Environmental Analysis of the best available finishing products to provide water, oil and dirt repellency in the textile sector. A Life Cycle Approach

Julio Fierro, Cristina Martínez
Centro Tecnológico de Investigación Multisectorial (CETIM), A Coruña (Spain)

LCM Conference 2017,
Luxembourg – September 5th
CETIM (Centro Tecnológico de Investigación Multisectorial)

• Private research centre located in A Coruña (Spain)
• Focus in R+D of technologies and processes.
• Offer transversal solutions applicable to all sectors.

Four main knowledge areas:
Outline

1. Introduction
   • Textile finishing products
   • LIFE MIDWOR project

2. Methodology

3. Results & discussion

4. Conclusions & next steps
What are DWORs?

• **Durable Water and Oil Repellency** products

• **Used in textile finishing processes** to provide water, oil and stain repellency to fabrics.

• Conventional DWORs are based in **perfluorinated chemistry** ($C_8$ & $C_6$) and often PTFE.

• Increases contact angle between water and fabric surface ($> 90^\circ$)
Environmental concern

• **DWORs** have a complex structure (comb-like) with several side chains.
• Perfluorinated chains are **severed** from DWOR structure and **released to the environment**.
• Forms **highly stable compounds**, with high transportation potential and lifespan.
Environmental concern

• As result, PFC degradation compounds can be detected all over the world.
• Production sites are the main source of emissions (wastewater).
• Bioaccumulation across food-chain also have been reported.
• Some reported as carcinogenic, mutagenic and reprotoxic.
  • PFOS and related compounds are listed under Stockholm Convention POP list.
  • PFOA and related compounds are candidate for inclusion and proposed for restriction by ECHA

Butt et al., «Levels and trends of poly- and perfluorinated compound in the arctic environment».
Reduce the environmental, health and safety impacts of current and future DWOR alternatives

- Technical, environmental and risk assessment of different DWORs
- Industrial validation (6 industries)
- Assess manufacturers on the best available technologies at present.
- Workshops and Policy recommendations for textile sector

Mitigation of environmental impact caused by DWOR textile finishing chemicals studying their non-toxic alternatives
Mitigation of environmental impact caused by DWOR textile finishing chemicals studying their non-toxic alternatives

LCA role in the project

Evaluate the **footprint of both finishing process** and the assumed improvement of replacing conventional DWORs by alternatives.

LCA will be based in results from **industrial validation:**

- 6 different textile industries
- Several DWORs evaluated (LC-PFC, SC-PFC, silicone based, sol-gel, etc.)
Mitigation of environmental impact caused by DWOR textile finishing chemicals studying their non-toxic alternatives

**LCA role in the project**

**Industrial results** not available until end of 2017

**Initial LCA** have been developed (draft version)

- Confirm **LCA boundaries**
- Identify **key stages & parameters** of the finishing process.
- Identify **LCA issues** to be addressed at final version
One common finishing process has been modelled:

- Fabric production/reception at finishing plant.
- DWOR application (Padding machine).
- Fabric drying and curing.
- Fabric winding and final conditioning (ready to be sold).
Description of the study: Methodology (II)

Two finishing products:

**Short-chain DWOR (Phobol CP-U)**
- Partially fluorinated copolymer (65%)
- N-Butyl acetate (35%)

**Silicone based DWOR (DRYOL S600)**
- Silicone (80%)
- Process water (17%)
- Etoxylated alcohol (3%)

- Results from **preparatory actions** (lab-scale)
- **DWOR composition** from references and **Safety data sheets** (SDS)
- **Raw matters** from Ecoinvent database

**Functional Unit:** 100 m² of finished fabric (ready to be shipped)
Description of the study: Methodology (III)

Two LCA approaches were initially studied on this draft-LCA:

- Including life cycle of fabric production (Cotton cultivation, yarning, knitting, etc.) → Cradle to gate
- Considering only the finishing process (DWOR application, drying, curing, winding) → Gate to gate

In both cases, the full life cycle of the DWORs were considered
Comparison of 100 m² of finished fabric with **Silicone DWOR (blue)** and **C6-DWOR (orange)**

Results shows a **slight difference between scenarios.**

**Footprint of fabric production** (woven cotton) **masks** the difference between the two DWORS evaluated.
Comparison of 100 m² of finished fabric with Silicone DWOR (blue) and C6-DWOR (orange)

If fabric production is omitted, difference between both scenarios becomes more evident.
Based on the results obtained, fabric production will not be considered in order to obtain a better focus on finishing stage (aim of LIFE-MIDWOR).

