

## SOLVETEX II

### quality performances of solvents

#### TKT

TKT is the Dutch technical knowledge centre for the textile care industry, for both the dry cleaning industry and the laundry industry. TKT initiates and coordinates technical and sustainable innovation projects for the Dutch and the International textile care industry. TKT is imbedded in international and networks and has extensive expertise about technological aspects of cleaning and washing such as (amongst others) sustainability of cleaning, alternative cleaning processes, energy saving, hygiene of cleaning and washing, life cycle assessments, environmental legislation for dry cleaners & laundries, textile functionalities and their relationship to washing processes. There are many ongoing projects about these aspects. Additionally, practical knowledge is transferred to the companies in the form of online educational material, both on a national and on an international level. TKT is closely affiliated to the Dutch national associations FTN (laundry) and Netex (dry cleaning), as well as the umbrella association CINET (the international committee of professional textile care).

#### Update march 2011

Expansion of results with dibutoxymethane (Solvon K4), iPura siloxane D5 (Green Earth), iPura HCS and a glycol ether.

Solvon K4 is a recent development from Kreussler. The iPura processes were developed by iLSA. The glycol ether is a recent development from Christeyns that will be launched on short notice. The results from Solvetex I have been expanded with these new solvents and machine technologies.

Over the last 2 decades, there have been many technological developments in the field of alternative cleaning technologies. These developments may be in the field of new solvents, new or improved machine technology or new or improved detergents. Today the dry cleaner can choose from siloxane D5, liquid CO<sub>2</sub>, professional wetcleaning, dibutoxymethane, iPura siloxane D5, iPura HCS and a glycol ether.

This is not without a reason, as the pressure worldwide on the use of perchloroethylene is increasing more and more. Most readers will be familiar with the phasing out of perchloroethylene in California by 2023. More countries/states are expected to review their position regarding perchloroethylene. Therefore, the developments of good alternatives for perchloroethylene are of the utmost importance for the dry cleaning industry. A study on the cleaning performance of today's established and alternative cleaning solvents has been conducted by TKT. The results are presented in this paper.

## Introduction

For a long time, alternatives for perchloroethylene meant other nonaqueous solvents. The main reason for this is that water based cleaning in the past would cause damage to sensitive garments in the form of shrinkage. This was caused by poor temperature control during the washing and poor control of drying conditions. Also the type of clothes that were brought to the dry cleaner by the customers was limited to clothes that could not be washed in the household washing machine. Therefore, water based cleaning technologies were not relevant for the dry cleaner.

However, we have seen a steady improvement in the machine technology, dryer technology and detergents of wetcleaning that have strongly decreased the risk of damage and shrinkage. Additionally, customers are broadening the mixture of clothes they bring to the professional cleaner and now a substantial amount of casual clothes is involved as well. This means that water based cleaning in the form of wetcleaning is now a serious alternative for a growing percentage of the textile mixture customers bring in. On the other hand, solvents will always be necessary for a certain percentage of the garments as we will see in the results of the experiments.

In this paper, we present results on cleaning performance under real life conditions of two established solvent based technologies (perchloroethylene and hydrocarbon solvents), and compare them with wetcleaning and alternative nonaqueous solvents (siloxane D5, liquid CO<sub>2</sub>, dibutoxymethane, iPura siloxane D5, iPura HCS a glycol ether).

## Worldwide trends on solvents and processes

Cinet has investigated the usage of common and alternative solvents worldwide; the results are shown in Table 1.

	Perchloroethylene	Hydrocarbon solvents	Wetcleaning	Other
Belgium	65	25	7	3
Denmark	50	40	6	4
Finland	70	1	29	
Germany	50	24	26	
Netherlands	45	25	30	
Norway	60	38	2	
Sweden	75	5	10	10
Romania	70	1	29	
UK	70	5		25
Japan	11	88		1
United States	70	27	1	2
Canada	95	5		

Table 1: % Solvent Usage worldwide in 2010

At the moment of writing, a market analysis of dibutoxymethane, iPura siloxane D5, iPura HCS and the glycol ether has not yet been done. Perchloroethylene is still dominating in the dry cleaning industry in most countries worldwide, with the exception of Japan. Also, a slightly less domination position is seen in North-Western Europe. Note that the alternative(s) for perchloroethylene are not the same everywhere.

