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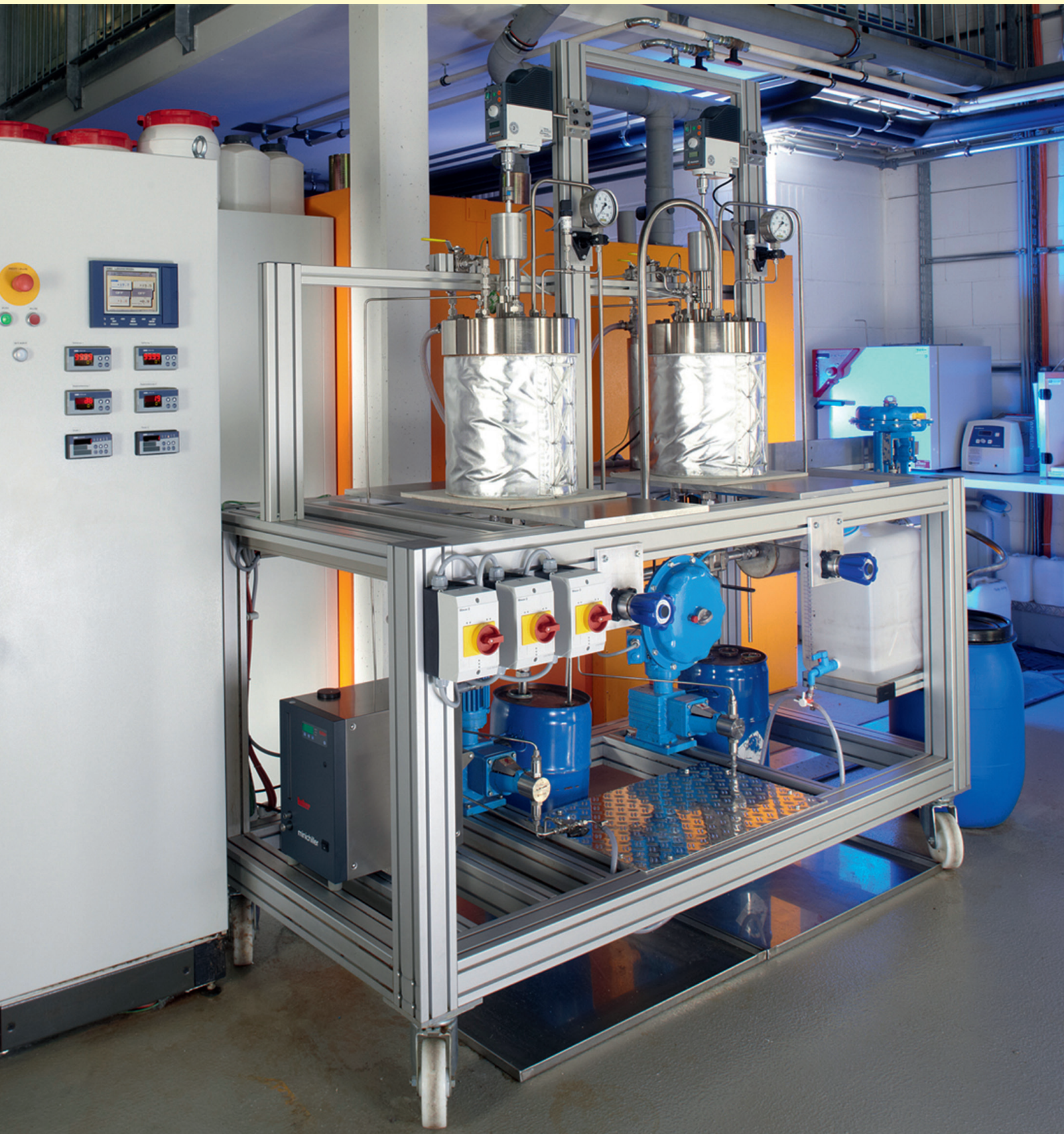
FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT

ENVIRONMENTAL ENGINEERING – REACTION AND SEPARATION TECHNIQUES



ENVIRONMENTAL ENGINEERING
REACTION AND SEPARATION TECHNIQUES

The research group for reaction and separation techniques works on chemical, thermal and mechanical processing techniques. Emphasis is placed on both the manufacture of new products, for example using chemical reactions, and the separation of individual components.

