

FRAUNHOFER INSTITUTE FOR ENVIRONMENTAL, SAFETY, AND ENERGY TECHNOLOGY UMSICHT, INSTITUTE BRANCH SULZBACH-ROSENBERG

# CHEMICAL RECYCLING



1 Closed loop recycling: mouth-nose-protection  
 2 Continuous pyrolysis plant (iCycle®70)  
 3 Electronic scrap (feedstock), pyrolysis oil (intermediate), and phenol (product)

## Goal: Plastics in virgin material quality

At Fraunhofer UMSICHT in Sulzbach-Rosenberg, we primarily develop thermo-chemical conversion processes as well as preparation and purification processes for pyrolysis products.

The goal of thermo-chemical conversion is the generation of monomers and chemical intermediates. The resulting compounds, which can be found in the pyrolysis oil or gas, can be re-polymerized. They form basic chemicals suitable for the production of virgin-quality plastics.

## Keywords

- Chemical recycling
- Thermo-chemical conversion of plastics
- Dehalogenation of pyrolysis oils
- Monomer recovery
- Petrochemical intermediates

## Chemical industry

- Plastics manufacturers
- Recycling companies/waste management
- Petrochemical industry
- Consumer goods industry
- Construction and energy

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1 Pyrolysis pilot plant

## Thermo-chemical conversion and research services

### Technical features

#### Pyrolysis plant laboratory

- Batch operation
- Sample mass 1-100 g
- Temperature up to 1100°C
- Atmosphere: any
- Quarz glass reactors or steel reactors
- Configuration flexibly modifiable (additivation, catalysis)
- Coupling with (catalytic) oil and gas treatment

#### Pyrolysis plant Technikum

- Semi-continuous operation
- Batch mass 50 - 350 g
- Temperature up to 750°C
- Atmosphere: N<sub>2</sub>
- Configuration flexibly modifiable (additivation, catalysis)

#### Pyrolysis plant pilot scale (iCycle @70)

- Continuous operation
- Capacity 10 - 70 kg/h
- Temperature up to 650°C
- Screw reactor
- Patented heat input system
- Atmosphere: N<sub>2</sub>

### Our service

From consulting to conception and application:

- **Development of processes** for the chemical recycling of plastics and waste containing plastics
- **Preparation and purification processes** (dehalogenation, extraction, distillation)
- **Generation** of chemical feedstocks
- **Provision of pyrolysis products** for the plastics or chemical industry
- **Technical, economic and ecological analysis** of waste streams and recycling processes
- **Recycling** of problem plastics and composite materials
- **Provision** of a test environment for feedstocks, additives, catalysts

### Your benefit

- **Technology-neutral consulting**
- **Technology development and transfer**
- **Specific know-how**
- **Support for technology implementation** and research and development
- **Platform for cooperation partners** to form networks Synergies through effective technology bundling
- **Synergies** through effective technology bundling





# Analytics and oil treatment

## Analytics

We offer a wide range of feedstock, oil, gas and solid analysis:

### Pyrolysis plant laboratory

- GCxGC-MS
- GC-FID/WLD
- CHNS elemental analysis
- XRF
- Calorimeter
- Water content KF titration
- Acid number TAN titration
- FT-IR
- XRD
- SEM-EDX
- Further analysis methods can be carried out by our external partners

## Distillation

### Laboratory distillation

- Reflux distillations
- Rectification (also fractionating)
- Flask volume: 0.1 - 6 l

### Distillation unit

- Batch rectification
- Flask volume: up to 20 l
- Nitrogen inerting during and before distillation
- Vacuum distillations up to 10 mbar abs.
- Distillation under reflux with automated reflux splitting
- Adjustment of different reflux ratios
- Column height: 1 m
- 25 theoretical trays, expandable up to 50 theoretical trays

