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REPORT

D4.4 Report on wash ability of the developed products

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Introduction and background

According to Swerea IVF knowledge and experience, washing in water will be the most common way to clean clothes during a foreseeable future. One example is that detergent suppliers continue to develop ingredients for washing in water. Therefore it is of importance that the garments and textiles developed in Mistra Future Fashion are water washable, and preferably easy to clean at low temperature. The washing procedure itself should be as gentle as possible. Short programs, low temperature, environmentally benign detergents etc. These general aspects are valid for both industrial and domestic washing.

One way to increase the life-span of a textile is to make it more durable, with a good mechanical strength. It should also maintain its color and shape. This will increase the life-span under the presumption that the consumer will use the textile until it is worn out - which is not always the case, especially for fashion. But for basic wear, workwear, bed linen, towels, curtains etc, this can be applicable.

In the Mistra project S'wash (Clean development and demonstration - Sustainable domestic washing) a prototype washing machine was developed with 60% reduced electricity consumption and 70% less water consumption[1]. The aim was to install this prototype in an apartment house for field trials within the Mistra Future Fashion, but due to the fact that the bacteria growth in the tanks for recycling the water was not fully solved in an environmentally benign way this was put on hold.

The consumer behavior also has a major impact on textile lifetime. How many times the textile is washed before it is regarded as worn out, which washing program is used, how dirty the textile is before washing it are examples of behavior that has an impact. Over-dosage of detergent is also a problem. According to a study performed by the Swedish Environmental Agency 50 000 ton detergent is used in Sweden, whereof 25% is calculated to be mere over-dosage[2]. This can be solved by introducing automatic dosage in the washing machines. Such systems are under strong development and new systems (for example i-Dos from Bosch and AWD10 from Miele) have been introduced on the market. However, these dosage systems have not yet reached a major breakthrough on the Swedish market.

From the consumer point of view, there are several actions that can be taken; buying textiles with long anticipated life-time, do not use extra detergent to be "on the safe side" – it almost always ends up as an over dosage, airing clothes instead of washing when used just a short time, do not wash single items separately, use short washing programs and at as low temperature as possible without affecting the cleaning performance, hang dry instead of tumble dry. Tenants in rental apartments could ask the proprietor to install an automatic dosage system in the laundry facilities.

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[1] Clean development and demonstration — Sustainable domestic washing - s'wash B2009 2011-10-31.

[2] http://www.hsb.se/omhsb/miljo/boklimatsmart/energi/tvattstugor/ratt-mangd-tvattmedel

In this study, 16 different materials have been evaluated regarding washing performances, including some tests conducted with the non conventional CelluNova material prototype.

Washing study

Within P6 (Mistra Future Fashion, Project 6 *Fashion for the public sector*) some materials have been washed different number of times to also perform tactile tests. Swerea IVF performed the washing as follows; samples were taken out after 0, 10, 50 and 100 washes. After approximately each fifth wash the goods were tumble dried. In total 16 different materials were washed divided into two batches. One batch was washed in a domestic machine at 40°C and the other batch in a professional industrial machine at 75°C with standard detergent from Testgewebe GmbH[3]. The materials are shown in table 1. Material 2 and 3 have cotton in the warp and the actual test material as insert.

Table 1 Materials in washing test

No.	Material	Construction	Washing preferences
1	Cotton	Woven	75°C professional laundering standard detergent (without bleach)
2	Viscose/cotton	Woven	
3	Bamboo viscose/Cotton	Woven	
5	Lenzing Natural (Lyo/PES)	Woven	
6	Lenzing Breeze (Lyo/PES)	Woven	
7	IKEA Lyocell/cotton	Woven	
8	IKEA Lyocell	Woven	
9	TvNo Tencel/PES	Woven	
4	Cotton	Knitted	40°C domestic laundering standard detergent (including bleach)
10	Wiges Bamboo viscose(elastane)	Knitted	
11	Milk/cotton	Woven	
12	Milk protein	Knitted	
13	Bamboo viscose	Knitted	
14	Viscose	Knitted	
15	Bamboo viscose (store)	Knitted	
16	Viscose (store)	Knitted	

To see how the materials are affected by the washing processes both reference samples and samples, washed 100 times, were taken out and evaluated in the Martindale equipment. Abrasion test was performed according to SS-EN ISO 12947-2:1999.