## The Solvetex Project

In order to judge the above mentioned trends and developments in cleaning technologies Cinet, the Dutch national dry cleaners association (NETEX) and the Technological Knowledge Center for Textile Care (TKT) have investigated the state of the art in performance of 9 cleaning technologies in the project called 'Solvetex'. In the Solvetex projects, we have compared the performance of PERC, and HCS with, siloxane D5, liquid CO<sub>2</sub>, professional wetcleaning, dibutoxymethane, iPura siloxane D5, iPura HCS and a glycol ether under real life conditions with relevant garments mixtures and model cloths for shrinkage, pilling and stain removal as well. Of each commercial item, 9 pieces were bought new. The garments and test materials have been cleaned thrice with the above named cleaning technologies in dry cleaning companies during working hours along with normal cleaning loads from customers. This means, this project has not been carried out as model tests.

### The textile mixture consisted of:

- a black men's suit (composition: wool 88%, polyamide 8%, elastane 4%)
- a ladies skirt (composition: polyester 43%, wool 30%, viscose 6%, nylon 3%, polyacryl 18%)
- a tie (100% silk) (PERC, HCS, siloxane D5, Wetcleaning and CO<sub>2</sub> only)
- a sweater (100% wool)
- test cloths for shrinkage
- test cloths for greying

### The results that have been generated include:

- stain removal from cloth with model stains (See Table 2 for details about the stains)
- greying of model cloths
- shrinking of cotton- and wool (both commercial textile items and model test cloths)
- Analysis of pilling/roughening/wrinkling of the articles

Below you will find a resume of our findings:

### Stain Removal from model stain cloths

In Table 2 and Figure 1, the results from stain removal from model stain cloths are presented. Please note that the stains did not undergo pre- or postspotting. The table shows the stain removal performance of the cleaning methods under real life conditions. The absolute values are shown in Table 2, where a higher score means a better removal; as to be expected, sebum(skinfat) is removed more easily by apolar solvents and is less easily removed by wetcleaning. We find the other way around for watersoluble stains, such as spinach from wool.

In the bottom row of Table 2 and in Figure 1, you find the overall score for each solvent, compared to HCS.

We clearly see that perchloroethylene is still the best cleaning system with respect to stain removal. The scores wetcleaning and the 2 bath processes of siloxane D5 and HCS are not too far apart, with a slight advantage for the 2-bath processes of HCS and siloxane D5 over wetcleaning. The stain removal of liquid CO<sub>2</sub> clearly lags behind the other technologies.

With the new solvents and machine technologies that were added in March 2011, we see that dibutoxymethane and a glycol ether show stain removal better than HCS with scores that are very close to those of PERC. The stain removal of the iPura processes is less compared to the 2-bath processes with the same solvents.

	Parc	HCS	Siloxane D5	WetClean	CO <sub>2</sub>	Dibutoxymethane	iPura Siloxane D5	iPura HCS	Glycol ether
Model stain									
Sebum (wool)	99,3	93,3	98,0	39,0	18,0	99	56	60,3	100
Red Wine	0,0	0,0	0,0	24,3	0,0	0	0	0	0
Coffee	0,0	0,0	0,3	1,0	0,0	0,7	0	0	1
Thea	0,3	0,7	1,3	3,7	0,0	0	0	0	1
Blood/Milk/Ink	1,0	1,0	1,0	8,3	1,0	1	0	0	1
Blood	1,3	1,0	1,3	7,7	0,0	1	0	0	1
Cacao/Lanolin	67,3	55,0	57,0	22,7	14,0	62	27,3	42,7	61,7
Olive oil/carbon	4,7	3,0	4,0	2,7	0,0	5,3	1,3	1,7	6,7
Mineral oil/carbon	8,0	4,0	6,7	3,7	1,0	5,7	1	2,7	7,7
Sebum (polyester/cotton)	48,7	31,3	28,7	14,3	6,0	39,7	9,7	18,7	50
egg yolk	65,3	56,7	51,7	36,7	18,0	69	21,3	40,3	70,3
Sebum	45,0	36,7	41,3	29,0	6,0	37,7	10,3	19,3	37,3
Spinach (wool)	22,7	15,7	22,3	100,0	6,0	21,3	8	9,7	46,7
Grass	0,0	0,0	0,0	0,0	0,0	0	0	0	0
Make-up	9,3	0,0	5,0	0,0	0,0	2,3	0	0	6,7
Lipstick	57,0	26,7	10,7	4,3	1,0	30	3,7	22	26,7
<b>Stain Removal (Relative (HCS is 100%))</b>									
<b>Absolute</b>	<b>429,9</b>	<b>325,1</b>	<b>329,3</b>	<b>297,4</b>	<b>71,0</b>	<b>374,7</b>	<b>138,6</b>	<b>217,4</b>	<b>417,8</b>
<b>Relative</b>	<b>132</b>	<b>100</b>	<b>101</b>	<b>91</b>	<b>22</b>	<b>115</b>	<b>43</b>	<b>67</b>	<b>129</b>

