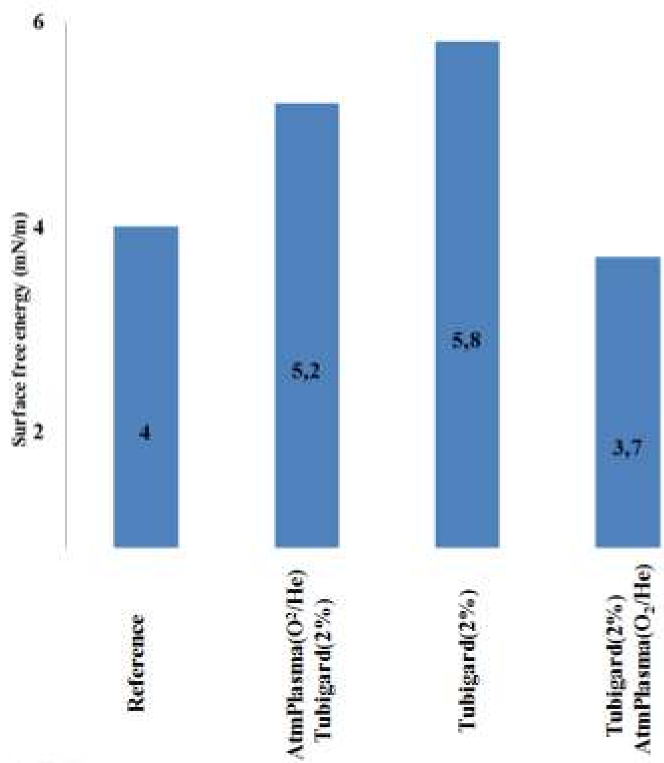


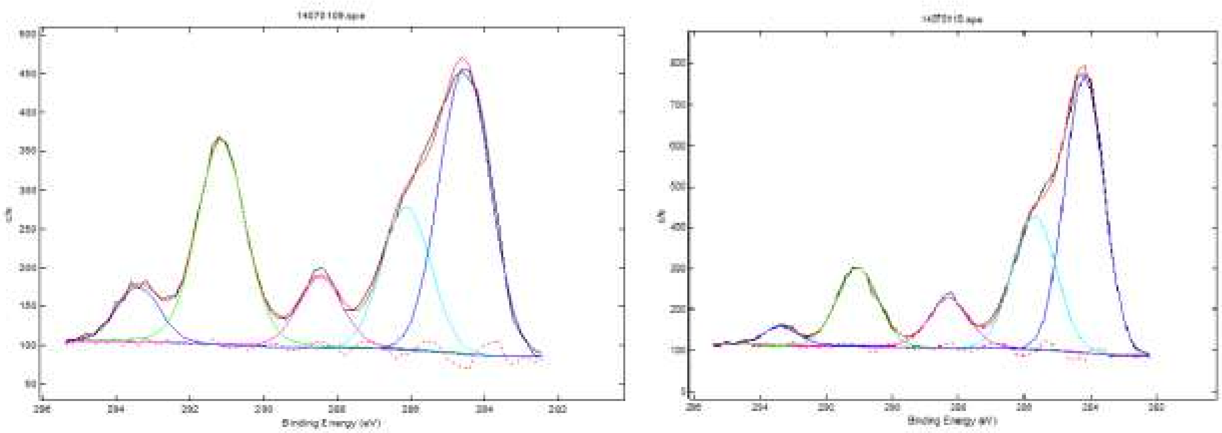
Figure 2.2.2. Surface free energy of different textile treated with different processes and under different conditions

The improved SFE when using plasma as post-treatment after application of FC may be a result of plasma-induced polymerization becoming a dominant reaction, leading to creation of stronger bonding between FC chemicals and surface fabric material. As a result, more FC compounds would be bond to the textile surface and hence, better hydrophobic and oleophobic properties would be observed. This argument can be verified by ESCA, in which the chemical composition of these two samples has been compared with each other (Table 2.2.3). This table depicts that while the level of carbon is almost the same; the intensity of fluor on the post-plasma sample sample surface is much higher than pre-plasma sample surface (29.91 versus 2.76).

Table 2.2.3. Surface free energy of different textile treated with different processes and under different conditions

Chemical element	C1s	N1s	O1s	F1s	Cl2p
Binding energy (eV)	[0.314]	[0.499]	[0.733]	[1.000]	[0.954]
Plasma+FC spraying	48.38	-	8.86	2.76	-
FC spraying+plasma	55.59	0.69	13.41	29.91	0.40

Figure 2.2.3 illustrates ESCA results for both post-plasma treated (left) and pre-plasma treated fabrics (right). Briefly, binding energies (eV) shows the type of chemical group on the fabric surface and the area of each peak shows the relative amount of the chemical group in that position. Based on the handbook in formation, binding energies 290.6 and 293-294 belongs to the (-CH2-CF2-) and (-CH3) respectively. As it can be seen in Figure 2.2.3, the intensity of these two groups (band 4 and 5) on the post-plasma sample is much higher that pre-plasma treated sample.



Band	Pos	PosSep	B_FWHM	%Area
1	284.52	0.00	1.61	38.22
2	286.10	1.58	1.55	18.43
3	288.44	3.93	1.40	9.01
4	291.15	6.63	1.52	27.94
5	293.41	8.89	1.36	6.41

Band	Pos	PosSep	B_FWHM	%Area
1	284.19	0.00	1.38	47.54
2	285.69	1.50	1.55	25.87
3	288.28	4.09	1.40	9.54
4	291.05	6.87	1.44	14.04
5	293.38	9.19	1.20	3.00

Figure 2.2.3. intensity of fluorinated chemical group on the post-plasma treated (left) is much higher that pre-plasma treated fabric (right).

Flourocarbon chemicals; Tubiguard, Luguard and Beygard

Figure 2.2.4 shows SFE result of textiles treated with different FC compounds; Tubiguard, Luguard and Baygard. All samples were sprayed with 2% concentration (%w/w) and treated under the same plasma parameters using O_2/He. All C6 FC treated textiles shows better results in comparison with the C8 reference. SFE of Beygard and Luguard treated samples was better than fabric treated with Tubiguard. All results have been verified by at least two separate experiments.

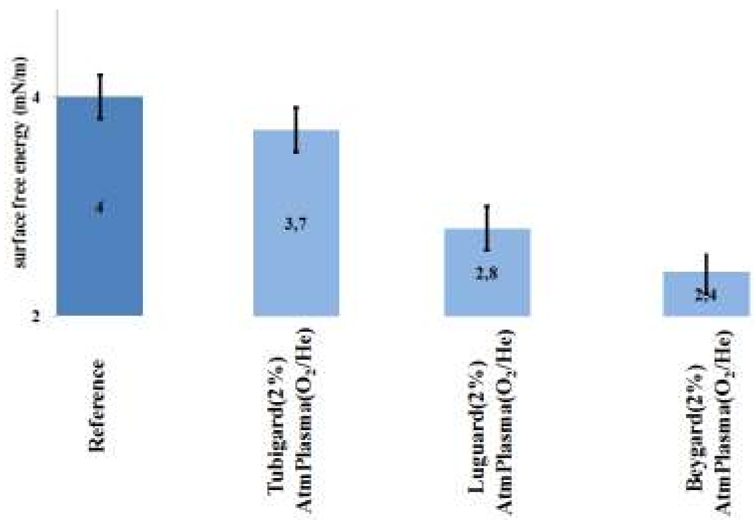


Figure 2.2.4. Surface free energy of different textile treated with different FC compounds; Tubiguard, Luguard and Baygard

Since the composition of the fluorocarbon suspensions are trade secrets at the chemical companies, not much is known about those. Thus, it is difficult to speculate on the reason for the differences seen in Figure 2.2.4 and it can only be concluded that there are clear differences related to the formulation of the suspensions.

Plasma polymer film deposition; APTMS and HDMSO

As it mentioned previously, HDMSO and APTMS were used to induce in-situ polymerization at the material surface, both alone and in combination with Tubiguard on the textile surface (Figure 2.2.5). The results show that a combination of HDMSO and Luguard has almost the same SFE as pure Tubiguard or reference, hence the monomer makes no significant difference in the energy of the surface. Likewise, the SFE values of APTMS+Tubiguard were in comparison with the other samples. Also pure monomers showed poor results in water- and oil repellency and high SFEs (results not shown).