The result of this test is shown in figure 1 & 2. For material description see table 1.

[3] Standard detergent from Testgewebe GmbH. Detergent used: 2 (IEC A*+ sodium perborate+TAED)/3 (ECE A+sodium perborate+TAED). Dosage:20 g/wash cycle.

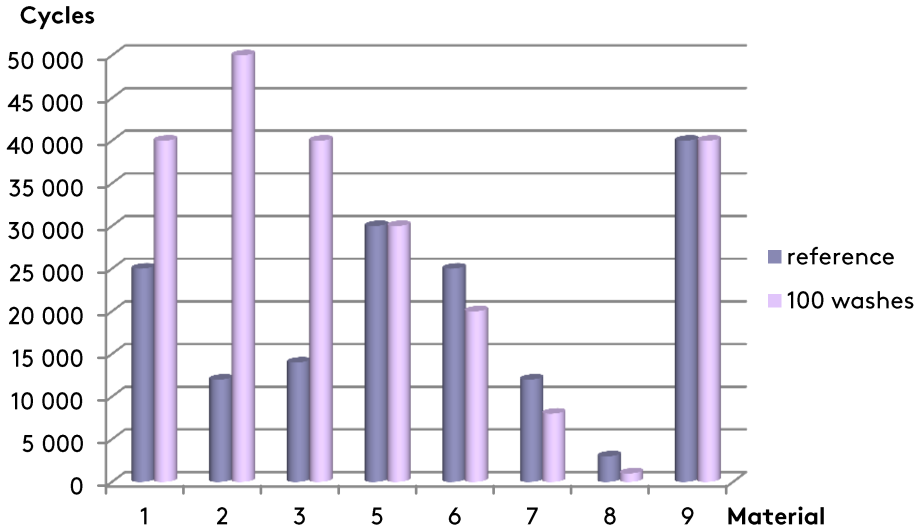

Figure 1: Materials washed in a professional machine at 75°C.Material no. as given in table 1. Number of cycles before material failure in Martindale equipment.

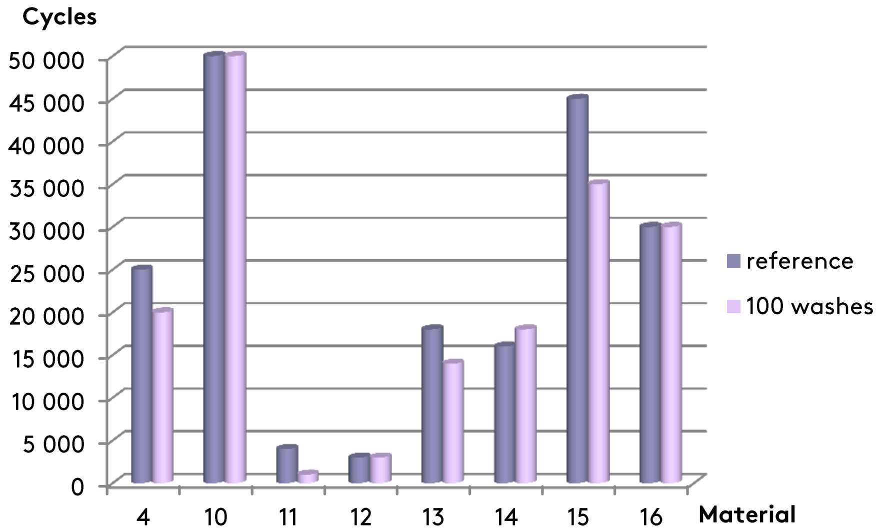

Figure 2: Materials washed in a domestic machine at 40°C. Number of cycles before material failure in Martindale equipment.

Materials 1, 2, 3 and 14 show better resistance to abrasion after 100 washes than reference material. This is most likely due to that the material shrinks and gets denser. Therefore, these samples could resist more abrasion before failure.

According to experience from Swerea IVF, a typical set point value, for material made for multiple use in the public sector and work wear, would be 20 000 cycles in the abrasion test.

