PFC's free alternatives combined with plasma treatment for increasing the water repellency performances in textiles.

Abstract

Since 2013 Benetton, in line with its long-term sustainability program, recognizes the urgent need for eliminating industrial releases of all hazardous chemicals such as the PFCs, a category of man-made products to make materials oils and water resistant, that may affect human health and environment.

This study demonstrates that by combining Atmospheric Plasma Treatment and PFCs free formulations it is possible to obtain a valid sustainable alternative to PFCs compounds. Joined together, these two components may guarantee a high repellency performance of textiles.

Substituted substance(s)

1. **Perfluorooctanoic acid (PFOA)**
   CAS No. 335-67-1 **EC No**. 206-397-9 **Index No**. 607-704-00-2

2. **Perfluorooctane sulfonic acid (PFOS)**
   CAS No. 1763-23-1 **EC No.** 217-179-8 **Index No.** 607-624-00-8

3. **Perfluorinated compounds (PFC)**
   CAS No. EC No. Index No.

Other type of alternative

Durable water repellent (non-fluorinated) product, combined with Atmospheric Plasma Treatment

Application

Sector
Manufacture of textiles, wearing apparel, leather and related products

Process
Finishing (metal, wood, ceramics, textiles etc.)

Enterprise using the alternative

Benetton Group srl – Villa Minelli – 31050 – Ponzano Veneto (TV) – Italy

Product & Processes Compliance
Phone: (+39) 0422 517910
E-mail: detox@benetton.it
Homepage: www.benettongroup.com

State of Implementation

Pilot study

Availability of alternative(s)

On the market

Reliability of information

Evidence of implementation: there is evidence that the solution was implemented and in use at time of publication

Substitution description

Due to the insistence of the market, the efforts made by chemical manufacturers undergone to a rapid acceleration.
In recent years, PFCs, especially long chains PFCs (known as C8 structures), that were historically used in the repellent coating of textiles and apparel, have been replaced by the shorter chains PFCs (C6 or less) and alternative formulations in which PFCs have been totally removed. In spite to the elimination progress, the long-chain PFCs (C8 structures) provide unrivalled repellency to a range of liquids and substances, from oil to water and wine, not yet reached by any of the proposed alternatives. Therefore, being less effective, a larger quantities of PFC's free substances may be required to provide the same performance.

The purpose of this study is to substitute the PFC's compound by a new technology based on a physical (non-chemical) process.

This is a ionizing treatment, named atmospheric plasma treatment, that improves the hydrophilic properties of the fabrics, by increasing their attitude to absorb or retain water. Consequently, additives, such as PFCs' free substances, are also better retained by the fabrics.

The atmospheric plasma technology makes the PFCs' free chemical additives more effective, by modifying the fabric surface until a nano-metric scale, varying the morphology of the individual natural fibers, controlling their surface roughness and consequently the wetting.

Therefore, this process allows fabrics to have water repellency characteristics similar to those obtained by using PFCs compounds, helping to offset the gap between the "harmful long chains" and the "safer alternatives".

Plasma technology is based on the physical principle stating that the aggregation state of a material changes when energy is added to it. In this way it pass from solid to liquid and from liquid to gaseous state.

Plasma represents the state of high-energy aggregation, often called "the fourth state of the matter", and it is obtained when a gas is ionized by adding energy to it.

It is important to point out that the changes introduced by a plasma treatment involves only the external layer of the substrate without any alteration of the physical-mechanical properties of the material: in a textile, for example, the properties of breathability and hand feel are not altered in tangible manner.

Technological description

Atmospheric Plasma Technology: Dielectric Barrier Discharge (DBD).

Raw Fabric: 100% PA nylon 20 DEN with a weight of 35 gr/m2, commonly used for producing down jackets.

Fabric's finishing process consisting of:
- F1) dyeing, applying of the DWR product and pad-dry-cure
  (maximum temperature, in drying process, 150-180 °C)
- F2) dyeing, plasma treatment, applying of the DWR product and pad-dry-cure
  (maximum temperature, in drying process, 150-180 °C)

Two variables (i.e. energy of plasma and DWR additives) have been considered in the research:

- Energy of plasma (E), due to the plasma field strength, has been varied to evaluate different effects:
  - E1) 82 KJ/m²
  - E2) 150 KJ/m².