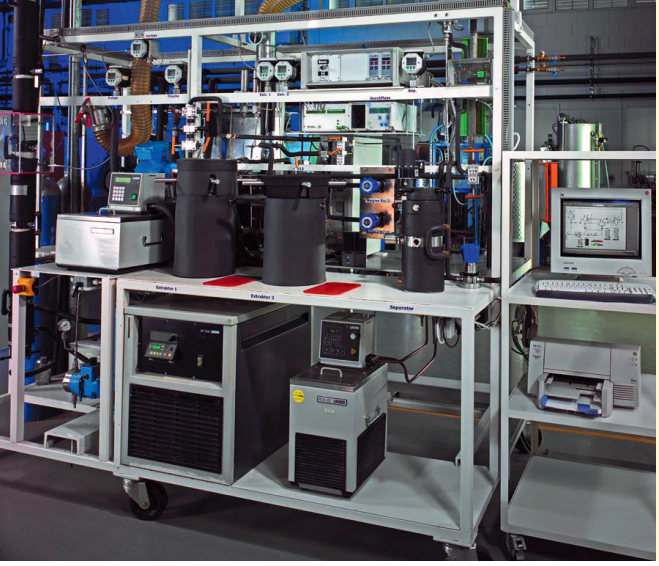
CHEMICAL REACTION TECHNOLOGY

Our work focuses on the development and optimization of environmentally-friendly, sustainable production processes for batch and continuous chemical engineering approaches. In a variety of high-pressure processing units the influence of process parameters on various reactions is investigated. These include pressure, temperature and residence time, as well as the use of catalysts, other fluids and oxidation or reduction agents.

SEPARATION TECHNIQUES

Another focal point of our work is the investigation and optimization of processes for the separation and/or concentration of individual components from different product mixtures.

A range of equipment is available for
- Distillation and rectification
- Extraction
- Crystallization
- Supercritical fluid extraction
- Membrane processes



PROJECT EXAMPLES

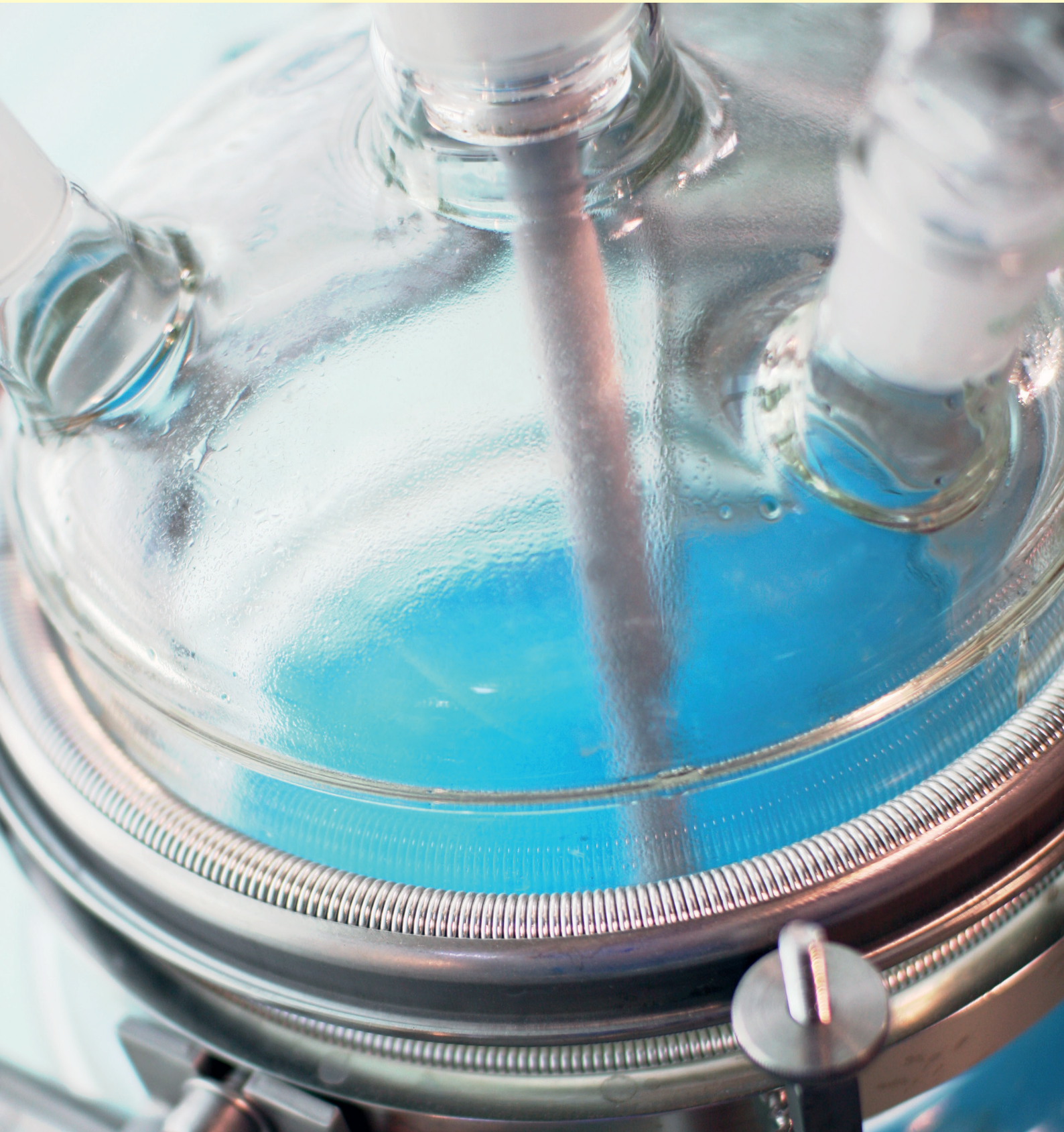
Increasing raw material prices and the depletion of fossil resources have led to an increased trend towards sustainable production processes and the use of renewable raw materials. Our research into reaction and separation techniques is therefore based on the recovery and purification of components from sustainable raw materials and on the recovery of high-value materials or the removal of hazardous substances from waste streams.