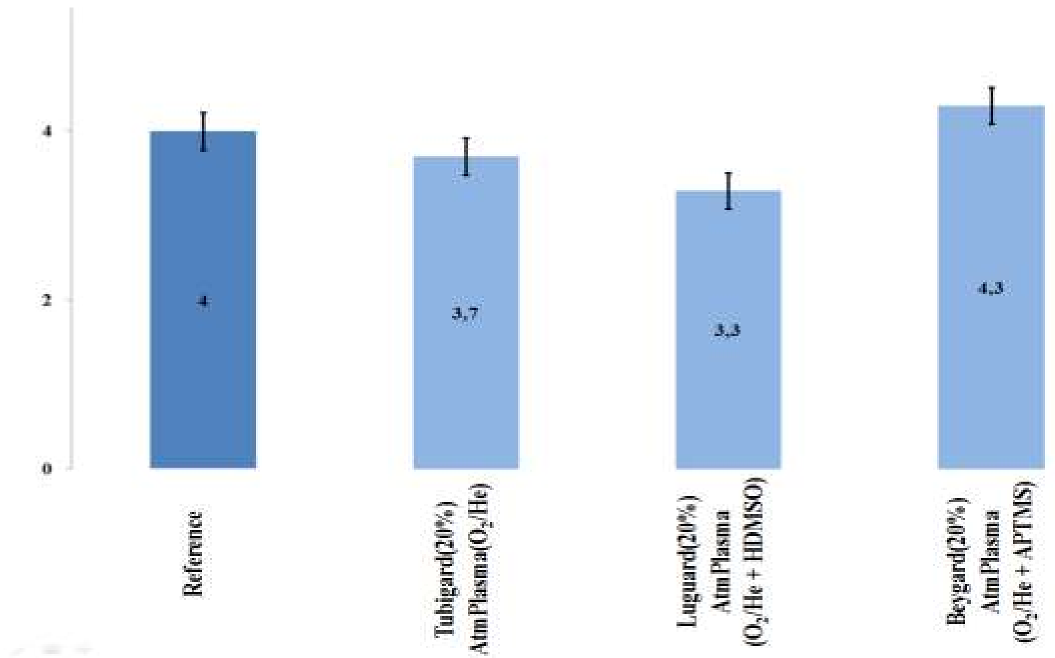


Figure 2.2.5. Surface free energy of textile treated with different precursors in plasma step. All precursors were added by evaporator inside the plasma.

Dendrimers

As previously mentioned, creation of nano/micro structure on the textile surface in combination with a low surface energy can impart Lotus-leaf-like self-cleaning properties and improve water and dirt repellency of treated fabrics. Dendrimers is a family of chemicals can be used for this task. In this project, completely FC-free chemical, RUCO-DRY ECO, has been used to treat fabrics alone, or in combination with FCs.

Figure 2.2.6 shows water contact angel (WCA) and SFE for different textiles treated with different solutions. All samples have been treated with O_2/He plasma at the same pressure and temperature.
Dendrimers used in this project can impart high water repellence property to the fabrics, comparable with FC dispersion. This is verified by right image of picture of 2.2.6 where the WCAs are comparable of both dendrimer- and FC-treated samples. It is seen though that the combination of the two, i.e. dendrimers and FCs results in higher WCAs, i.e. higher water repellency. The error bars are quite high, due to the structural nature of a textile.

The SFE values are calculated using both WCA and the contact angles of diiodomethane. The SFE values shown in Figure 2.2.6 shows that the combination of dendrimers and FC (2% of each) gives the best repellent properties, i.e. the lowest SFE. The SFE of pure dendrimer was not possible to measure due to absorption of diiodomethane.

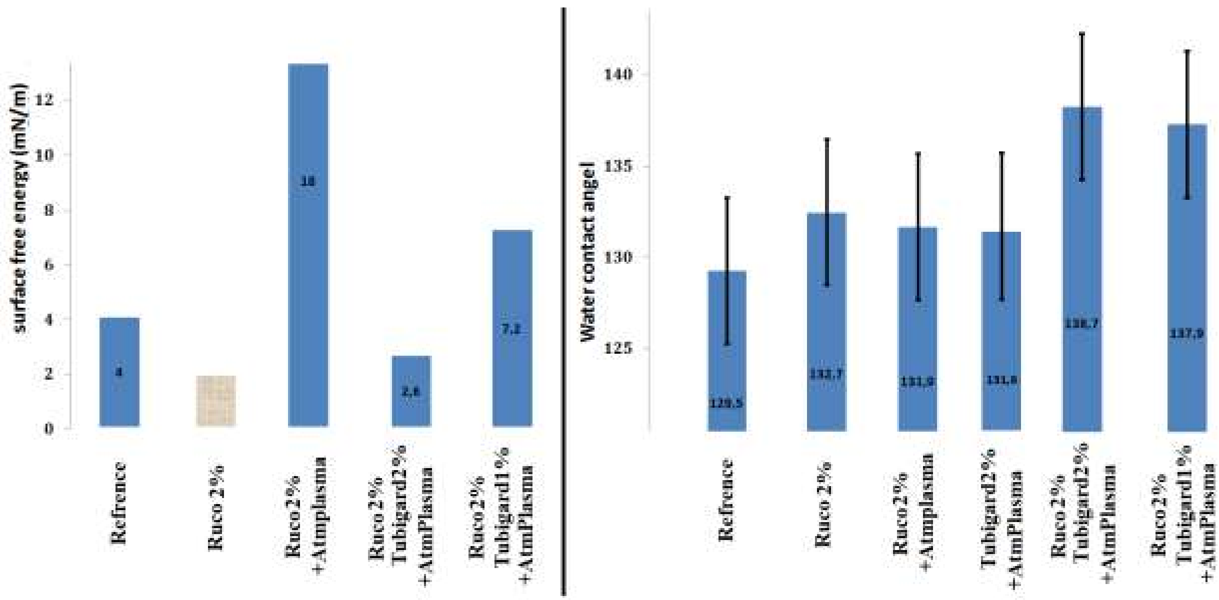


Figure 2.2.6. Surface free energy (left) and water contact angles (right) of textile treated with dendrimer and mix of denrimer and FC dispersion.

Summary

It can be concluded from the results presented here that using plasma in combinations with Tubiguard, Luguard and Bayguard, shows lower SFE than reference, hence indicating better water repellent properties. Using HDMSO + Luguard or APTMS + Bayguard give similar results to use of Tubiguard without any additive. Using plasma as post-treatment, i.e. directly after spraying FC, seems to give the best result, with SFE lower than reference (C8-treated from Borgstena) and also lower than spraying alone. The post-treatment most likely allow for polymerization to occur, as opposed to just activation as in the case of plasma as pre-treatment. Using non-fluorinated dendrimers shows comparable water contact angles as C8 or C6 , but because of lack flour in structure, will not show any oil repellency.

WP3, Evaluation of textiles and processes

Task 3.1 Evaluation of treated textiles (water- oil and dirt repellence, abrasion resistance)
Task 3.2 Evaluation of developed processes

WP leader: Anna Thorvaldsson, Swerea IVF

Mile stone: M3.1 Evaluation of treated textiles
M3.2 Evaluation of developed processes
Deliverable: D2 Report on defined plasma- and spraying parameters with evaluation of treated textiles and developed processes

Introduction

The work in WP3 aims at evaluating the textiles and processes developed in WP2. The two WP:s are thereby closely interconnected. WP3 is divided in two tasks, Task 3.1 Evaluation of treated textiles and Task 3.2 Evaluation of developed processes.

