

5-HMF from plant residues – sustainable production of a versatile platform chemical

An innovative process chain enables the continuous production and purification of the versatile platform chemical 5-hydroxymethylfurfural (5-HMF) from plant-based raw materials. This allows agricultural residues and side streams to be utilized for the production of high-value bio-based chemicals.

- Use of cost-effective plant-based raw materials for 5-HMF production
- Aqueous hydrothermal processing
- Technical testing at biorefinery scale
- Modular adaptability to various biomasses and biorefinery concepts

Fields of application

- Production of bio-based platform chemicals
- Material utilization of agricultural residues and side streams
- Decentralized and modular biorefineries
- Processing of lignocellulosic biomass
- Utilization of Miscanthus, chicory, and comparable plant-based raw materials
- Production of 5-HMF and derivatives thereof
- Feedstock for bio-based polymers and plastics
- Production of packaging and polymer materials
- Integration into existing biorefinery and biomass utilization concepts

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Development Status

TRL6 Pilot plant

Patent Situation

EP 4032881 A1 pending

Reference ID

20/011TLB

Service

Technologie-Lizenz-Büro GmbH
has been entrusted with exploiting
this technology and assisting
companies in obtaining licenses.

Background

5-Hydroxymethylfurfural (5-HMF) is an important bio-based platform chemical that can serve as a starting material for a wide range of other chemical products, including polymers and bio-based plastics.

To date, the industrial production of 5-HMF has been limited primarily by the availability and cost of suitable sugar feedstocks. While fructose enables high HMF yields, cost-effective alternative carbon sources are available in the form of plant-based raw materials containing glucose, cellulose, or inulin—such as Miscanthus and chicory roots.

Problem

Producing 5-HMF from plant biomass is technically more challenging than converting pure sugar solutions due to the complex composition of the starting materials. Depending on the biomass, carbohydrates must first be made accessible and converted into suitable sugars.

During the subsequent hydrothermal conversion, unwanted derivatives—such as formic acid and levulinic acid—as well as higher-molecular-weight by-products can form alongside the 5-HMF. Furthermore, following the reaction, the generated 5-HMF exists within an aqueous reaction mixture alongside unreacted sugars and other constituents. Efficient separation of the 5-HMF that preserves product quality is therefore a crucial part of the process chain.

Solution

The technology developed at the University of Hohenheim combines the processing of plant-based raw materials with continuous hydrothermal 5-HMF synthesis and selective product separation.

Lignocellulosic biomass (such as Miscanthus) can first be hydrolyzed and converted into a sugar-containing solution. With suitable raw materials like chicory, the carbohydrates they contain can be extracted directly. The resulting sugar solutions are subsequently converted into 5-HMF continuously under acidic, aqueous conditions. The reaction process allows for the precise control of temperature, pressure, pH value, and residence time.

Another component of the technology is the selective purification of 5-HMF from the aqueous reaction mixture. In this process, the furan derivative is adsorbed onto activated carbon, while a large proportion of the other water-soluble components passes through the adsorption stage. Subsequently, the adsorbed 5-HMF is desorbed using a suitable solvent, and the solvent is separated off to yield purified 5-HMF. The use of multiple adsorption columns also enables continuous operation.

The modular design allows the process chain to be adapted to different types of biomasses and biorefinery concepts. For lignocellulosic raw materials, for

example, modules for biomass breakdown, sugar provision, HMF synthesis, and product separation can be combined.

Various trials have already been conducted in a pilot-scale biorefinery. These achieved an HMF yield of 36.7 weight-% for Miscanthus hydrolysate and 16.2 weight-% for chicory extract. The results demonstrate the fundamental suitability of various plant-based raw materials for the continuous production of HMF.

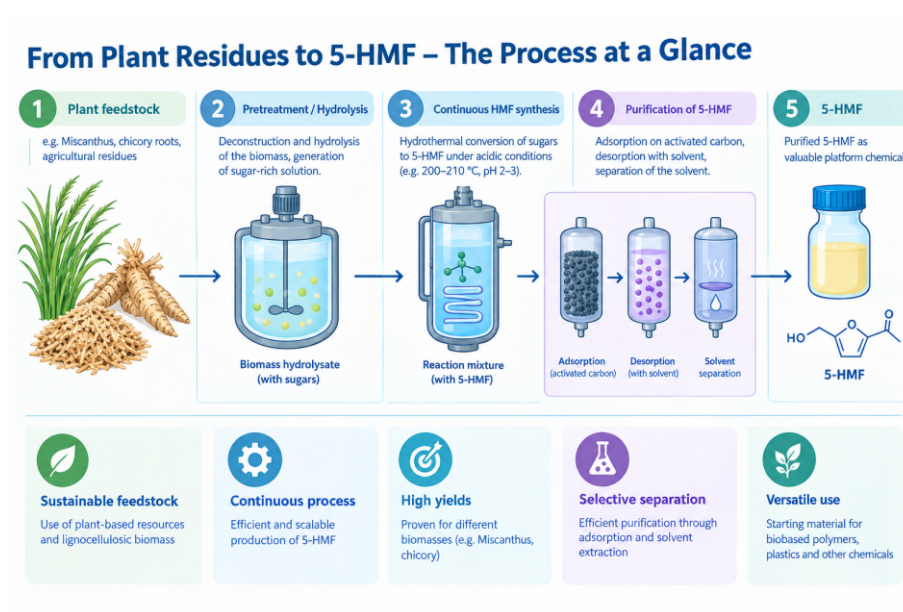


Figure 1: AI generated [TLB GmbH]

Publications and links

K. Swiatek et al., *Continuous synthesis of 5-hydroxymethylfurfural from biomass in on-farm biorefinery*. GCB Bioenergy 2021.