SUCCESS STORY

CHASE
Chemical Systems Engineering

Programme: COMET – Competence Centers for Excellent Technologies

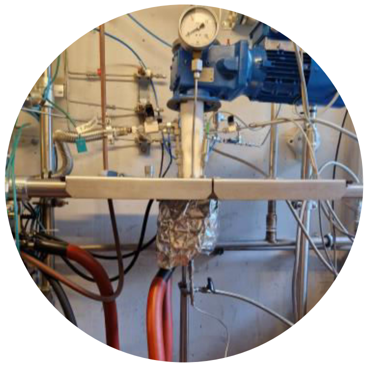
Programme line: COMET-Zentrum (K1)

Type of Project: Circular Process Streams, multi-firm,

MFP3.1, 10/23-12/28

Polymer flakes before the process

Reactor setup



SOLVENT-BASED RECYCLING OF HIGH-DENSITY POLYETHYLENE

EVALUATION OF THE DECONTAMINATION EFFICIENCY USING A DESIGN-OF-EXPERIMENT APPROACH

High-density polyethylene (HDPE) is one of the most widely produced plastics worldwide, with production reaching 52.1 million tons in 2024, based on fossil raw materials. One of the main areas of application for HDPE is packaging, which has a short life cycle. European Union (EU) directives stipulate that 50% of plastic packaging materials must be recycled by the end of 2025. Similarly, new, stricter regulations will apply to the production and marketing of packaging from 2026 onwards, which will also stipulate mandatory recycled content for HDPE food packaging from 2030.

For the successful recycling of packaging types, existing technologies must be improved and alternative, complementary processes researched. Competence Centre CHASE is working with ALPLA to test ways of purifying used HDPE materials.

So-called challenge tests are carried out to demonstrate the cleaning efficiency of the developed recycling process. In these tests, virgin HDPE flakes are deliberately contaminated with model substances of a known concentration. These chemicals represent different classes of contaminants that are intended to simulate the imagined and improper use of the materials. The aim is to minimize the proportion of contaminants in a single treatment step to such an extent that the processed materials can be used to produce new, food-grade packaging.

In the recycling process investigated, the contaminated HDPE flakes were dissolved. After precipitation, the solvent is removed, and the purified polymer is analyzed by gas chromatography.

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The test plan was created as a Design of Experiments (DoE) based on statistical methods in order to examine and evaluate three selected parameters: temperature, time and solvent quantity. Temperatures below and above the melting point were selected. The quantity of solvent used was varied from easily soluble to a significant excess.

The results of the DoE showed that the removal of contaminants was mainly dependent on the amount of solvent, as the cleaning efficiency increased with a larger excess. Time had no significant influence. Temperature had a minor influence on decontamination, with moderate to high temperatures having a positive effect.

Analysis of the treated materials showed that toluene, chlorobenzene and butyl salicylate could be completely removed with high amounts of solvent. For other model contaminants, a reduction depending on the respective substance class was observed. A reduction of 65–81 % was achieved compared to the reference measurements before treatment. The individual values for the individual experiments and contaminants are shown in Figure 1.

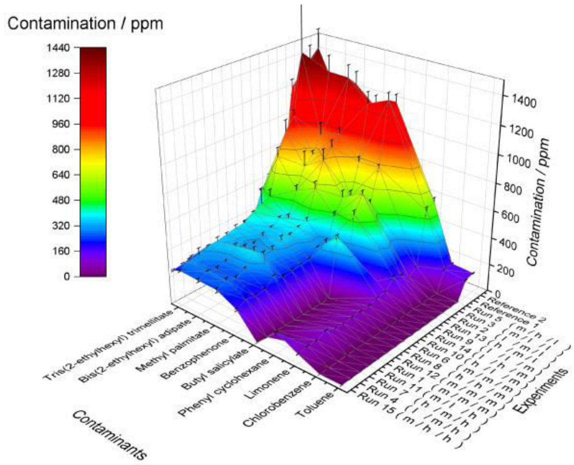

Figure 1: Measured contamination concentration (in ppm) for the experiments performed, including the untreated reference.

The process was optimized within the parameters considered. Subsequent validation experiments confirmed the results obtained. Parallel to the evaluation of the cleaning efficiency, work is being carried out on scaling up the process.

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This success story was provided by the centre management and by the mentioned project partners for the purpose of being published. CHASE is a COMET Centre within the COMET – Competence Centers for Excellent Technologies Programme and funded by BMIMI, BMWET and the provinces Upper Austria and Vienna. The COMET Programme is managed by FFG. Further information on COMET: www.ffg.at/comet