Task 3.1 Evaluation of treated textiles (water- oil and dirt repellence, abrasion resistance)

Introduction

In WP3, Task 3.1 the plasma treated textiles will be characterized regarding water- and oil repellence before and after abrasion. Initial characterization will be done using:

- Contact angle and surface energy measurements
- Scanning electron microscopy/light microscopy
- Water repellence (SSEN24920)
- Oil repellence (ISO14419)
- Abrasion tests (Martindale)
- ESCA (chemical surface analysis)

Also, end-user testing performed by VCC will be done to provide feedback, following the conclusions of WP1, i.e. methods as specified in Table 1.2

Materials and methods

<u>Materials</u>

Same fabric and chemical as Task 2.2 were used to test water and oil repelling properties, i.e. sport uni blonde PES fabric, Tubiguard (CHT-Germany), Luguard (CTF 2000-Belgium), Baygard (Tanatex-Netherland), Hexamethyldisiloxane (HDMSO, 98.5%, Sigma-Aldrich) and 3-Aminopropyltrimethoxysilane (APTMS, 97%, Sigma-Aldrich)

Plasma treatment

The plasma treatment was done as in Task 2.2, using settings found in Table 2.2.1.

Spraying and drying process

The spraying and drying/curing was done as explained in Task 2.2.

Spray test

The resistance of treated textiles to wetting was measured according to a standard
Spray test (24920:1992 SS EN, 4920:1981 ISO) under controlled climate condition (temperature: 20°, humidity: 64%). The sprayed samples were graded according to standards ISO 1-5, as demonstrated here:

ISO 1 - Wetting of both sides of sprayed sample surface, complete wetting
ISO 2 - Wetting of sprayed side of the fabric
ISO 3 - Partial wetting of the sprayed surface
ISO 4 - No wetting but sticking of small droplets
ISO 5 - No wetting or adherence of droplets

Oil repellency test

The oleophobic property of treated textiles was evaluated according to the Swedish standard SS-EN ISO 14419:2010. Eight different oils with decreasing surface tension were placed on the textiles surfaces with a glass pipette. The apparent contact angle and spreading of the drops were estimated after 30 seconds and compared to pictures and descriptions.

Martindale abrasion

The Martindale test is a method to determine the abrasion resistance of the fabric. This is done by mounting fabric specimen in a special apparatus and rubbing them with standard wool fabric in 5000 circles under a pressure of 12 kPa.

Flammability, soiling and clean ability

Flammability, soiling and clean ability were tested by VCC according to standard procedures VCS 5031, 19 and 85000011 respectively. These initial tests were done using unlaminated material, although according to the standard it should be laminated for correct values of comparison.

Results and discussion

The untreated textile, reference fabric and textiles treated under different condition were analyzed under oil and water repelling standard test for comparative reasons. Also Martindale test has been done to test abrasion resistance of different textiles.

Plasma

In the previous WP, the effect of plasma treatment and spraying was evaluated by measurements of contact angles and surface free energies. These are great first evaluation points as they provide simple means of comparing and analyzing surfaces subjected to different treatments. More realistic, however, are the tests of water- and oil repellency which are done according to standard methods for textile materials, as described above. Table 3.1.1 shows water and oil repelling results for samples, prepared with different plasma condition.

As indicated by the SFE measurements in Task 2.2, samples which were treated with spray and immediately plasma shows better oil and water repelling performance in comparison to reference (Table 3.1.1). As explained in task 2.2, the reason can be due to plasma induced polymerization and grafting of fluorocarbon chemicals on the textile surfaces when using plasma as post-treatment. Also results showed if plasma treatment is applied direct after spraying, on the wet fabric, the resulted textile show better performance than if left to dry before plasma. In addition, different gases have been tested as processing gases. Nitrogen and oxygen shows almost same results (Table 3.1.1), which was better than other gases (i.e. pure He and Ar).

Table 3.1.1 water and oil repelling values of different textiles

	Water repellency	Oil repellency
Untreated	1	-
Reference	4	6
Tubiguard(2%)	4	6
Tubiguard(2%)+ drying+AtmPlasma(O^2/He)	4	7
Tubiguard(2%)+AtmPlasma (O^2/He)	5	7
Tubiguard(2%)+AtmPlasma (N^2/He)	5	7
Tubiguard(2%)+AtmPlasma(O^2/He+HDMASO)	5	6
Tubiguard(2%)+AtmPlasma (O^2/He+APTMS)	5	6

In addition to the fluorocarbons also polymeric precursors such as HDMDO and ATPMS were applied to the textiles to possibly enhance the binding between fluorocarbon and fabric and, in the case of HDMSO, also provide complementary repellent properties. Table 3.1.1 shows the water and oil repellence results when testing fabrics treated with the different precursors, and as can be seen there was no significant difference when comparing with the samples treated with fluorocarbon only.

Fluorocarbon and Dendrimers during abrasion

In order to evaluate the abrasion resistance of the developed processes, Martinedale tests were performed and the samples evaluated with water- and oil repellency, according to standards, before and after abrasion.

Table 3.1.2 shows water- and oil repellency values of samples treated with different fluorocarbons, alone or mixed with dendrimer before and after abrasion. As seen, the samples treated with FC and thereafter plasma treated all show better oil- and water repellency than the reference, and also better then samples not plasma treated. This confirms the results of the SFE measurements. After abrasion, the water- ad oil repellence of all samples decreases, but the plasma treated samples still show better performance than the reference. As a reminder, this is with a very low concentration of C6.

The dendrimers (RUCO-GUARD DRY) used are FC-free and therefore gives no oil repellent properties. This is confirmed in the performed tests presented in table 3.1.2. On the other hand, the fabrics treated with dendrimers show high water repellency and good resistivity against abrasion, so that fabric treated with mix of normal concentration of Tubiguard and high concentration of dendrimers, shows great both water- and oil repellency, even after abrasion.

Table 3.1.2 water and oil repelling values textiles treated with different fluorocarbon solutions and precursors

	Water repellency		Oil repellency	
Martindale test	Before	After	Before	After
Untreated	1	-	-	-
Reference	4	1	6	1
Tubiguard(2%)	4	2	6	5
Tubiguard(2%)+AtmPlasma (O2/He)	5	2	6	5
Beygard(2%)+AtmPlasma (O2/He)	5	2	6	5
Luguard(2%)+AtmPlasma (O2/He)	5	2	6	6
Ruco(2%)+ AtmPlasma (O2/He)	5	2	0	0
Ruco(1%)/Tubiguard(1%)+ AtmPlasma (O2/He)	3	1	2	1
Ruco(2%)/Tubiguard(1%)+ AtmPlasma (O2/He)	4	2	2	2
Ruco(4%)/Tubiguard(1%)+ AtmPlasma (O2/He)	5	3	2	2
Ruco(2%)/Tubiguard(2%)+ AtmPlasma (O2/He)	5	2	5	2
Ruco(4%)/Tubiguard(2%)+ AtmPlasma (O2/He)	5	4	5	2
Ruco(4%)/Tubiguard(4%)+ AtmPlasma (O2/He)	5	5	5	3
Ruco(4%)/Luguard(2%)+ AtmPlasma (O2/He)	5	4	6	5
Ruco(4%)/Beygard(2%)+ AtmPlasma (O2/He)	5	4	6	5

It can be seen in Table 3.1.2 that the highest concentrations of chemicals give the best results, especially when taking into consideration the effect of abrasion, which is smaller the more chemicals are added. This makes a logical sense and illustrates the need to weigh product function against health- and environmental issues.

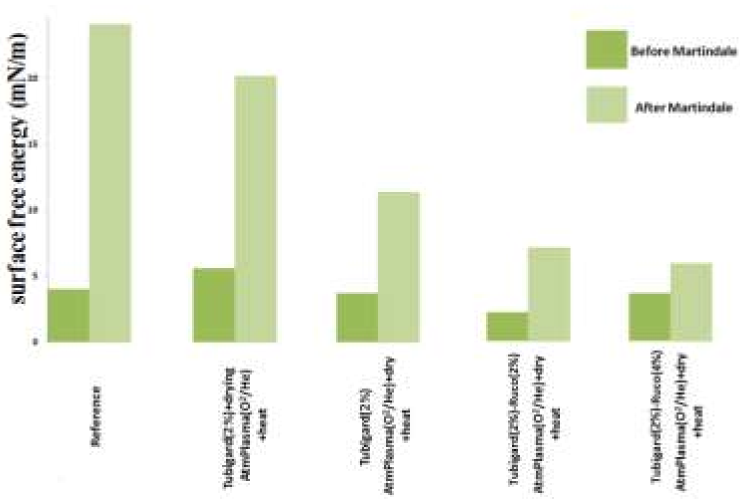


Figure 3.1.1 surface free energy values of textiles treated under different conditio

The influence of abrasion on the SFE is illustrated in Figure 3.1.1 and confirms the above results, i.e. a combination of FC and dendrimers give the best results regarding repellent properties.

