

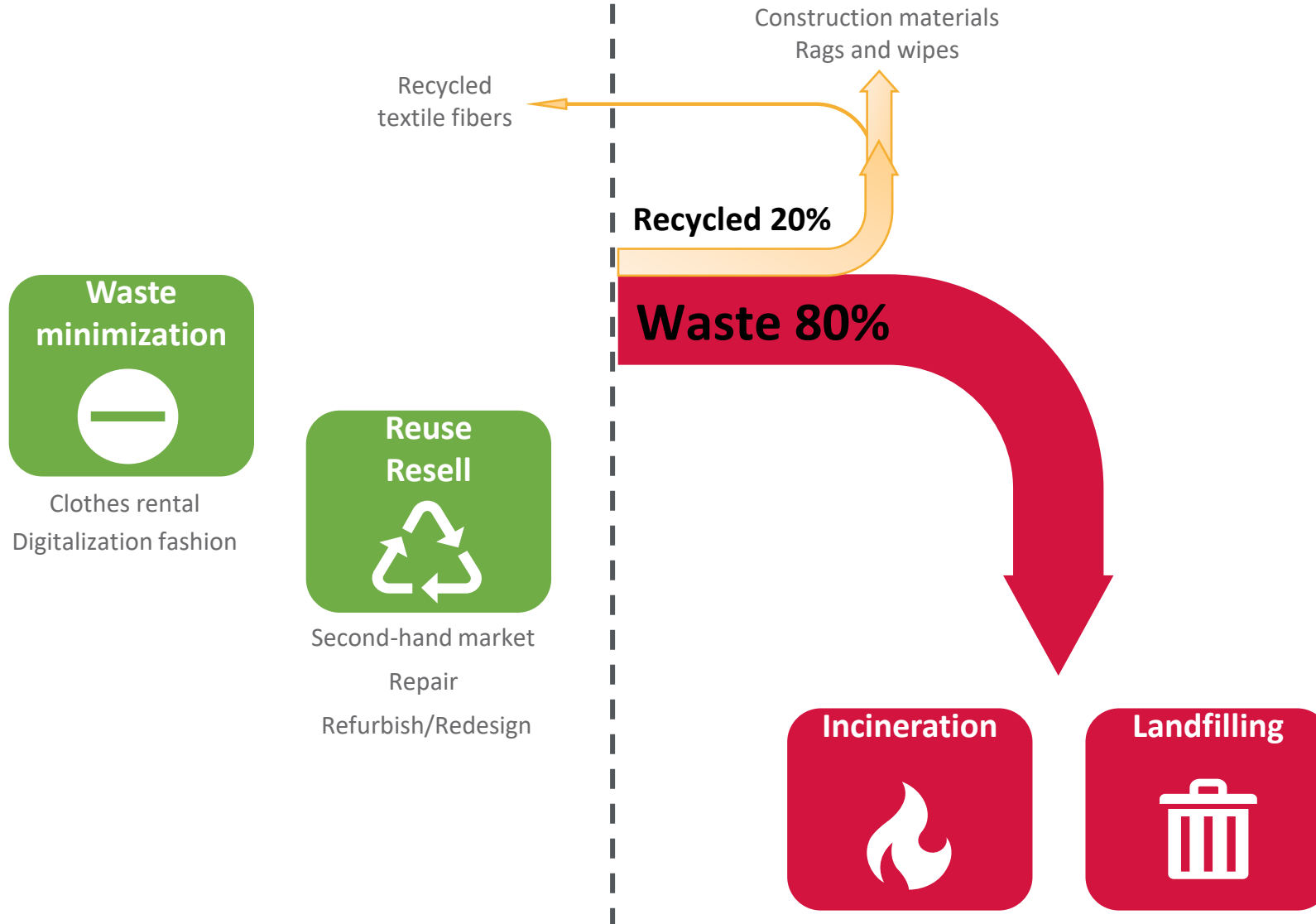


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Open-end recycling man-made cellulose fibers

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Recycling rates in the textile industry