Drape test

Does the washing affect the drape ability? To investigate this, a drape test was performed on some of the material described in table 1. The amount of fabric was not enough to perform test on all materials. Table 2 shows a drape coefficient that is a mean value from front and reverse side of each material tested. Figure 3 shows a drape test on a woven fabric.

Figure 3: A woven fabric is placed in the testing equipment. The fabric drapes and an up light creates a shadow. From this, the drape coefficient is calculated as quotient between the shadow and the whole surface. A small shadow gives high drape ability.

Table 2 Drape coefficient and rating for some of the unwashed materials.
*Washed 100 times.

Materials	Drape coefficient	Drape difference 0-100 washes	Rating
1	0,45		Middle
2	0,28		Good
3	0,28		Good
5	0,64	0,19	Low
5 (100)*	0,45		Middle
6	0,66	0,19	Low
6 (100)*	0,47		Middle
7	0,53	0,08	Low
7 (100)*	0,45		Middle
8	0,39	-0,02	Middle
8 (100)*	0,41		Middle
11	0,32		Good

In general the materials get more smooth and pliable after washing and processing. That is why the drape effect can increase after 100 washes. Material 5, 6 and 7 drapes more after 100 washes than before washing see the rating in table 2. Material 8 drapes the same after washing as before.

The abrasion result decreases, according to figure 1, for these materials, which means that the fabric gets more comfortable but weaker.

Washing test on CelluNova

CelluNova fibers available in this project were produced at IBWCH in Lodz in Poland 2011. The amounts of fiber were very limited so only tests that do not require much material could be performed at this stage.

Nonwoven

A Nonwoven sample in 100% CelluNova, from batch RC-MIX, was produced at Swerea IVF. This sample was split into small pieces and washed according to varied conditions showed in table 3. Standard detergent from Testgewebe GmbH[4] was used and all samples, except the larger sample, were washed in Gyrowasher equipment. The large sample was washed together with ballast in a domestic laundry machine.

After washing a tensile test was performed in Vibrodyn equipment. Titer was measured on single filaments with 100 mg load. The tensile testing gave results according to table 3 and figure 4.

Table 3 Nonwoven CelluNova samples washed under different conditions

Sample	cN/tex
Unwashed	16,1
40°C with detergent	15,1
40°C without detergent	14,0
60°C with detergent	15,0
60°C without detergent	14,8
40°C big sample with detergent	15,5

[4] Standard detergent from Testgewebe GmbH. Detergent used: 2 (IEC A*+ sodium perborate+TAED)/3 (ECE A+sodium perborate+TAED). Dosage:20 g/wash cycle.

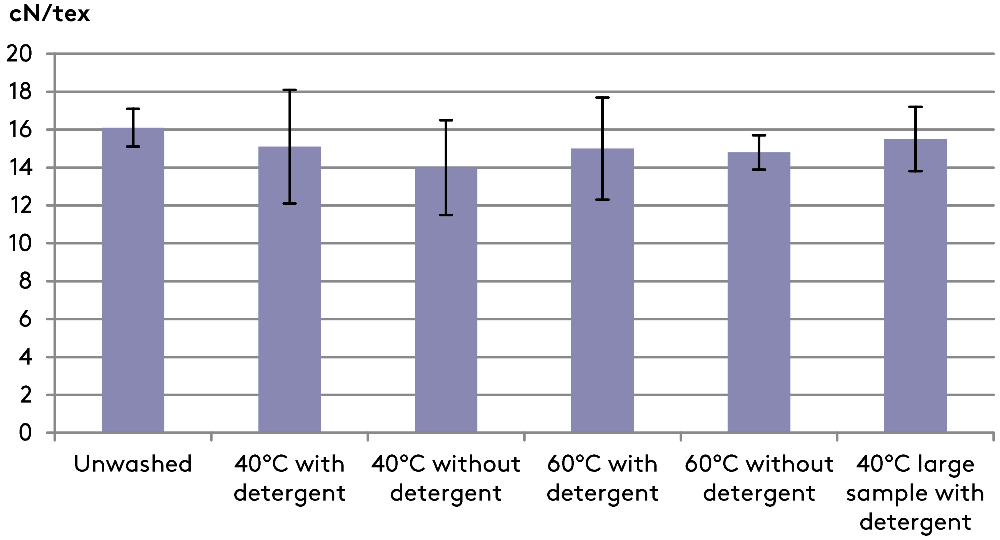

Figure 4: Strength of single filament from the washed samples.