The effect of the addition of the different FC:s and plasma on flammability is highly important for application as seating material, hence the first property to be evaluated by VCC according to their own standards. Also, the clean ability is of great importance and one of the properties expected to be enhanced using the developed plasma- and spray processes.

<u>Flammability, soiling and cleanability</u>

As seen in Table 3.1.3 the untreated fabric does not burn, so the textile in itself is not flammable. However, the addition of FC greatly increases the flammability to the extent that those samples do not pass the set limit of the standard test (80mm/min). The reference fabric, i.e. the C8-treated fabric from Borgstena, shows the least tendency to burn of all the FC-containing samples.

Table 3.1.3 Flammability, soiling and clean ability

Material	Flammability max 80 mm/min VCS 5031,19	Soiling and clean ability VCC testing code 85000011	
		Soiling	Clean ability
Untreated	Se-Se/nbr	Large stain	Stain left for chocolate Large water marks
Production	Se- Se/nbr- Se/b50	Small concentrated stain	Weak stain for coffee
Plasma + R6 Bayguard (1/3 amount)	B 87-114 mm/min	Small concentrated stain	No visible stain No watermarks
Plasma O2 /He + Luguard 2%	B/Se/b-71-96	To be done	To be done
Plasma O2/He + Tubiguard 2%	Se-B95	To be done	To be done

The soiling and clean ability tests show good results (Table 3.1.3) for the samples treated with plasma and Bayguard, and will be performed also on Luguard and Tubiguard as soon as possible for comparison.

The tests done so far have been on unlaminated material and should be performed also on laminated material as stated in the standard procedures. The unlaminated samples will, however, be used as a first screening to select promising alternatives for the more labor-intensive lamination process.

Summary

A combination of dendrimers and FCs give the best results if simultaneously considering both water- and oil repellence. The FCs contribute with oil repellent properties, whereas the dendrimers contribute with the water repellence. Hence, optimizing the relation between the two components allows for close matching of desired material surfaces properties. The flammability is so far not satisfactory, although there are more such evaluations to be done. It also known from previous tests at Borgstena that flammability is decreased upon lamination; hence tests on laminated material should be done next.

WP4, Up-scaling
Task 4.1 Demonstrator and Evaluation of Demonstrator
Task 4.2 Prototype and Evaluation of Prototype

WP leader: Borgstena

Mile stone: M4.1 Demonstrator
M4.2 Evaluation of demonstrator
M4.3 Prototype
M 4.4 Evaluation of Prototype
Deliverable: Prototype of textile for car interior – final report on evaluation of prototype according to end-use specification.

Introduction

The work in WP4 aims at up-scaling of the process based on the best material and processes of WP3, and starting evaluation of demonstrator. WP4 is divided in two tasks, Task 4.1 Demonstrator and Task 4.2 Evaluation of demonstrator. The results so far within Task 4.1 are reported herein to complement the reported method developments in Task 2.1 and 2.2, and also 3.1 and 3.2. Initial result of 4.2 will be reported here.

Task 4.1 Demonstrator and Evaluation of Demonstrator

Introduction
In WP4, Task 4.1 two different materials will be selected to produce demonstrator; laminated plasma treated textiles. The treatment process will be done in Swerea IVF, Mölndal, and resulted treated textiles will be sent to Borgstena, Portugal to laminate them. Evaluation has been done in Swerea IVF and VCC.

Material and methods

Materials
Same fabric as Task 2.2 was used to test to produce demonstrator; sport uni blonde PES fabric. Two chemicals, best in test of Task 3.1 (Tubiguard (CHT-Germany)), and C6 FC which was selected by partners have been used; PHOBOL (Huntsman-Germany).

Plasma treatment
The plasma treatment was done as in Task 2.2, using settings found in Table 2.2.1.

Spraying and drying process

For spraying, we used spraying chamber which made by Baldwin company-Sweden; this device design to spray fabrics in roll-to-roll system, in fully controlled environment.
Drying/curing was done as explained in Task 2.2.

Test equipments

- Flammability rig TUMA 540:1
- Weather meter TUMA 703:1
- Light cabin TUMA 550:1
- Grey scale TUMA 546:1
- Heat cabin
- Climate chamber
- Martindale TUMA 644:*1*

Tests performed

- Flammability, VCS 5031,19
- Colour fastness to artificial light at 75oCand 50%RH, STD 1027,359
- Resistance to wear, STD1024,7122
- Snagging resistance – Taber, SS-EN ISO 5470-1
- Resistance to ageing in heat, 90oC 1000h
- Ageing in moisture, 38oC, 95%RH, 1000h
- Ageing in moisture, 70oC, 55%RH, 1000h
- Resistance to stain remover, Volvo testing code 850 428 02
- Soiling resistance and cleanability, Volvo testing code 850 000 10A
- The abrasion resistance of the finish, VCC test code 850 000 11

Result and discussion

Plasma/FC treated fabrics has been prepared and sent to Borgstena. Laminated textiles have been sent to VCC to evaluate.

Flammability acc to VCS 5031, 19

Material	Length	Cross	Result
Sports Uni Blond, lam4mm, Phobol	B 65, 61, Se/nbr Se/b 57, 56	B 59, 66, 64, 51, Se/b 56	OK
Sports Uni Blond, lam4mm, Tubiguard	Se/b 62, 62, 72, B 58, 56	B 54, 69, 66, 66, 67	OK

Requirement: Burning rate max 80 mm/min

<u>Soiling resistance and clean ability; VCC test code 850 000 10A</u>

Sports Uni Blond, Plasma+ Phobol	Stain	After cleaning
Coffee	Small stain	Weak stain
Chocolate	Small stain	No stain, no watermark
Coke	Small stain	No stain, no water mark
Orange drink	Small stain	No stain, no watermark
Sports Uni Blond, Plasma+ Tubiguard		
Coffee	Small stain	Weak stain
Chocolate	Small stain	No stain, no watermark
Coke	Small stain	No stain, no water mark
Orange drink	Small stain	No stain, no watermark
Reference 1: Sports Uni Blond in production(C8)		
Coffee	Small stain	No stain, no watermark
Reference 2: Sports Uni Blond in development for production (C6)		
Coffee	Small stain	Weak stain

Requirement: After cleaning; the stain disappears almost completely (hard to discover).
No visible water mark

<u>The resistance to abrasion of the treatment; VCC test code 850 000 11</u>

Material/ wear	0 wear cycles + coffee	2500 wear cycles + coffee	5000 wear cycles + coffee
Phobol	Small stain	Not totally absorbed	Totally absorbed
Tubiguard	Small stain	Not totally absorbed	Totally absorbed
Ref 1 Uni inproduction	Small stain	Totally absorbed	Totally absorbed

<u>The resistance to cleaning of the finish; VCC test code 850 000 11</u>

Material/cleaning agents	Water	VCC textile cleaner
Phobol	Absorbed stain	Absorbed stain
Tubiguard	Absorbed stain	Absorbed stain
Phobol, longer drying time	Small stain on surface	Small stain on surface
Tubiguard, longer drying time	Absorbed stain	Absorbed stain
Phobol, heat treated	Small stain on surface	Small stain on surface
Tubiguard, heat treated	Absorbed stain**fire**	Absorbed stain
Ref 1 Uni in production	Small stain on surface	Stain on surface
Ref2 Uni C6	Absorbed stain	Absorbed stain
Ref2 Uni C6	Small stain on surface	Stain on surface

1ml of coffee is used for staining

Longer drying time = min 24h in room temperature

Heat treated= highest temperature on an iron (three dots)

<u>Ageing</u>

Material	Climate	Result, greyscale
Sports Uni Blond, FC C6	Heat 90˚C, 1000h	Week 13
Sports Uni Blond, FC C6	Moisture 38˚C/95% RH, 1000h	Week 13

Summary

Two plasma/C6 fluorocarbon treated textiles have been tested in VCC and compared with required standards and with C8 treated textile which is in production line today. The summary of results is detailed as follows:

- Flammability is within VCC requirement for both Phobol and Tubiguard treatments
- Soiling and clean ability are comparable for the two C6 fluorocarbon and nearly as good as today’s C8 treated textile production. Coming C6 treatment is in the same level as plasma/FC treatment
- The abrasion resistances of the C6 treated textiles are better for FC/plasma treatment than for today’s production.
- The resistance of the treatment after cleaning is not good for Plasma/Tubiguard.
- Plasma/Phobol and today’s C8 and C6 treatments have good resistance, after one cleaning.