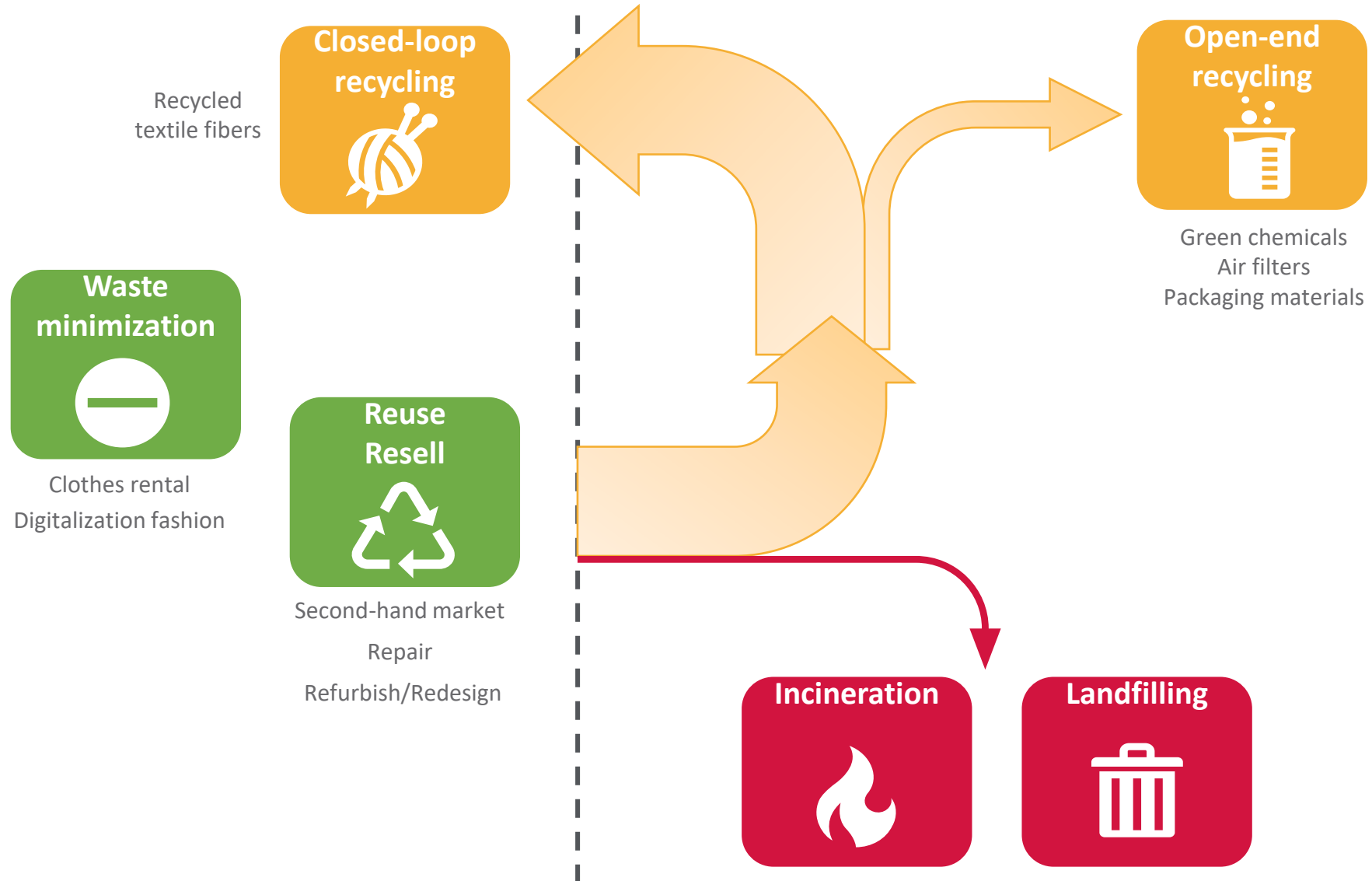


Compare to recycling rates for other materials:

Paper – 84%	
Metal – 83%	
Glass – 76%	
Plastics – 42%	

EUROSTAT, Recycling rate of packaging waste by type, 2020

New technologies to increase circularity



Open-end recycling via depolymerization of fibers



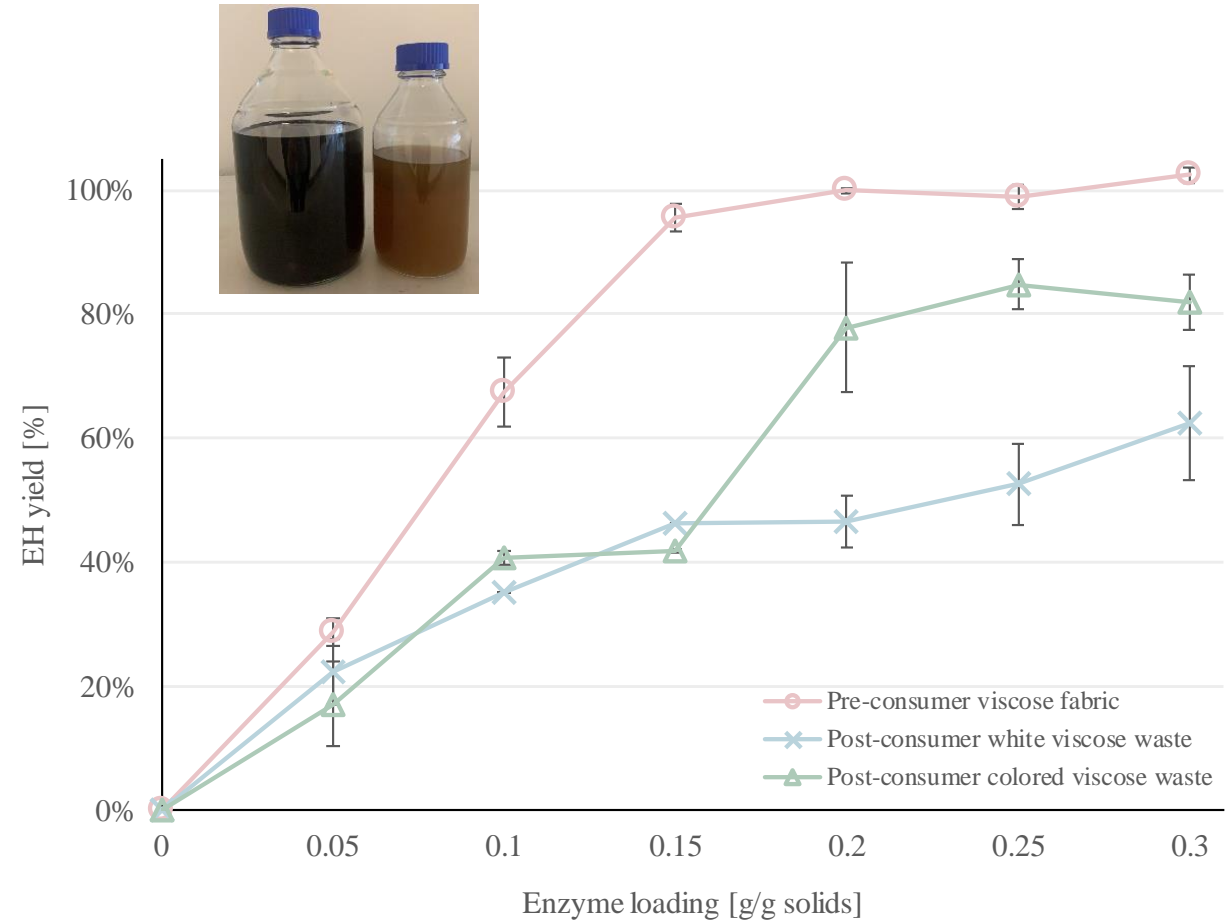
- Hydrolysis technology that breaks down cellulosic fibers into sugar
- Drop-in material for biochemical and chemical processes to produce green chemicals (replaces 1st generation feedstocks)
- Technology tested at pre-pilot scale (TRL 4), verified with potential suppliers/customers and ready to be scaled
- Residual fibers can be used as a source of recycled cellulose in other industrial applications. The proportion between unhydrolyzed fibers and sugar can be easily adjusted
- Feedstock flexibility, but preferred hard-to-recycle materials to avoid competition with closed-loop alternatives (prioritize value recovery)