The washed nonwoven samples had shrunk, which made it hard to separate the filaments. It was difficult to obtain fibers long enough for titer measurements. No significant decrease in strength could be obtained from this washing test, see Figure 4.

Knitted jersey

Conventional viscose and cotton threads were knitted with the same parameters as the CelluNova material. The viscose and cotton was used as reference material to compare the CelluNova material with.

Textile testing on these three materials has been performed on both washed and reference (washed only one time) fabric.

CelluNova fibers were crimped and cut to staple fibers, then carded and stretched and finally ring spun to a yarn. This is described in D4.3 *Report describing processing windows for production processes of fabrics made of sustainable fibers (e.g. CelluNova fibers)*. The thread became slightly uneven due to small amount of available material and limited adjustment possibilities in lab spinning equipment. The thread worked well in the knitting machine and a single jersey fabric was produced. The uneven thread creates a stripy effect on the fabric, which is due to the thread spinning process, and not related to the CelluNova material.

The fabrics were dyed into a turquoise color, also described in D4.3 *Report describing processing windows for production processes of fabrics made of sustainable fibers (e.g. CelluNova fibers)*. The dyed fabrics were then washed 40 times in a domestic laundry machine at 40°C with standard detergent from Testgewebe GmbH[5], without bleach. The reference samples that are not washed 40 times are in fact washed one time to eliminate residues from the manufacturing process.

[5] Standard detergent from Testgewebe GmbH. Detergent used: 2 (IEC A*+ sodium perborate+TAED)/3 (ECE A+sodium perborate+TAED). Dosage:20 g/wash cycle.

Table 4 show the test methods that were performed for the CelluNova, viscose and cotton materials.

Table 4 Testing methods for reference materials and washed 40 times materials

Testing method	Standard	Comment
Abrasion	SS-EN ISO 12947-2: 1999	Mean value of two samples
Pilling	SS-EN ISO 12945-2:2000	Only tested against wool
Color measurement	Konica Minolta CM 3600d	4 layers, mean value of 5 measurements/material.
Mass per unit	SS-EN 12127:1997	With fewer samples due to lack of material

Abrasion results:

Table 5 Number of cycles before material failure.

Material	Reference CelluNova	Washed CelluNova	Reference Viscose	Washed Viscose	Reference Cotton	Washed Cotton
No cycles	4 000	4 000	18 000	16 000	25 000	25 000

Pilling results:

Table 6 Pilling rate, 5 is no changes and 1 is a lot of pills.

Cycles	Reference CelluNova	Washed CelluNova	Reference Viscose	Washed Viscose	Reference Cotton	Washed Cotton
125	4	4	3,5	4,5	3	3
500	4	4	3,5	4,5	3	3
1000	3,5	3,5	3,5	3,5	3	3
2000	3	3,5	3	3	2	1,5
5000	2,5	3,5	2,5	2,5	2	1,5