Task 4.2 Prototype and Evaluation of Prototype

<u>Material and methods:</u>

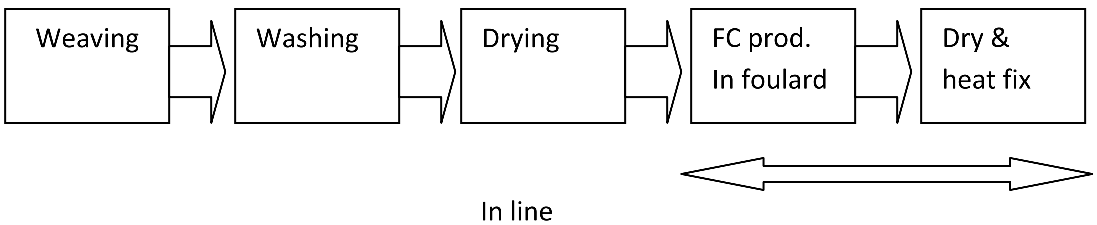
The material used, is a woven material in 100% polyester for seat application in cars. It needs to fulfill a number of different requirements concerning colour, touch, abrasion, sew ability, flam ability, clean ability etc. according to a Technical Regulation from the OEM. For light colored material, it also means that the material needs to be treated with a water and dirt repellant chemical. To be repellant to both water and oily substances, the only now existing chemical to use is a flour carbon. Until now, the most frequently used is C8, but after new restrictions for Europe there is a transition to a flour carbon with a shorter carbon atom chain. For the up-scaling, a number of meters was taken from a larger production batch of a material in colour Blond and given a simpler finishing, meaning just washing to remove lubricants and drying of the material. The material was later on sent to Grinp in Torino, Italy, to continue the finishing process with the spray / plasma treatment.

Grinp is the plasma machine manufacturer that has supplied Swerea with the lab scale machine and it was quite natural that the up-scaling also would be processed in the same kind of machine to avoid technical deviations.

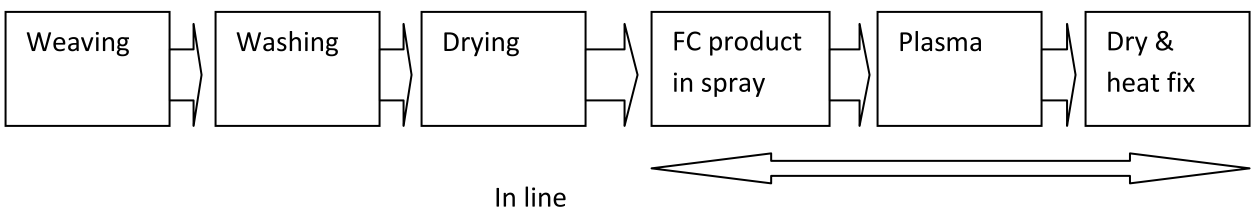
<u>Up-scaling</u>

The up-scaling was made to give a better view that the idea of spraying Flour Carbon 6 before plasma treatment and a thermal fix, on the woven material, in a full width scale, would give the same good results as the lab scale trials from Swerea lab had showed. The aim was to achieve a product with equal or better properties than with the normal production process today. Normally the material is treated with Flour Carbon in a padder/foulard equipment before it's dried and fixed in a Stenter.

The normal production process:



The new process with plasma:



<u>The spray and plasma parameters</u>

The spraying was performed in a WEKO system in line with the atmospheric pressure plasma equipment in a industrial company which was approved by Grinp technical technicians. It was applied 8g/m2 of Phobol Flour carbon 6 product by spray right before the textile entered the plasma area. The speed through spray and plasma was there for the same. After spraying the textile looked wet, after plasma treatment it looked dry.

Parameters	Settings
Plasma power	8000 W
Electrode distance	4 mm
Material speed	10 m / minute
Cycles through plasma	1
Process gas and pressure	He/02 10/1
Electrodes temperature	Room temperature

Material and methods:

Test equipments

- Flammability rig TUMA 540:1
- Weather meter TUMA 703:1
- Light cabin TUMA 550:1
- Grey scale TUMA 546:1
- Heat cabin
- Climate chamber
- Martindale TUMA 644:*1*

Tests performed

- Flammability, VCS 5031,19
- Colour fastness to artificial light at 75oCand 50%RH, STD 1027,359
- Resistance to wear, STD1024,7122
- Snagging resistance – Taber, SS-EN ISO 5470-1
- Resistance to ageing in heat, 90oC 1000h
- Ageing in moisture, 38oC, 95%RH, 1000h
- Ageing in moisture, 70oC, 55%RH, 1000h
- Resistance to stain remover, Volvo testing code 850 428 02
- Soiling resistance and cleanability, Volvo testing code 850 000 10A
- The abrasion resistance of the finish, VCC test code 850 000 11

Result and discussion

The plasma treatment and parameters was the same all through the material, but the spray solution was in two different ways. First part with the flour carbon 6 in a concentrated form and the second part in a diluted form, But the spray speed has been adjusted in the way that both resulted fabrics has been treated with the same amount of FC. All parameters and details of settings were transmitted from Swerea to Grinp after an NDA was signed between them.

Flour carbon product was sent to Grinp, but during first trial in a production set up it was clearly not enough of chemical product to cover the production system minimum volumes in the WEKO system. A new trial was immediately planned and executed with enough solution to cover the spray system's minimum volume.

It should be noted that industrial scale spray and plasma equipments are completely customized systems; they are designed in different ways based on the needs. In this project, we used best industrial spray and plasma equipments, but still they could not meet all of our needs. For example, plasma equipment was not capable of treating full wet textiles, that's why GRINP engineers had to use more concentrated FC solution than what we used in the lab.

During inspection of material and comparing it to both production master and material treated in lab scale, we could see that visually the up-scaled material had a considerable darker shade, was stiff and had a more rough surface touch. We could also see that the surface very easily got white scratch marks of finger nails or just by folding the material.

Since the material looked very different from the Swerea lab scale samples, we were not sure that the dilution and the parameter settings had been followed. After discussion with GRINP engineers and check all technical information, we noted that FC concentrations on the textiles are higher than lab scale textiles. the main reason, as mentioned in last chapter, was disability of the industrial scale plasma to treat completely wet fabrics, and also limitation of spray system to work with highly concentrated solutions; engineers had to use concentrated solutions in spray step to minimize water content, but the spray system could not spray such concentrated FC that we needed. As a result the final fabrics could not followed lab scale procedure; 8mgFC/g fabrics was the minimum level of FC that they could apply.

Material was laminated by flame lamination as normal process for this seat material, Sports Uni Blond. Requested amount was sent to Volvo Surface Material Laboratory for testing. Resulted values will be presented separately here:

Borgstena initial testing

Some initial tests were made at Borgstena Laboratory to find if the deviation of surface touch and colour could have other effects on the material that would affect the technical properties. The more complete test report on the material was performed by Volvo Car.

Borgstena test report.

