ChemTex

Water and chemical recovery in a textile recycling process

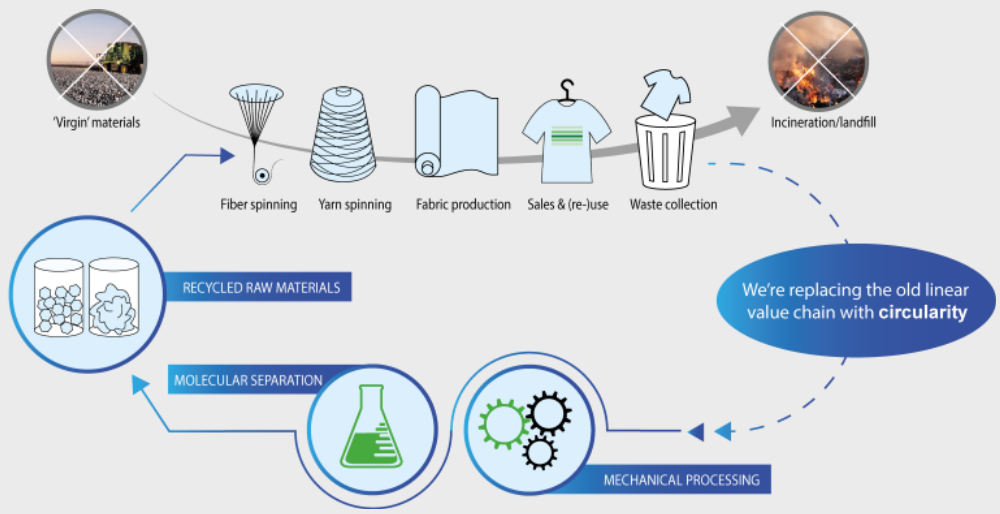
ChemTex aims to optimize resource efficiency in the frame of a Danish, mixed textiles fibre-to-fibre recycling project. ChemTex focuses particularly on water and chemical recovery and re-use.

THE CONTEXT

Textile industry creates about 10% of the green house gas emissions, and is responsible for very high water consumption (~2700 L per cotton shirt). Moreover, a huge amount of textile waste - about 92 million tons - is produced annually. Currently, only 1% of the textile is recycled, and more than 50% is incinerated or ends up in a landfill.

To incentivize a more sustainable textile industry, worldwide different legislative and technological initiatives are taken. In Europe, the EU directive 2018/851 mandates separate collection and recycling by 2025. Furthermore, a multitude of technology development projects are funded, searching for energy and resource efficient recycling processes. One of them is a Danish project partnering Textile Change (https://textilechange.com/) and B4C.

Typically, sustainable textile recycling asks for a complex combination of mechanical and chemical processes, taking into account the circular resource optimization of all auxiliaries required. Efficient recovery of water and chemicals typically used for fibre dissolution is paramount to create a fully circular and sustainable process.



Vision on textile recycling by Textile Change (www.textilechange.com)

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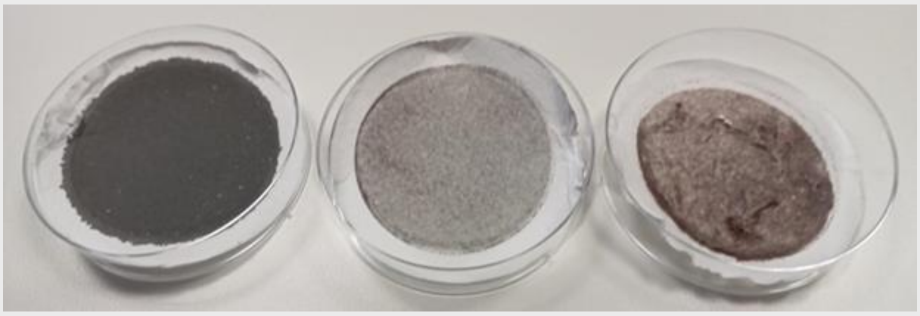
THE CHALLENGE