Open-end recycling via depolymerization of fibers



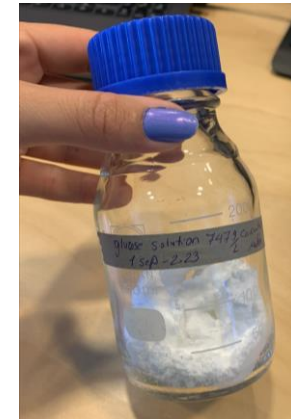
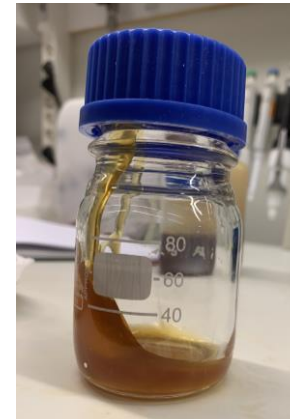
- Laboratory tests to evaluate the behavior of different types of waste, both pre- and post-consumer
- Complete hydrolysis could be achieved for pre-consumer viscose (no additives or finishers)
- Viscose post-consumer waste exhibited an inhibition effect that decreased the sugar yield to 60-80%
- Colored post-consumer waste behaved better than its white counterpart. Dyes do not inhibit more than other types of additives
- The inhibition effect is most likely caused by impurities from use, textile dyes and additives used in the manufacturing



Open-end recycling via depolymerization of fibers



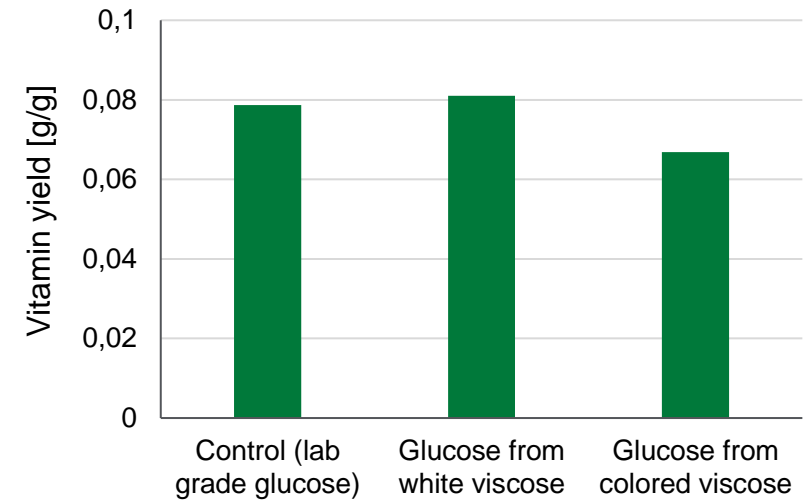
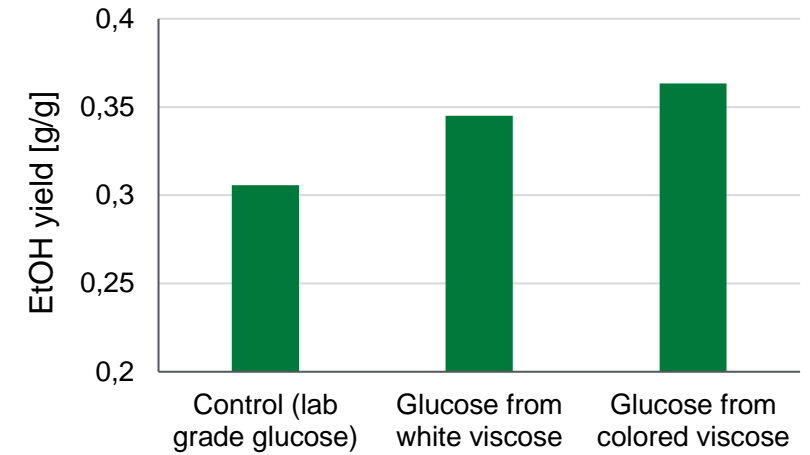
- Concentrate product to increase shelf-life and reduce transport costs. Samples could be concentrated to 700 g/L without any major issue
- The concentrated samples remained at room temperature for 2 months and no bacterial growth was observed
- Samples concentrated at 75 °C did not exhibit any significant sugar degradation, avoiding the generation of any fermentation inhibitors
- Fermentation inhibitors were detected in samples concentrated at 85 °C, as sugar begins to degrade around 80 °C
- Energy costs for evaporation would represent only 10% of the price of the final product. Concentrating after depolymerization seems more promising than increasing concentration in the hydrolysis
- Possible to crystallize the sugar with pre-consumer materials, but difficult with post-consumer materials. Challenging to deliver to customers requiring crystals