SUPPLIER	SAMPLE NUMBER	ARTICLE NUMBER	BATCH NUMBER	LAMINATION
Borgstena Textile, Ltd		253106/1-4-4		laminated

CUSTOMER	PROJECT	PART NAME	TECHN. REGULATION	DESIGNATION
VCC	LOTEX	Sports Uni Blond Phobol Spray+Plasma diluted solution	TR 31832991-003	Woven seat textile

Flammability (mm/min)	Normal Upholstery Door panel	VCS 5031,19	Length: Max 80 Cross: Max 80	L: SE/B 121 C: B 142		NOK
14 days @ 70º +- 2ºC	Heat Upholstery Door panel	VCS 5031,19	Length: Max 80 Cross: Max 80	L: B_132mm/min C:B-116mm/min		NOK NOK
14 days @ 38º +- 2ºC 95 +- 5% RH	Moisture Upholstery Door panel	VCS 5031,19	Length: Max 80 Cross: Max 80	L:B-108mm/min C:B-101mm/min		NOK NOK
Gravimetric Fogging mg condensate		VCS 1027,2769 Temperature: 85 +- 1ºC (from P14)	Max 0,5 mg condensate	0,02	OK	

Adhesion	Lab. Conditions	STD 1024,28519	Min: 4N	Fab/Foam L: 9.0 C: 6.7 Scrim/Foam L: 8.4 C: 7.6	OK
	After Ageing in heat	1000 hours at 90+/-2ºC	Min: 4N Minimum grey scale class 4, no change in colour tone allowed		Was not performed
	After Ageing in moisture	To be store for 1000h Temp. + 38+/-2ºC Relative humidity 95+/- 5% RH	Min: 4N Allowed change of appearance max 4-5		Was not performed

Resistance to soiling and cleanability resistance of woven and knitted textile materials	Volvo code 850 000 10A	Soiling resistance: the behaviour of the stain shall be reported. Cleanability- After cleaning: Grade 3, the stain disappears almost completely. No visible water mark.	Before after VCC cleaning Water Coffee: 3 - 2WM -3 Choc: 3 -3 -3 Coke: 3- 2wm -3 orange: 3-2wm-3	NOK

Volvo Car Corporation Test Report
The textile has been treated with a combination with plasma and Phobol, a fluorocarbon built with C6 chains.
The textile in the trial have been sprayed with Phobol, treated with plasma, dried and fixed.
Phobol is the same chemical used for sports uni blond production material. The production material is treated in a padder, dried and fixed.

Sports Uni Blond, lam4mm Plasma +FC C6 Phobol is tested in;
Flammability ·Colour fastness to artificial light at 75°C/50%RH ·Resistance to wear Snagging resistance – Taber ·Resistance to ageing in heat 90°C/1000h ·Ageing in moisture at 38°C/ 95%RH/ 1000h ·Ageing in moisture at 70°C/55%RH/1000h ·Resistance to stain remover Soiling resistance and cleanability ·Abrasion resistance of the finish.

Sports Uni Blond, lam4mm production material, FC C6 Phobol is tested in;
Snagging resistance – Taber ·Resistance to stain remover ·Soiling resistance and cleanability Abrasion resistance of the finish.

The Sports Uni Blond, lam4mm Plasma +FC C6 Phobol treatment impacted the colour and the handle of the textile. The colour is much darker and the handle is very stiff. The textile is too stiff to use for seat upholstery. It also becomes white scratch marks and creases very easy.

Flammability acc to VCS 5031, 19

Material	Length	Cross
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	B 75, 79, 81, 80, 73	B 78, 75, 70, 75, 76

Requirement: Burning rate max 80 mm/min

Ageing

Material	Climate	Result, greyscale
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	Heat 90˚C, 1000h	Not ready yet
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	Moisture 38˚C/95% RH, 1000h	Not ready yet
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	UV light, 400h, 75˚C	Not ready yet

Resistance to wear acc to STD1024,7122, 12 kPa

Material	12 500 cycles	25 000 cycles	50 000 cycles
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	OK	OK white surface	OK white surface

Snagging resistance – Taber acc to SS-EN ISO 5470-1
Load 500g, Abrasion wheels CS10.

Material	1 500 cycles
Sports Uni Blond, lam4m Plasma +FC C6 Phobol	OK white surface
Sports Uni Blond, lam4mm production material, FC C6 Phobol	OK little white surface

Requirement: No catch or snag of individual fibres or threads at 1 500 cycles.

Resistance to stain remover acc to Volvo testing code 850 428 02

Material	Distilled water	5% ammonium solution	Petroleumeter boiling pnt 40oC-60oC	Volvo´s recommended cleaning agent for textile
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	OK	OK	OK	OK
Sports Uni Blond, lam4mm production material, FC C6 Phobol	OK	OK	OK	OK

Requirement: Colour and surface unchanged compared with untested material.

Soiling resistance and cleanability acc to Volvo testing code 850 000 10A

Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	Stain	After cleaning
Coffee	Small stain	NOK
Chocolate	Small stain	No stain, no watermark
Coke	Small stain	No stain, no water mark
Orange drink	Small stain	No stain, no watermark
Sports Uni Blond, lam4mm production material, FC C6 Phobol		
Coffee	Small stain	No stain, no watermark
Chocolate	Small stain	No stain, no watermark
Coke	Small stain	No stain, no water mark
Orange drink	Small stain	No stain, no watermark

Requirement: After cleaning; the stain disappears almost completely (hard to discover) No visible water mark.

The abrasion resistance of the finish acc to VCC test code 850 000 11

Material/ wear	0 wear cycles + coffee	2500 wear cycles + coffee	5000 wear cycles + coffee
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol	Small stain	Not totally absorbed	Not totally absorbed
Sports Uni Blond, lam4mm production material, FC C6 Phobol	Small stain	Totally absorbed	Totally absorbed

Summary of results

- Flammability is on the borderline for the plasma treated material, worse than the production material.
- Colour fastness to artificial light for the plasma treated material is not ready yet.
- Resistance to wear is ok, but the surface became white for the plasma treated material.
- Snagging resistance- Taber is ok for the both materials, the plasma treated got a white surface, the production material also got a white surface but not as bad as the plasma treated.
- Resistance to ageing in heat, 90oC, 1000h for the plasma treated material is not ready yet.
- Resistance to ageing in moisture 38oC, 95%RH for the plasma treated material is not ready yet.
- Resistance to ageing in moisture 70oC, 55%RH for the plasma treated material is not ready yet.
- Resistance to stain remover is ok for the both materials.
- Soiling resistance and cleanability, the cleanability for coffee is nok for the plasma treated material.
- Abrasion resistance of the finish, the plasma treated material was better than the production material.

WP5, Management

WP leader: Farshad Toomadj, Swerea IVF

Mile stone: M5.1 6th month report
M5.2 1 year report
M5.3 18th month report
M5.4 Final report
M3.2 Evaluation of developed processes

Meetings

18 June 2014 – Meeting at Swerea IVF, discussing possibilities of patenting
Participants: Cecilia Wieslander, VCC, Sofia Royson, VCC, Anneli Vaern, Borgstena, Philip Gillgard, Swerea IVF, Elis Carlström, Swerea IVF, Anna Thorvaldsson, Swerea IVF
5 Sep 2014 – Meeting at Swerea IVF, continuing discussion of patenting
Participants: Cecilia Wieslander, VCC, Sofia Royson, VCC, Anneli Vaern, Borgstena, Paulo Gameiro, Borgstena Elis Carlström, Swerea IVF, Anna Thorvaldsson, Swerea IVF
9 Sep 2014 – Meeting with Borgstena at Swerea IVF, discussing progress so far and how to proceed with WP4. Representatives from Baldwin, spray equipment company, also joined for discussion of spraying in textile finishing process.
Participants: Anneli Vaern, Borgstena, Linda Costa, Swerea IVF, Farshad Toomadj, Swerea IVF, Per Stenflo, Baldwin, Joachim Wellander, Baldwin
15 Sep 2014 – meeting in Borgstena office, Borås, discussing on the progress of project and preliminary results of cleanibility test, by VCC. Also full water-oil results of fabrics were presented by Swerea IVF.
Participants: Anneli Vaern, Borgstena, Cecilia Wieslander, VCC, Sofia Royson, VCC, Ann-Britt Tollhag, VCC, Farshad Toomadj, Swerea IVF, Anna Thorvaldsson, Swerea IVF
21 Oct 2014 – meeting in Borgstena, Boras, discussing on how we can scale-up fabric and produce demonstrator.
Participants: Anneli Vaern, Borgstena, :Cecilia Wieslander, VCC, Sofia Royson, VCC, Ann-Britt Tollhag, VCC, Farshad Toomadj, Swerea IVF,
18 Jan 2015 – meeting in Borgstena Borås, discussing about arrangement for demonstrator
Participants: Anneli Vaern, Borgstena, Farshad Toomadj, Swerea IVF
5 Feb 2015 – meeting in VCC discussing on flammability, celeanibility results of laminated C6 and C8 treated textiles. Also we started to plan for 18 months report.
Participants: Anneli Vaern, Borgstena, : Ann-Britt Tollhag, VCC, Sofia Royson, VCC, Farshad Toomadj, Swerea IVF
20 April 2015 – meeting in Swerea IVF. Discussing about scaling up, spray systems
Participants: Farshad Toomadj, Swerea IVF, Markus Andersson Trojer, Swerea IVF, Anneli Vaern, Borgstena, Per Stenflo (Baldwin)
3 December 2015 – meeting in Swerea IVF.
Participants: Markus Andersson Trojer, Swerea IVF, Anneli Warn, Borgstena, Sofia Royson, VCC, Ann-Britt Tollhag, VCC, and Linda Costa, Borgstena

