Bioethanol fuel from wastewater and residues from breweries

Dipl.-Ing. Björn Schwarz, Dr. Ralf Wyrwa, Dr. Marcus Weyd

Sustainably produced bioethanol from residues can contribute to decarbonizing the transport sector. In the BMWK-funded "Bieranol" project, Fraunhofer IKTS and its partner BFC Trading GmbH have focused on utilizing bioethanol potential from breweries. Two streams of materials were analyzed and treated. On the one hand, the production of non-alcoholic beers produces wastewater with varying ethanol content, which is often disposed of. Secondly, brewer's spent grains, a residue from the brewing process, contain large amounts of cellulose – a potential source material for ethanol production.

The aim of the wastewater treatment process was to separate and concentrate the ethanol until it can be used as fuel (> 99.5 %). Two membrane stages developed at Fraunhofer IKTS were used for this purpose. The first stage (Fig. 1) consists of specially developed planar hydrophobic mixed-matrix membranes (MMM), which were installed into a plate and frame module (Beroplan GmbH) with a membrane area of 1 m².

The membrane selectivity is significantly higher than that of distillation. Therefore, with this module, ethanol concentrations of more than 50 % can be achieved from low-concentration mixtures at temperatures of only 40 °C – all in just one step and with high energy efficiency.

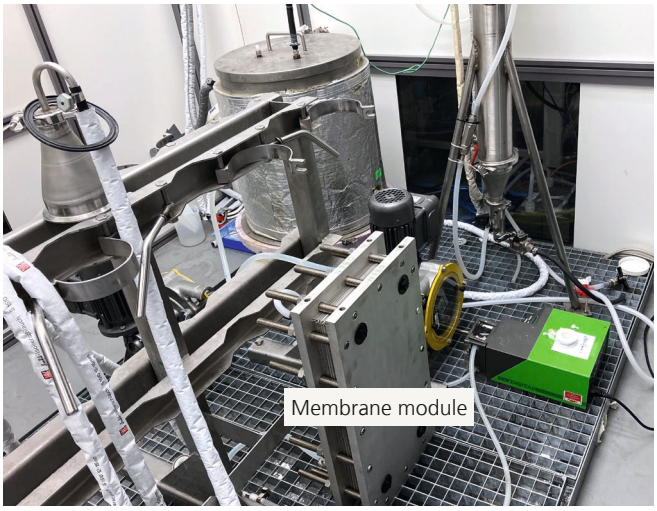

Fig. 1: Pervaporation system with integrated MMM module for hydrophobic EtOH separation (Fraunhofer IKTS).

Pre-concentration in the MMM module is a requirement for further processing in the second membrane stage. Tubular hydrophilic ceramic membranes were used in a vapor permeation process for concentrating to 99.9 % ethanol. For this purpose, a test plant for fuel dehydration was jointly designed and implemented by the industrial partner (Fig. 2).

Fig. 2: Unit for water separation using hydrophilic membranes for ethanol absolutization (Fraunhofer IKTS).

In the project, two different membrane types, hydrophobic MMM and hydrophilic ceramic membranes, were successfully used to concentrate ethanol from wastewater to 99.9 % ethanol in a second step. The membrane technology is efficient and allows energy savings of up to 80 % for the dehydration step.

Brewer's grains consist of about 80 % water and 20 % organic dry matter. The dry matter contains around 20 % cellulose and 35 % hemicellulose. In the project, up to 80 % of the cellulose was converted into bioethanol. For this purpose, the spent grain was subjected to acidic and thermal disintegration in order to make the cellulose available for enzymatic conversion by cellulases into glucose. Ethanol was formed during the final yeast fermentation. It would be possible to increase the ethanol concentration by utilizing the hemicelluloses using special yeasts and by minimizing the amount of water used during digestion. Further research shows that the generated ethanol-containing process waters can be easily processed into fuel grade ethanol using the membrane technology described.

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag
BFC Trading GmbH