- DWR Additive (A): different kind of fluorine free additives are available on the market, but as starting point our choice has fallen in a well know finishing chemical – already object of a SUBSPORT's case story – produced by an important chemical company, renewably-sourced and bluesign® approved.

The product, even if declared as PFCs' free from the producers, has been submitted by Benetton to a certified third party laboratory for chemical testing, that has confirmed the complete absence of PFCs , as well as free from many other harmful substances such as Alkylphenol and Alkylphenol Ethoxylates, Chlorobenzenes and Chlorotoluenes, Chlorophenols, Dyes (Azo), Dyes (Carcinogenic and Disperse), Glycols, Halogenated Solvents, Organic substances, Phthalates, Polycyclic Aromatic, Hydrocarbons (PAH), Flame Retardants, Metals, Chromium (VI), Formaldehyde, Isocyanate (test report is available on request).

Organizational measures of fabric performance

All the samples deriving from the combination of the two variables, i.e. E x A, have been tested by:

- Determination of resistance to water penetration by hydrostatic pressure test (Method ISO 811:1981)
- in "as received state"

- Determination of resistance to surface wetting, Spray Test (Method ISO 4920:2012)
- in "as received state"
- after 1 washing according to ISO 6330:2012 procedure 3M tumble dry 1 dot, no ironing
- after 5 washing according to ISO 6330:2012 procedure 3M tumble dry 1 dot, no ironing
- after 10 washing according to ISO 6330:2012 procedure 3M tumble dry 1 dot, no ironing
- after 20 washing according to ISO 6330:2012 procedure 3M tumble dry 1 dot, no ironing

- Determination of certain PFCs by HPLC analysis on fabric after DWR and plasma treatment
- Determination of certain PFCs by GC analysis on fabric after DWR and plasma treatment

Costs

The costs of the additional plasma treatment is very low and could affect the finishing of the fabrics in the order of few cents per meter. A significant parameter for cost estimation derives from the fact that, thanks to the great capability of industrial and non-stop atmospheric plasma treatment, an average of 1000 meters can be treated in one hour, much more greater than the usual capability of dyeing and finishing process.

Results

From the objective evaluation of the tests it has been possible to observe how F2 fabric finishing (the one with plasma) has obtained mostly greater or equal results, in terms of performance, compared to the F1 fabric finishing (without plasma).

The spray test after 20 washing for both F1 and F2 fabric finishing show a little decay, lightly bigger in F2.
However, this result has been positively evaluated considering very unlikely that a garment, such a down jacket or similar, could be washed 20 times throughout its entire lifecycle.

As expected it confirms that plasma treatment provides greater hydrophilicity to the fibrous substrate and when the water-repellent film (obtained by adding the DWR additive) goes away, the morphology of the fabric, modified by the plasma, returns to show its full water's absorption.

It has also been noted that low energy plasma (E1) treatment, in addition to be less expensive, has proved to be even more effective.

Combined with the use of the additive – which already showed by its own high capacity of repellency – plasma treatment has proved to be very effective in water penetration by hydrostatic pressure test with an improvement of the performance almost close to 50% (from 19 cm to 28 cm).

Conclusion

Although plasma treatment has shown different behaviors depending on the different combinations, by deepening the study in a timely manner and finding the right balance between fabric, energy applied to plasma treatment and DWR finishing over the proven efficacy of the outlined process, further reduction in the use of chemicals can be assumed.

Plasma treatment can be easily integrated into a production line: it is easily controllable electronically, much more precise than liquid treatments and it reduces the impacts on wastewater.

Plasma, therefore, cannot only reduce the negative aspects of applying traditional chemical processes to the manufacturing cycle of the textile industry, but also involves the use of innovative, cost-effective and environmentally friendly processes.

Case/substitution evaluation

This case story from a user presents substitution of PFC containing durable water repellent products by the atmospheric plasma treatment technology combined with non-fluorinated DWR products.

Who provided the information

Type of information supplier

User

Contact

Benetton Group srl – Villa Minelli – 31050 – Ponzano Veneto (TV) – Italy

Product & Processes Compliance
Phone: (+39) 0422 517910
E-mail: detox@benetton.it
Homepage: www.benettongroup.com