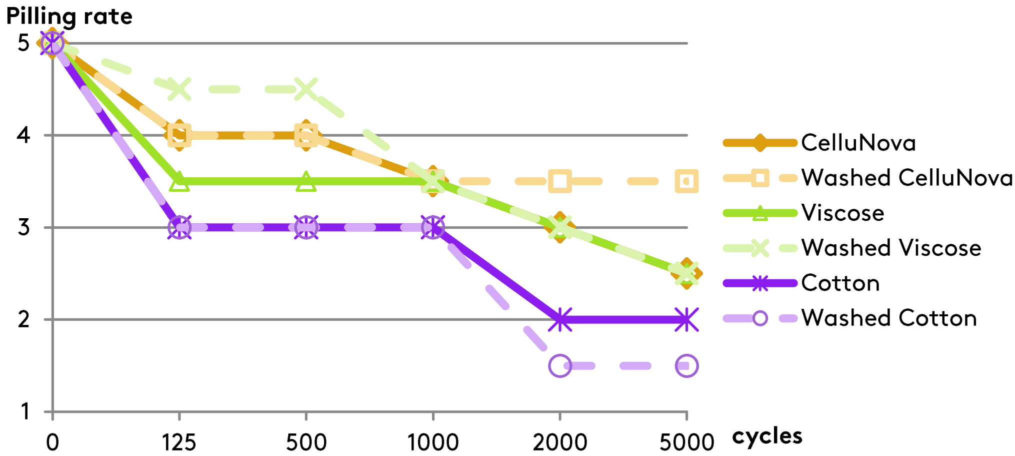

Figure 5: Pilling rate of tested materials after defined number of cycles.

Color measurements results:

Table 7 Color measurements. ΔE is the color difference between reference and washed 40 times material.

	L*	a*	b*	ΔEcmc(2:1)
Reference CelluNova	39,37	-50,21	-5,93	0
Washed CelluNova	43,46	-49,71	-4,13	2,4
Reference Viscose	50,75	-47,62	-6,9	0
Washed Viscose	55,46	-45,76	-2,47	3,2
Reference Cotton	51,86	-42,15	-10,23	0
Washed Cotton	55,55	-42,41	-7,69	2,2

Table 8 Explanations of the color measurements parameters and the dyed material.

Reactive dyes 7,5 % 1:20
Single Jersey, Ne 30 Gauge 18

L* = Brightness (100 = white; 0 = black)
a* = Red - Green (+a* = red; -a* = green)
b* = Yellow - Blue (+b* = yellow; -b* = blue)
$\Delta_{Ecmc(2:1)}$ = Color difference, < 0,8 ΔE limit for "same color"

Mass per unit:

Table 9 Mean value of two samples from each material and wash.

Weight (g/m2)	CelluNova	Viscose	Cotton
Reference	136,525	106,615	121,92
Washed	165,105	101,3	116,07
Difference	*-28,58*	*5,315*	*5,855*

The CelluNova material has shrunk and increased in density. Both viscose and cotton show reduced density after washing. This may be due to fiber loss or dimensional changes for the viscose and cotton fabric.

Conclusions

These washing trials can be seen as initial screening tests. The amount of materials was limited and full scale trials were not possible to perform. The result and conclusions can therefore only be seen as guidelines and indicators for future tests.

In the abrasion test on samples washed 100 times, the materials which contain polyester performs best, approximately twice as good as the materials containing blends with cotton. The results were expected, as polyester is a strong fiber which often is used in blends to increase the wear resistance. To be able to manage around 20 000 cycles in a Martindale equipment, some synthetic material is needed to be blended in to give the cellulose based materials higher strength. This is why, for example, a 50/50 cotton/polyester (or lyocell/polyester) composition is suitable in work wear and for public sector clothes.

The more washing cycles a material is exposed to, the smoother and softer the fabric generally becomes - if it manages the washing without any negative impact. This is one explanation to why the drape ability increases on some of the studied materials. The drape ability can be compared with the comfort rating in the tactile test within P6 (*Fashion for the public sector*). In this test, the Lyocell/polyester blend materials number 5 and 6 increases in comfort rating according to the tactile test, just as the drape ability shows in this study.

The CelluNova material available in this study is a prototype which is continuously developed, and the textile properties are not yet set. Washing tests on this material will continue, but these first trials will give an indication regarding the washing performance. CelluNova manage well to be washed 40 times in 40°C. The strength of the material did not significantly decrease after the washing process. Pilling is not affected and the color loss is in line with expected value compared to viscose. So far one can conclude that the CelluNova material could be competitive as alternative to cotton and viscose regarding washing aspects.

MISTRA
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About Mistra Future Fashion

The purpose of the Mistra Future Fashion Program is to deliver knowledge and solutions that the Swedish fashion industry and its stakeholders can use to improve the fashion sector's environmental performance and strengthen its global competitiveness. The program is structured so that it leverages the expertise and networks of leading Swedish and international research institutes and universities. Stakeholders engaged in the program include governmental agencies, voluntary organisations, and companies within the entire textile value chain: forestry, pulping, textile manufacturing and recycling. To find out more please visit www.mistrafuturefashion.com.