Product validation with BASF



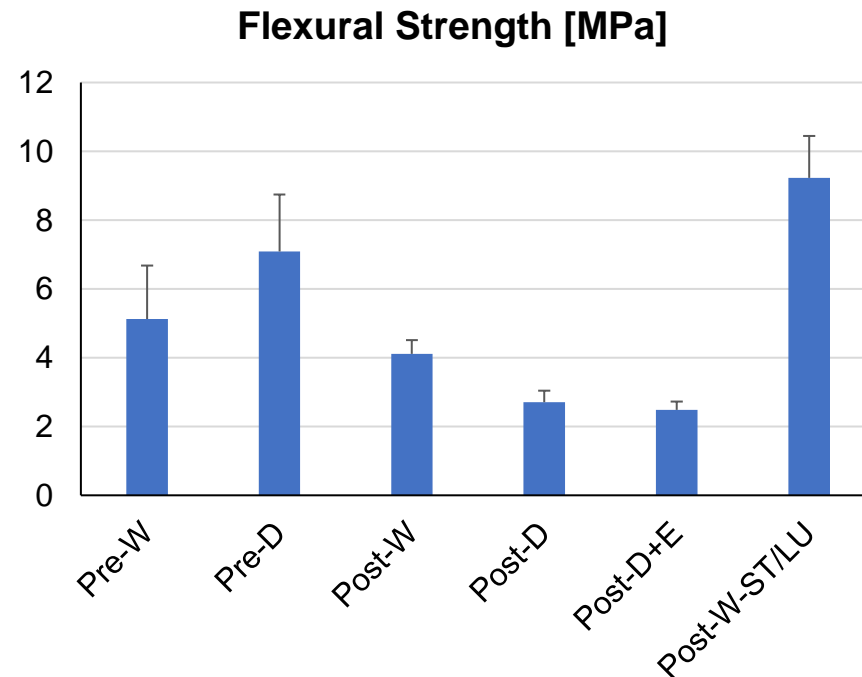
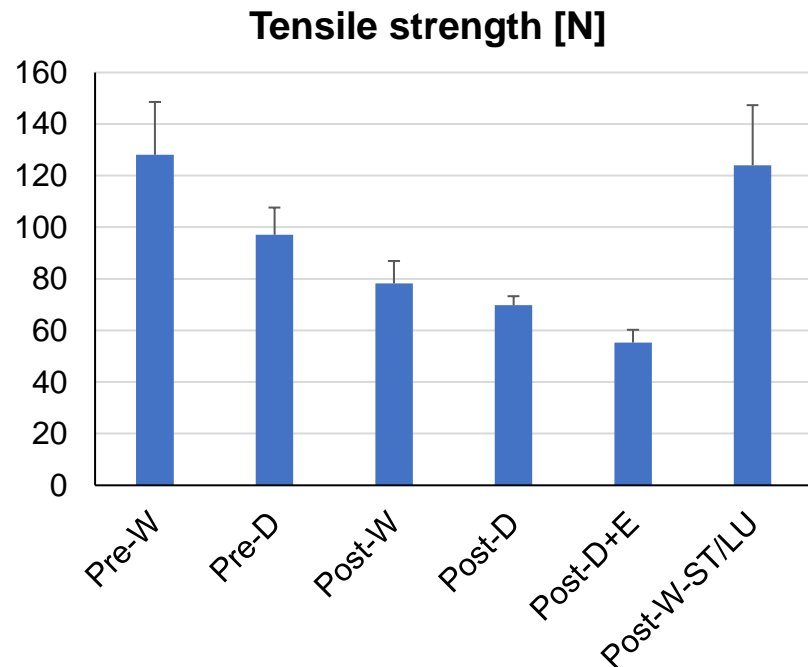
- BASF evaluated biocompatibility of i) concentrated syrup from white post-consumer waste and ii) diluted solution from colored post-consumer waste
- Sugar from waste textiles showed better performance than lab-grade glucose in bioethanol fermentation based on yeast, even in the presence of textile dyes
- Impact of dyes on ethanol purification remains a question, but recycling process could potentially be operated without bleaching
- Textile dyes lowered the performance in vitamin production based on E. Coli, although the “white” sample performed equally well as lab-grade glucose
- Sugar from waste textiles was biocompatible with different microorganisms, although textile dyes seem to inhibit some microorganisms more than others



