PureGluc

Membrane-based downstream separation and purification of glucose-rich stream obtained from tertiary cellulose

PureGluc aims to develop and demonstrate an efficient membrane-based post-treatment process for sugar streams resulting from hydrolysis of tertiary cellulose present in wastewater streams.

THE CONTEXT

The demand for carbon-rich bio-based raw materials is increasing sharply in the chemical sector. Sugars play an important role in this transition because they can serve as a replacement for fossil raw materials for production of chemicals such as acetic acid or (bio)plastics such as PLA and PHA. Recell has developed an innovative technology for recovery of tertiary cellulose from residual waste(water) streams with the aim of processing the cellulose present into high-quality glucose that can be used as a raw material for the chemical industry (so-called third generation glucose).

The distinguishing feature of Recell's unique Chem process is that glucose is made from residual streams and does not compete with food applications. This has a clear impact on the CO_2 footprint of the process and the obtained renewable sugars.

A pilot plant (TRL 7) is currently in operation in Leek, The Netherlands. Recell's ambition is to have a facility to produce 50 kt sugars in 2025. The recovery and purification of the sugar-rich streams from Recell's process, studied in PureGluc, is crucial to reach market demand. Obtaining generic semi-finished glucose products with standardized quality is considered essential for the development of the value chain and application as renewable feedstock for high added value bio-based molecules in tomorrow's chemical industry.

The how and why of tertiary cellulose (www.recell.eu)

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THE CHALLENGE

The PureGluc project aims to develop and demonstrate an efficient membrane-based process for recovery of high-purity glucose from a hydrolysate of a complex residual wastewater stream obtained through Recell's Chem process. In the framework of a previous project (funded by the Dutch government), membrane filtration was shown to provide a promising technology option for downstream purification.

An efficient post-treatment process is envisioned with the aim to purify and concentrate glucose to the highest standards. The experimental results of this project allow to perform a first techno-economic evaluation and estimate glucose recovery costs, while providing robust data for industrial process design or further research.

Renewable third generation cellulose (left) and glucose (middle) obtained from residual streams, hydrolysate before and permeate after membrane filtration (right)

THE RESULTS

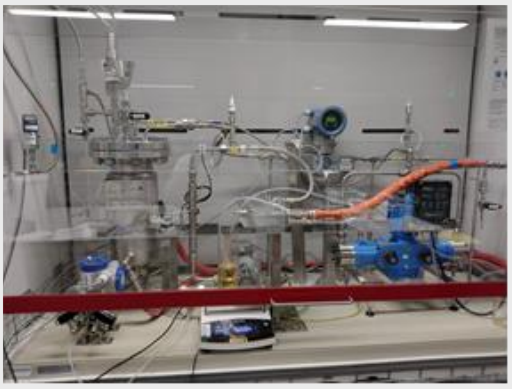
In consultation with Recell and based on previous experience, selected UF and NF/RO membranes from various suppliers were systematically screened on a real-life hydrolysate. The raw hydrolysate was pre-treated by a variety of methods, and various operating conditions were studied (crossflow velocity, feed pressure, temperature).

The tests revealed that for all UF membranes selected, the retention of raw materials is very high, well above 99% (KPI 1), with almost unhindered passage of the glucose. Longer-term experiments with selected UF membrane modules showed constant retentions and decreasing fluxes when stretching to higher permeate recoveries.

NF tests on UF permeate allowed to select two promising membranes combining high glucose retention and rather low salt retentions. In longer-term scale-up tests with small industrial NF module, however, the reachable glucose concentration and recovery levels remained below the targets set in KPI 2 and 3.

Therefore, besides pressure-driven membrane filtration, other technologies were tested as alternative for glucose concentration. Promising results were obtained here, meeting the recovery and concentration targets of KP2 and KP3. The membrane tests also included assessment of fouling propensity and cleaning options.

Demo factory of Recell in Leek



Membrane filtration installation at VITO

CONCLUSION

The following promising conclusions can be drawn from the PureGluc project:

- All selected UF membranes exhibit high raw materials retentions > 99% (KPI 1) in combination with a high recovery of glucose in the permeate.
- Several NF membranes show high glucose retentions > 95%, however maximal glucose concentration and yield in longer-term concentration tests are relatively low.
- However, when applying other techniques on UF permeate, targets on glucose concentration > 200 g/L (KPI 2) and glucose recovery > 85% (KPI 3) are met.
- Alkaline membrane cleaning allows for process flux recovery > 80% in UF (KPI 4).

TECHNIQUES USED

In PureGluc the following services and capabilities of the INNOMEM OITB, all available at INNOMEM partner VITO, were used:

- Options to pre-treat the raw hydrolysate of Recell.
- Lab-scale testing of UF and NF membranes using flexible crossflow filtration units.
- Proof-of-concept testing of UF-NF separation process under realistic conditions using small industrial membrane modules.
- Lab-scale testing of an alternative concentration technology on UF permeate.
- First techno-economic evaluation based on results of proof-of-concept tests.

For more information, you can get in touch with us by sending an email: pieter.vandezande@vito.be and m.godoy@recell.eu