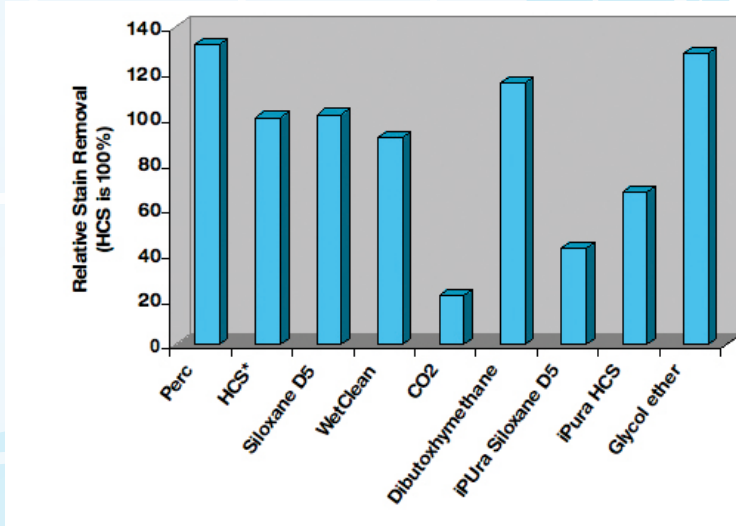


Table 2: Stain removal from model stain cloths by the different solvents. A higher value means better stain removal.

Figure 1: Relative stain removal for all investigated cleaning technologies. The stain removal of the 2 bath process with HCS was chosen as 100% (marked with an asterisk). So, a value above 100% means more stain removal; a value below 100% means less stain removal.

### Shrinkage of wool and cotton

#### Model cloths

In Figure 2, you find the average shrinkage of the model cloths after 3 cleaning cycles. These are the results directly after the cleaning processes, so without a finishing step.

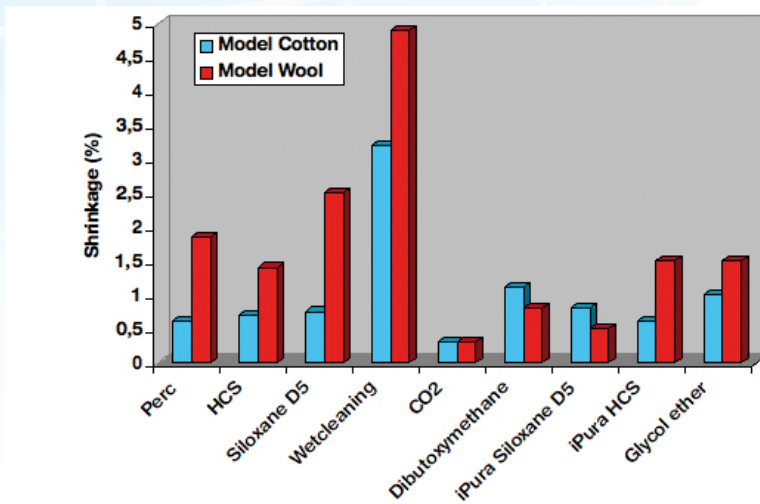


Figure 2: Shrinkage of model cloths after 3 cleaning cycles

We see that with the model cloths the shrinkage after 3 cleaning cycles is the largest with wetcleaning, especially with wool. The very mild nature of the 'drying' process with liquid CO<sub>2</sub> is seen in the very low shrinkage values.