Flowchart of the environmental impact of C6-DWOR scenario (with and without textile production)

**Contributing from “woven cotton fabric” accounts for nearly 94% of the environmental impact.**

Omitting stages before DWOR finishing allows a better comparison between finishing process.
Results showed **two main issues** (to be addressed in final LCA)

1. **Lack of information for modelling DWOR production.**
   - **Composition** of DWORs is **not always specified** in Safety datasheets.
   - Often composition is a **trade secret**
   - **Only general steps** of its production, raw matters and origin are **known**.
     - Electrochemical fluoration, telomerisation process, etc...

2. **LCA methodologies does not reflect the impact of PFCs properly**
Life Cycle Assessment - Initial draft (II)

2. LCA Methodologies does not reflect the impact of PFCs properly

- Main concern of DWORs is related with **PFC emissions** to environment.

- Currently, **global accepted methods** (ILCD 2011+, ReCiPe, USETox, CML, etc.) does not include **PFC substances** in its substance inventory, and thus they does not reflect PFCs impact of those emissions.
  - Only one exception: **Ecological Scarcity 2013**
  - Includes several PFC related compounds
    - 10:2 FTOH (10:2 fluorotelomer alcohol)
    - 8:2 FTOH (8:2 fluorotelomer alcohol)
    - EtFOSA (N-ethyl perfluorooctane sulfonamide)
    - MeFOSA (N-methyl perfluorooctane sulfonamide)
  - Includes a specific Impact Category “**POP into water**”
  - Developed by the Swiss environmental Government, and thus all impact are assessed from a Swiss perspective, based in Swiss Environmental targets.
Comparison of **Silicone DWOR (blue)** and **C6-DWOR (orange)** using two different methods

**ILCD 2011+**

PFCs are not considered. Differences shown are related with other emissions (COVs, etc.). This explains the small differences between both scenarios.
Comparison of Silicone DWOR (blue) and C6-DWOR (orange) using two different methods

Ecological Scarcity 2013
Includes a specific Impact Category, “POP into water” where PFCs are heavily considered
Conclusions and Future steps

Two key issues that need to be addressed in final LCA version in order to fulfil the objectives of LCA in MIDWOR project.

- **Include** perfluorochemical substances and assign *Characterisation factors* to reflect properly environmental impact of conventional and alternative DWORS.

- **Improve** knowledge about $C_8$-DWOR production and composition.
Conclusions & Future steps

1. **Inclusion of PFC emissions** used for DWOR production

   - **First approach** creating a generic PFC substance
   - **Three** selected *Categories of Impact* according with chemistry and reported environmental behaviour of PFOA and PFOS in literature:
     - *Human toxicity, Cancer effects,*
     - *Human toxicity, non-cancer effects*
     - *Freshwater ecotoxicity*
   - Provisional **Characterisation Factors** assigned in the range of other POP with similar properties (such pesticides, wide known chemicals, etc)
Conclusions & Future steps

1. Inclusion of PFC emissions used for DWOR production

*Modified* method shows a higher *environmental impact in those categories* with assigned *Characterisation Factors*.

This would provide a **better approach** for achieving *LCA objectives in MIDWOR project*

Still need to verify reliability of selected *Characterisation Factors*.
Conclusions & Future steps

2. Synthesis of conventional C8/C6-DWORs (base scenario):

- Improvement in DWOR production and composition by contacting with stakeholders from textile sector (DWOR producers, retailers, etc.)
- Regarding C8/C6-PFC base scenario (Perfluoroalkyl polymer):
  - Telomerisation process from tetrafluoroteylene (TFE) and pentafluoroethyl iodide (C₂F₅I).
  - Produced in Asia and shipped to Europe for DWOR production
  - PFOA/PFOS emissions & waste flows included according to references (*)

(*) Paul et al. (2009), Environmental Science & Technology 43, n.° 2; Lassen et al. (2013), Survey of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl substances The Danish Environmental Protection Agency
Environmental Analysis of the best available finishing products to provide water, oil and dirt repellency in the textile sector.

A Life Cycle Approach

Thanks for your attention...!

Julio Fierro Fernández, PhD
Senior Researcher of Environmental Area
R&D Department
+34 881 105 624 Ext. 2
jfierro@fundacioncetim.com

CAMPUS DE ELVIÑA - EDIFICIO CICA
Rúa As Carballeiras s/n 15071
A Coruña | Galicia | España
www.fundacioncetim.com

MIDWOR-LIFE is a project co-funded by the European Community under the LIFE+ Financial Instrument within the axe Environment Policy and Governance and under the Grant Agreement n. LIFE14 ENV/ES/000670
Based on the results obtained, **fabric production will not be considered** in order to obtain a better **focus on finishing stage** (aim of LIFE-MIDWOR).
Conclusions & Future steps

1. Inclusion of PFC emissions used for DWOR production

Provisional *Characterisation factors* compared with values set for different POPs with similar behaviour (pending of review)