Valorization residual fibers with The Loop Factory



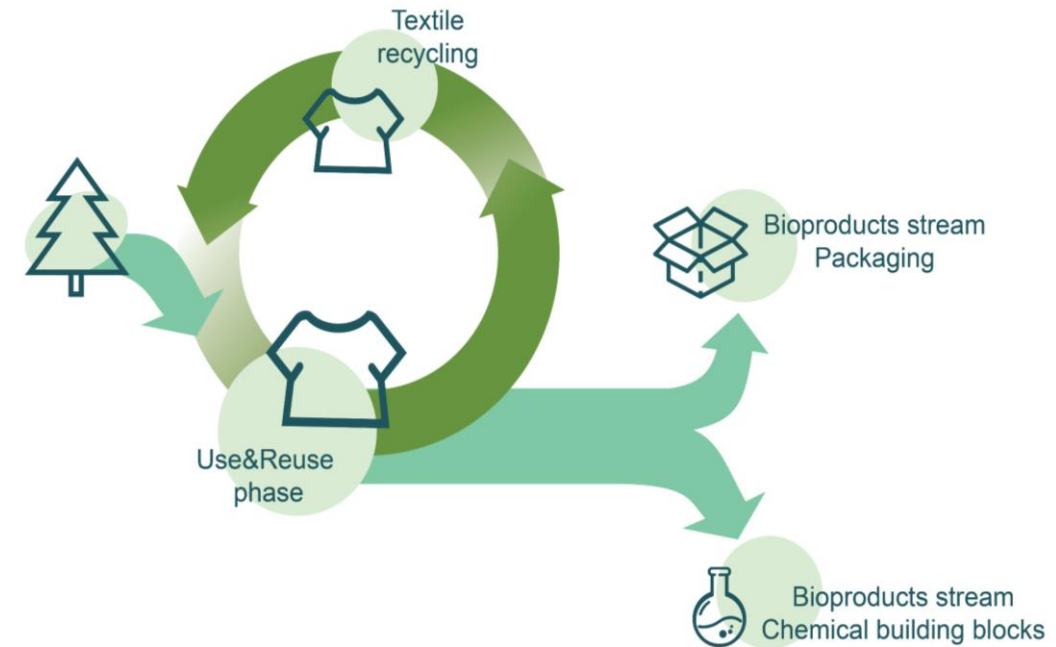
- The Loop Factory mixed textile materials with a polymer to evaluate the possibility of 3D pressing the material to produce packaging for accessories
- Post-consumer viscose exhibited lower strength and stiffness compared to pre-consumer viscose
- Textile dyes and other fibers (elastane) seem to have a negative effect on the properties of the product, so it would be even more challenging to work with colored post-consumer waste or blended fibers
- Residual fibers from ShareTex comparable with pre-consumer viscose. Depolymerization process seems to have a positive effect and helps the polymer to bind better to the fibers



Take-aways from the project



- Textile-to-textile recycling captures the most value, but it has many limitations. Especially for (post-consumer) MMCF
- Textile-to-textile recycling needs to be combined with open-end technologies to offer alternatives for hard-to-recycle materials
- Symbiosis between value chains could replace incinerators or landfills at the end of life. Cellulose could find new “lives” in other industries
- Green chemicals could be produced from waste textiles instead of biomass or edible feedstocks. Chemicals could be used both within and outside the textile industry
- Recyclers need to act as enablers to use the material again, adjusting its properties to different types of requirements, instead of just manufacturing product A from feedstock B





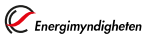
Thank you for listening!

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