### Commercial textile articles

In Figure 3, you find the average shrinkage of the commercial textile items after three cleaning cycles and finishing. The high value with wetcleaning was caused mostly by the sweater. Without the sweater (100% wool) the results are not as far apart. Also here, the very mild nature of the 'drying' process with liquid CO<sub>2</sub> is seen in the very low shrinkage values. In general the percentages are very low and below 1% except for the average value of wetcleaning.

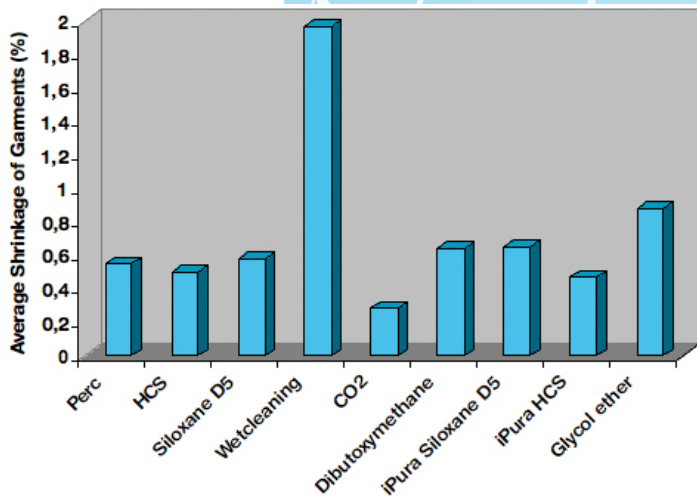


Figure 3: Average shrinkage of the garments with all tested solvents and machine technologies.

### Greying of wool and cotton test materials

In Figure 4, the average greying of cotton and wool test materials after 3 cleaning cycles is shown. The greying shows little variation, except for iPura HCS.

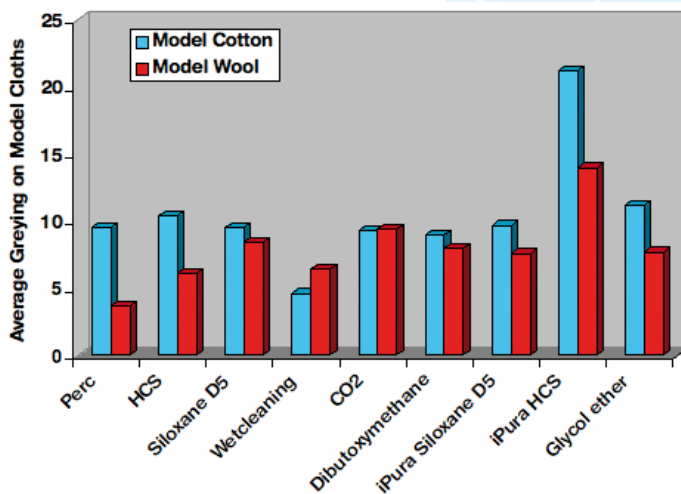


Figure 4: Average greying on model cloths after 3 cleaning cycles for all tested solvents and machine technologies

### **Wrinkling, pilling, roughening**

Directly after cleaning, the men's suit was wrinkled strongly with the wetcleaning process, yet the wrinkles were 'shallow' and were easily removed by a finishing process.

Pilling and roughening are difficult to measure, so one has to rely on visual observations. As to be expected, some pilling and roughening was seen with the sweater (100% wool) in the wetcleaning process. Due to the long drying times, a slight roughening was seen after the siloxane D5 process. With all other cleaning processes, no pilling was observed.

### **General observations**

No changes in colour were observed for all tested solvents and machine technologies. A very slight decrease in shine was observed with men's the suit after wetcleaning. The grip of the suit was somewhat less after the wetcleaning process; with all other solvents and machine technologies, no changes were observed in grip.

