



CIRCULAR FOAM

Chemical recycling technologies: – results, upscaling and demonstration of the technology of choice

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How is a polyurethane (PU) rigid foam produced and what needs to happen at end-of-life (EoL)?



- PU rigid foams have good insulation properties and are used in construction and refrigerated appliances.
- Two main components for production required: **polyol** and **isocyanate** (plus blowing agent and additives).
- In the case of rigid foams, the isocyanate is a material known as „pMDI“.

- At EoL the PU foam cannot readily be recycled mechanically (re-bonding of powder possible).
- Ideally recycling would lead back to the original main components: **polyol** and **isocyanate**.
- In practice, the isocyanate will not be generated directly so that an intermediate will be obtained, that can be converted to the isocyanate.



Chemical recycling via chemolysis or catalytic pyrolysis



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Chemolysis (also known as solvolysis)



- Breaking plastics into individual components via chemical reactions.
- Using solvents, catalysts, heat and sometimes pressure.

Target molecules with CIRCULAR FOAM approach:
- polyol and „pMDA“

“pMDA” can be converted in 1 step in the existing production train to the isocyanate “pMDI”.

Catalytic pyrolysis



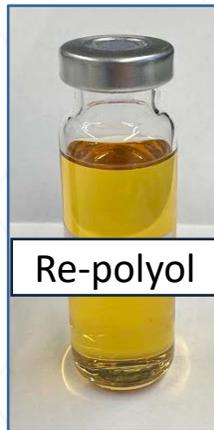
- Breaking plastics into individual components without solvents via heat.
- Catalyst to steer reaction and to enable use of relatively low temperatures

Target molecule with CIRCULAR FOAM approach :
- aniline

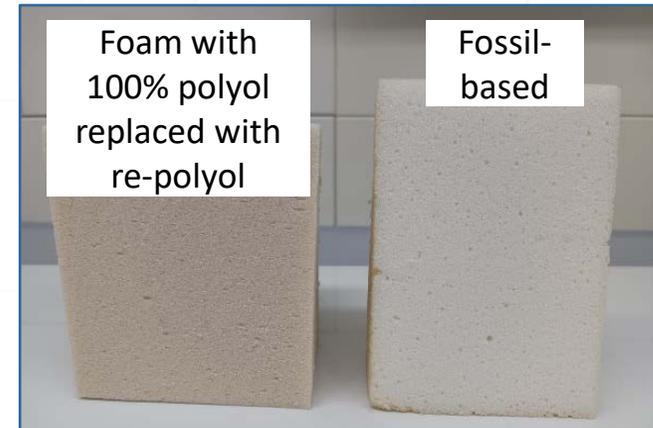
Aniline can be converted in 2 steps in the existing production train to the isocyanate “pMDI”.



Summary of results chemolysis including application testing



Re-pMDA



- Successful conversion of EoL foam to re-polyol and „re-pMDA“.
- The re-polyol was of very high quality.
- The re-pMDA was of high purity but the purity did not meet the very high purity requirements.

- Re-polyol from EoL foam could be used to replace the polyol completely for the preparation of a new foam (**recycled content of ca. 36 %**).
- The new foam showed comparable properties to a foam based on fossil-based materials.

The Life Cycle Assessment (with focus on global warming potential, GWP) and economic assessments for chemolysis were not as good as with catalytic pyrolysis.



Summary of results catalytic pyrolysis including application testing



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- Successful development of catalytic pyrolysis process to a pyrolysis oil (high aniline yield).
- Successful development of separation process to obtain re-aniline from pyrolysis oil.
- Re-aniline with a purity of ca. 99% could be made from EoL foam.
- High quality appliance foam was produced with re-isocyanate made from re-aniline.
- Life Cycle Assessment (LCA) shows a CO₂ emission reduction of up to 80% compared to fossil-based aniline.





Demonstration of catalytic pyrolysis at scale

- Successful transfer of pyrolysis process to mini-plant scale at Fraunhofer Umsicht.
- 300 L of pyrolysis oil produced without any clogging/problems.
- Separation of aniline at required purity at mini-plant scale was carried out at Sulzer.



CIRCULAR FOAM demonstrated that

- EoL rigid PUR foam can be recycled chemically at scale to aniline of suitable quality for conversion to isocyanate and for making new PU rigid foams
- this circular process is economically viable and environmentally of benefit





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Thank you!