Material transfers

June 23th 2014 Fabrics sent from Borgstena to Swerea IVF

- SPORTS UNI BLOND – 6 rolls of ≈30cm width with ≈15mts each roll, untreated

June 17th 2014 Treated fabrics sent from Swerea IVF to Volvo for flammability and cleanability tests
January 15th 2015 100m Farbrics treated by two different formulations sent by Swerea IVF to Borgstena for laminating
Mars 2015 laminated fabrics sent from Borgstena to Volvo flammability and cleanability tests
October 2015 treated textiles sent from Grinp to Borgstena for lamination
October 2015 treated textiles sent from Borgstena to Swerea IVF and Volvo final tests

Mile stones

Mile stones			Month	Completed
WP1	M1	Specification of material requirements	4	X
WP2	M2.1	Selection of precursors/particles	5	X
	M2.2	Definition of plasma parameters	12	X
	M2.3	Definition of spraying parameters	10	X
WP3	M3.1	Evaluation of treated textiles	13	X
	M3.2	Evaluation of developed processes	13	X
WP4	M4.1	Demonstrator	20	X
	M4.2	Evaluation of demonstrator	24	X
WP5	M5.1	6th-month report	6	X
	M5.2	12th month report	12	X
	M5.3	18th month report	18	X
	M5.4	Final report	24	Ongoing

*A new spray equipment, allowing for continuous plasma- and spray treatment was delivered to Swerea IVF in September and will be used for the final definition of spray parameters in a continuous setting.

Deliverables

Deliverable	Deliverable title	Completed
D1	Report on material specifications and suitable precursors/particles	X
D2.	Report on defined plasma- and spraying parameters with evaluation of treated textiles and developed processes	X
D3.	Prototype of textile for car interior (car seat)	X
D4.	Report on evaluation of prototype according to end-use specifications	Ongoing

Appendix:

Images:

1: Resistance to wear acc to STD1024,7122, 12 kPa

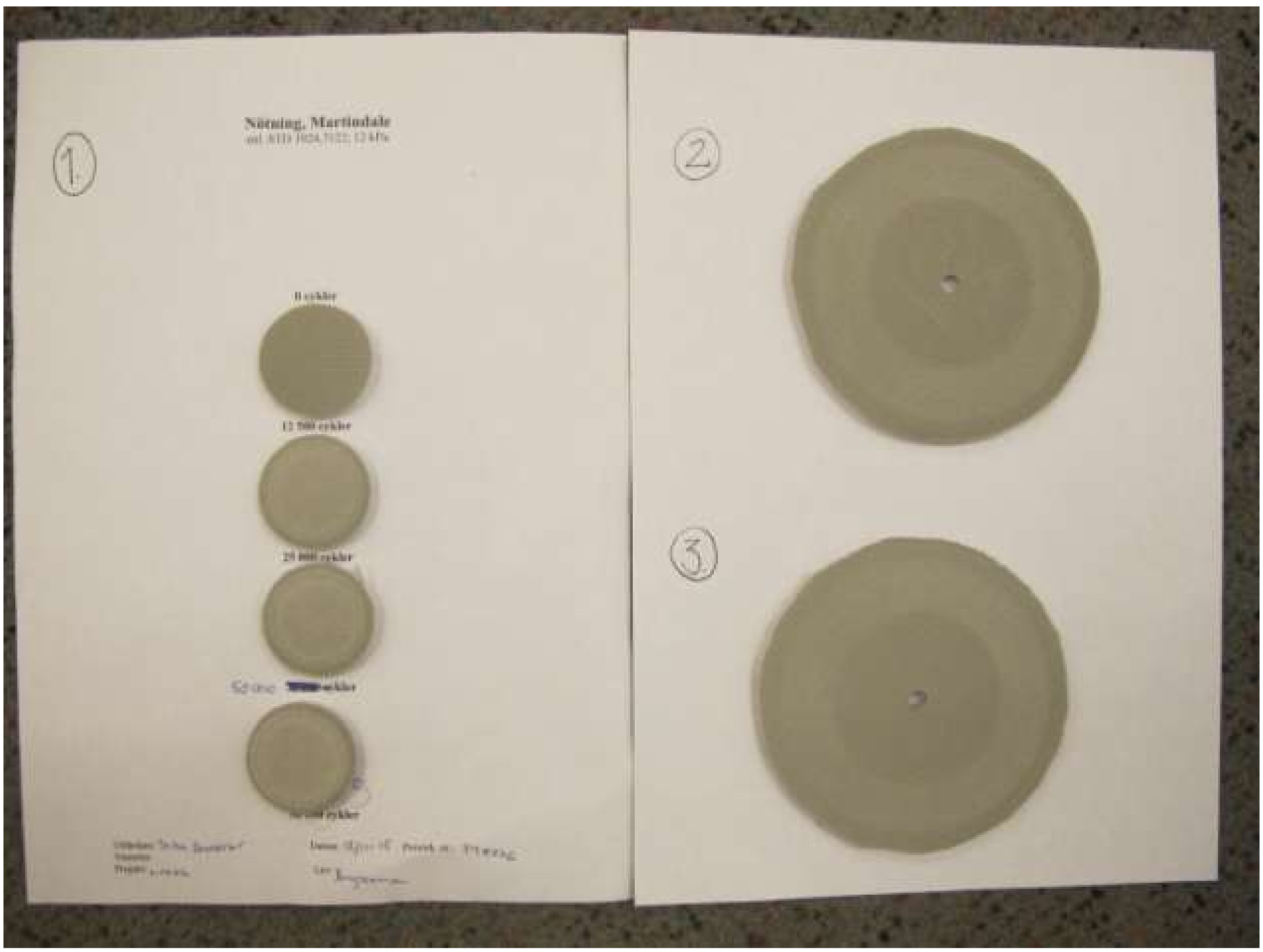
Sports Uni Blond, lam4mm Plasma +FC C6 Phobol