ChemTex focused on one core component of the textile recycling project: water and chemicals recovery - and more particularly the reuse of strong alkaline solutions or oxidizing alkali solutions, and strong organic acid solutions. Recycling of strong alkaline/acid streams has great commercial potential in the textile recycling project itself, but also in general as these solutions are frequently used in chemical and food industries for synthesis and for cleaning of process equipment. The project partners studied to recycle these solutions with membrane technology, as energy consumption of traditional distillation is not sustainable. The use of ceramic membranes was considered the best option, in view of membrane durability and the high treatment temperature (>50°C). To guarantee good removal of the textile debris and dye components present, a two step ultrafiltration + nanofiltration (UF+NF) process was envisioned. ChemTex aimed to test the feasibility of the two-step membrane process, to identify the optimal membranes and membrane process conditions for 3 different streams, and to perform Proof of Concept at intermediate scale. This will allow to define the next step for future piloting and upscaling of the process.

Ceramic membranes



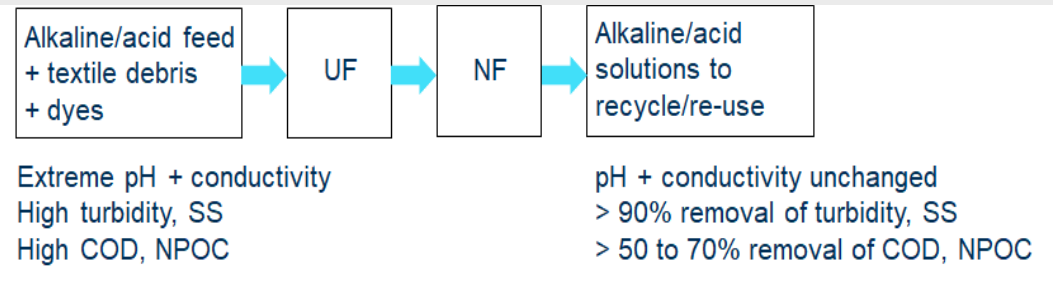
Textile debris in the alkaline/acid solutions of the ChemTex project

THE RESULTS

Three relevant process streams were selected: one alkaline stream, one oxidizing alkali stream, and one organic acid stream. All streams were thoroughly analysed. This showed that all streams have extreme pH and correlated high conductivity, high turbidity and correlated high suspended solids (SS) due to the textile debris, and high organic carbon (COD + NPOC non-purgeable organic carbon) originating from dyes and other impurities.

Subsequently, the 30 nm TiO_2 UF membranes, and the 0,9 nm TiO_2 NF membranes, commercially available from partner Rauschert, were chosen for first screening tests with the 3 solutions. The results showed that turbidity and SS are partly removed by the UF step with further polishing by the NF step. Organic carbon is only partly removed by the NF step. pH and conductivity remain unchanged during the whole process, allowing direct recycling of water and chemicals.

Subsequent Proof of Concept testing with multichannel membranes (0.1 m^2 membrane area) showed the feasibility to recycle at least 80% of the purified alkaline/acid solutions, with relative low flux decline during the concentration process. For the UF process optimal process parameters were defined, and efficient processes to clean the membranes investigated.



Effect of the two-step UF+NF process and pictures of feed, UF and NF permeates

CONCLUSION

The ChemTex project was successful and the following conclusions can be drawn:

- A two-step ultrafiltration + nanofiltration process with ceramic membranes (commercially available from INNOMEM partner RKV) removes the textile debris and dye impurities from the alkaline or acid process streams originating from textile recycling, up to > 90% (KPI2).
- Proof of concept testing at intermediate scale of membranes, proved the feasibility to recover the alkaline and acid solutions up to 80% at least (KPI3).
- The two-step did not change the pH or conductivity of the process solutions (KPI1) allowing to recover and re-use them as such (water and chemicals recovery in one step).

TECHNIQUES USED

In ChemTex the following services and capabilities of the INNOMEM OITB were used:

- Extensive analysis of the process solutions selected, feasible at INNOMEM partner VITO.
- Synthesis of ceramic ultrafiltration and nanofiltration membranes up to commercial scale at INNOMEM partner Rauschert.
- Screening and Proof of Concept testing of ceramic ultrafiltration and nanofiltration membranes with the alkaline and acid streams at high temperature, requiring specialized filtration equipment at lab and intermediate scale (including the possibility to use back-flushing), available at INNOMEM partner VITO.

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