## Hydrogenation

### Laboratory hydrogenation unit

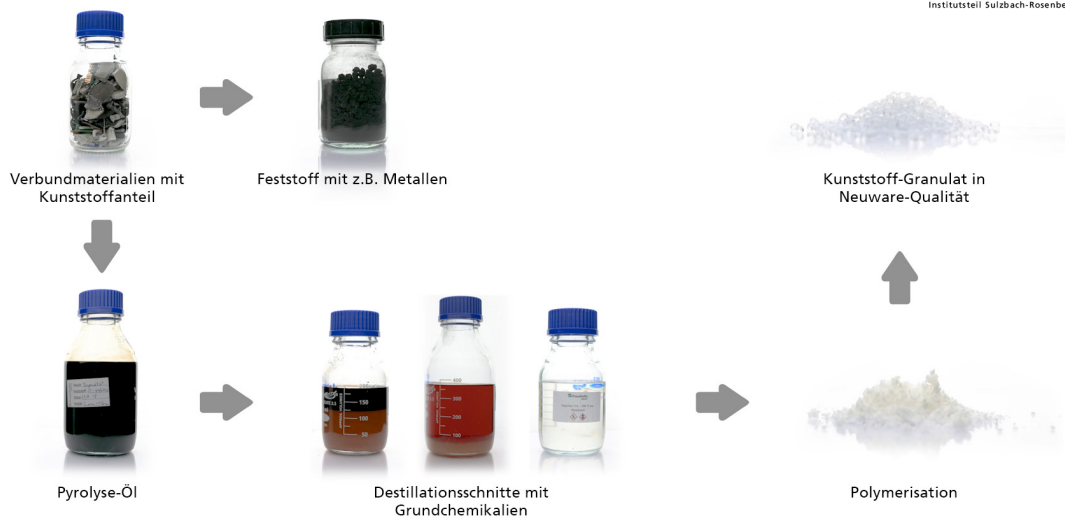
- Sample volume up to 30 ml
- Pressure up to 100 bar
- Temperature up to 400 °C
- Gases H<sub>2</sub>, N<sub>2</sub>

### Continuous hydrogenation/ catalytic reaction

- Heterogeneous catalysis between gas/liquids and solids
- Flow rate up to 4 l/min
- Catalyst mass up to 3 g
- Pressure up to 100 bar
- Temperature up to 330 °C
- Gases H<sub>2</sub>, CO, CO<sub>2</sub>, He, N<sub>2</sub>, Py gas, etc.
- Test environment for catalysts

### Continuous pilot hydrogenation reactor

- Hydrogenation of gases and liquids
- Sample volume 3 kg/h
- Catalyst up to 7.5 l
- Pressure up to 200 bar
- Temperature up to 400 °C
- Gases H<sub>2</sub>, CO, CO<sub>2</sub>, He, N<sub>2</sub>, py gas, etc.
- Online analytics: GC-FID/WLD



*Chemical recycling from composite material to virgin-quality plastic pellets*

## Selected project references

### Industrial projects

- **Recovery of metals and energy** from residues of electronic scrap processing
- **Development of a pyrolysis plant** for thermo-chemical recycling of electronic waste (recovery of metals and chemical recycling of the polymer fraction)
- **Chemical recycling of wind turbine rotor blades** for the recovery of aromatic hydrocarbons and phenols as well as glass and carbon fibers
- **Chemical recycling of mixed plastics** (various post-consumer and post-industrial wastes) and oil processing for the production of steam crackerfeed
- **Chemical recycling of condensation polymers** to produce chemical intermediates for plastics production
- **Chemical recycling of plastics** from medical devices (closed-loop recycling)
- **Chemical recycling of plastics** from hygiene products
- **Pyrolysis of construction site waste** for material recycling
- **Chemical recycling of personal protective equipment (PPE)** (closed loop)

### Public projects

- **Improved recycling** of plastics by froth flotation
- Chemical recycling of plastics, market analysis, legal framework conditions
- **Phenol recycling** by integrated extraction from pyrolysis oil
- **Utilization of glass fiber reinforced plastics** as a raw material source for foam glass production
- **Platform technologies** for the recycling of chlorinated waste and recovery of critical metals
- **Coupling** of pyrolysis and other chemical and mechanical recycling processes
- **Combined plastics recycling** to produce high-quality new materials
- **Modular process chain** for decentralized recovery of selected technology metals



For more information,  
 please visit:  
[www.umsicht-suro.fraunhofer.de/en/Our\\_Solution/chemical-recycling](http://www.umsicht-suro.fraunhofer.de/en/Our_Solution/chemical-recycling)