With dibutoxymethane and the glycol ether it was observed that the zippers were more difficult to open and close after the cleaning processes. There was hardly any scent detectable on the garments at the time of analysing the results (this was several days after cleaning and finishing the garments). Although no extensive comparison could be made on the ease of the finishing process after the different cleaning technologies, no large differences were determined apart for after the wetcleaning.

## **Conclusions**

What conclusions can we draw from this? If we put the results in a historical context, it is to be expected that the results for Perc (and to a lesser extent for HCS) have not changed dramatically over the last 15 years as they are mature cleaning technologies. With respect to overall performance, Perc was historically always the best cleaning solvent, followed by the HCS bath process. These two are the well-established cleaning technologies with which we have compared wetcleaning and the solvent based alternative technologies.

Siloxane D5 is a relative new technology, where further improvements might be expected in the near future. Due to the nature of the solvent, which is less volatile than Perc and HCS, improvements of the drying process are especially interesting. The long drying times tend to damage the textile slightly more than with Perc and/or HCS. The overall performance of the siloxane D5 bath process with respect to shrinkage and stain removal are on a good level and are comparable to Perc and HCS.

The siloxane and HCS iPura processes are interesting from a technological point of view, due to low solvent amounts in the machine and claimed energy savings.

Both iPura processes show shrinkage that is comparable or less compared to PERC and HCS. This was seen with both the model cloths, where especially iPura siloxane D5 Earth shows very low shrinkage values, and with the garments where the shrinkage was comparable to that of PERC and HCS. Hardly any pilling or roughening was seen on the test cloths. The stain removal of both iPura processes clearly lags behind the bath processes with the same solvents. Additionally, the iPura HCS shows rather high greying values.

Liquid carbon dioxide needs strong improvement of detergents, as the stain removal and the greying, which is the job of the detergent, clearly lag behind the other technologies. With respect to the care aspect for the garments, liquid carbon dioxide gives excellent results.

Wetcleaning has seen many improvements over the last 20 years in the fields of machine technology, drying technology and detergents. The stain removal shows a different profile compared to the nonpolar solvents, yet the overall score is comparable to HCS. This means that different stains need pre- or postspotting compared to the solvent based technologies. With respect to shrinkage and pilling/roughening, we clearly see that knitted woollen articles are not suited for wet cleaning. The other articles show somewhat more shrinkage directly after the cleaning process compared to solvent based cleaning. We know from practice that this can be resolved perfectly by the finishing process.

We have to accept that wetcleaning is a cleaning technology that requires extra time and attention when it comes to the finishing. Also, we have to accept, as is shown by the results in this article, that not 100% of the articles are suitable for wetcleaning, such as knitted woollen articles. As was stated during the IDC in Dublin in 2010:

- Many/most plants can readily achieve 40%-60%
- With high effort some can achieve 60%-80%
- With extraordinary effort, 90% can be done

Dibutoxymethane shows a good stain removal that is almost on the same level as PERC. The shrinkage with model cloths somewhat higher with cotton compared to PERC and HCS; yet with wool the shrinkage is lower. With the garments, the average shrinkage is comparable to that of HCS and PERC. The greying is comparable to that of PERC and HCS with cotton and somewhat higher with wool. Hardly any pilling or roughening was seen on the test cloths. Interesting is the claimed biodegradability of the solvent which is a novelty.

The glycol ether shows good results with respect to stain removal and greying; somewhat more greying has occurred compared to PERC and HCS. The stain removal is very close to that of PERC. The shrinkage with the model cloths is comparable with PERC and HCS; the shrinkage with the garments is somewhat higher than with PERC and HCS. Yet, it must be noted that this solvent was tested on a somewhat older multisolvent machine where the drying process was not optimized. Hardly any pilling or roughening was seen on the test cloths.

Although it was not possible in the Solvetex project to investigate all aspects of dibutoxymethane and a glycol ether, these first results indicate that these could also be good alternatives for PERC.

Today's dry cleaning industry can choose from many good alternatives for PERC. The alternative solvents and machine technologies cover the entire spectrum of textiles that the dry cleaner receives from customers and show a much more favourable environmental profile compared to PERC whereas the performance is comparable to PERC. This offers many chances to improve the sustainability and the image of the sector without jeopardizing the quality and service.