2: Snagging resistance – Taber acc to SS-EN ISO 5470-1

Sports Uni Blond, lam4mm Plasma +FC C6 Phobol

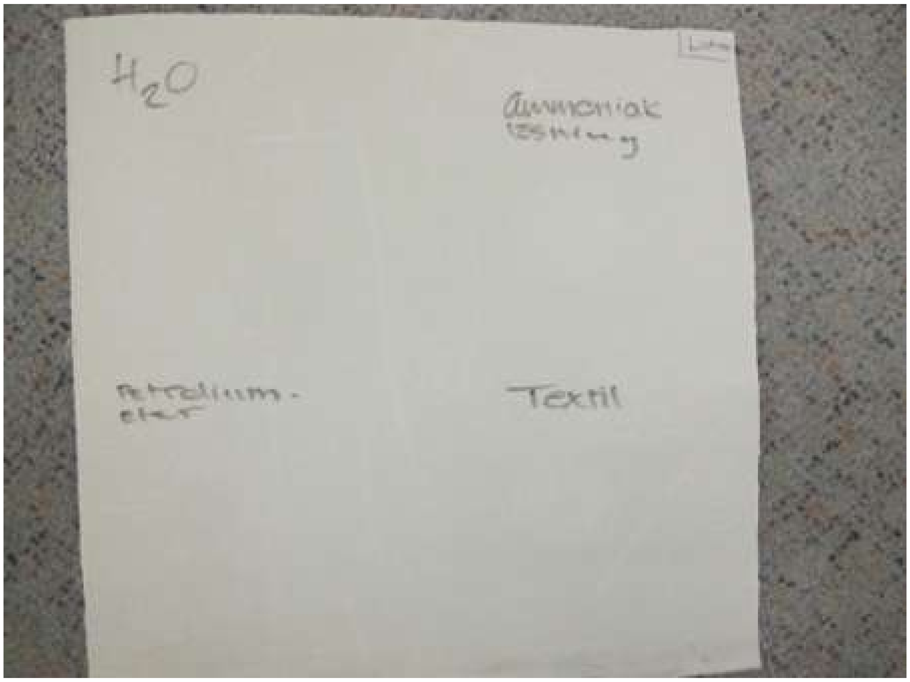
3 : Snagging resistance – Taber acc to SS-EN ISO 5470-1

Sports Uni Blond, lam4mm production material, FC C6 Phobol



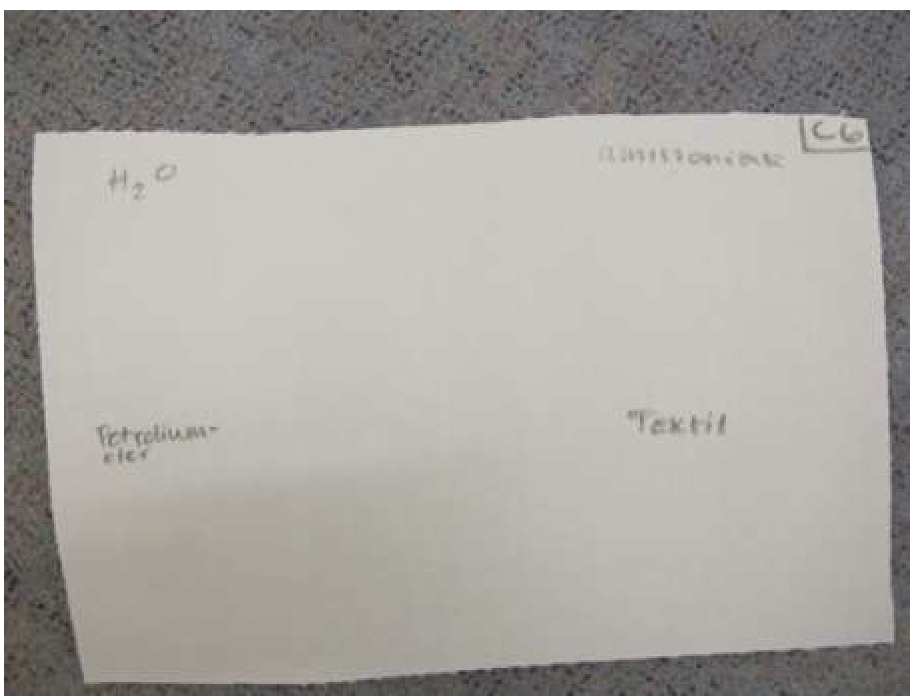
Resistance to stain remover acc to Volvo testing code 850 428 02

Sports Uni Blond, lam4mm Plasma +FC C6 Phobol



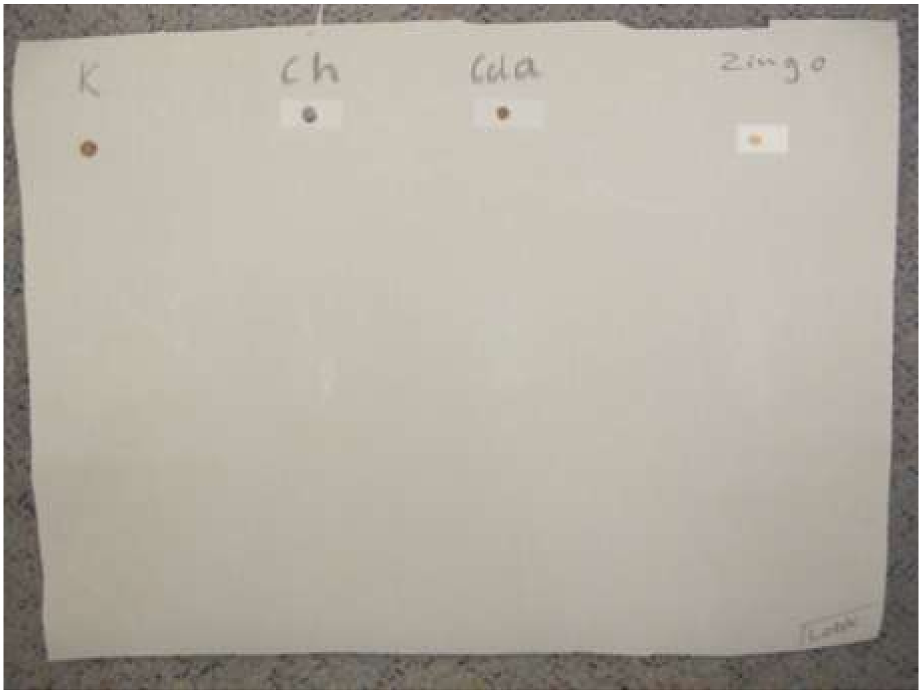
Resistance to stain remover acc to Volvo testing code 850 428 02

Sports Uni Blond, lam4mm production material, FC C6 Phobol



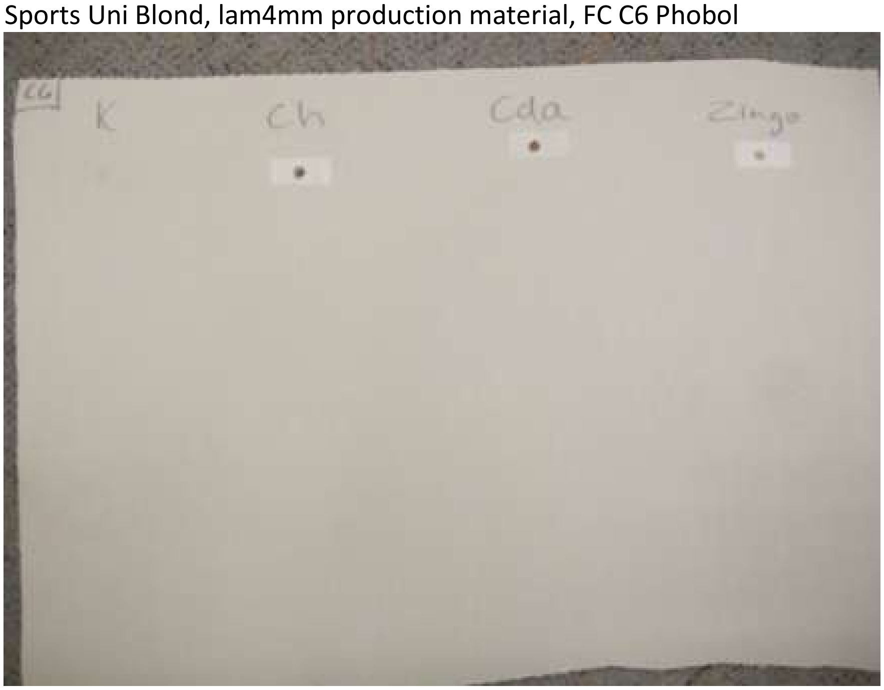
Soiling resistance and cleanability acc to Volvo testing code 850 000 10A

Sports Uni Blond, lam4mm Plasma +FC C6 Phobol



Soiling resistance and cleanability acc to Volvo testing code 850 000 10A

Sports Uni Blond, lam4mm production material, FC C6 Phobol



The abrasion resistance of the finish acc to VCC test code 850 000 11

Left : Sports Uni Blond, lam4mm Plasma +FC C6 Phobol

Right : Sports Uni Blond, lam4mm production material, FC C6 Phobol