Our activities include:

- Separation of fats and oils
- Hydrogenation of sugars to generate sugar polyols
- Fractionation of biomass and the recovery of lignin, cellulose and hemicellulose
- Synthesis of sugar-derived products such as HMF or furfural
- Synthesis of bioethylene, biopropylene and other bioolefins under supercritical conditions
- Breakdown of lignin into phenolic building blocks
- Removal of hazardous substances using supercritical water oxidation
- Purification of tarry synthesis gases
- Fractionation of tall oil
- Purification of bio-based monomers for polymerization
- Purification of product mixtures and waste water streams using membrane processes
- Recovery of phosphates from sewage sludge ashes
- CO_2 extraction of hazardous substances and production residues, and of active ingredients and flavors
- Development of processing concepts for biotechnology
- Production of high-value fatty acids from refining residues

FACILITIES AND EQUIPMENT

Reactors	Batch reactors	Volumes: 0.1 l; 0.25 l; 0.5 l; 2 l; 13 l and 2 x 15 l stirred tanks cascade
		Temperatures up to 600 °C
		Pressures up to 1000 bar
		Turbine, anchor and gas-inducing agitator
		Also available as CSTRs
	Continuously-operated fixed-bed reactors	Temperature up to 650 °C
		Pressures up to 350 bar
		Flow rate up to 12 l/h
		Reactor length 0,1–12 m
Distillation and rectification	Laboratory-scale distillation equipment	
	Batch-rectification	10 l distilling flask or circulation evaporator
		DN30 column, 20 theoretical steps
		Bubble-tray tower (with 6 trays)
	High-temperature rectification (HTR)	Max. temperature of evaporator 350 °C
		Min. operating pressure ~1 mbar
		Throughput: 0.1 to 1 kg/h
		DN50 column, 40 theoretical steps
		Batch or continuous operation
	Thin-film / short-path evaporator	Max. temperature of evaporator 350 °C
		Min. operating pressure 0.001 mbar
		Throughput: approx. 0.3 to 1.5 kg/h
Extraction	Stirred extraction column DN30	1200 mm DN30 column with 34 cells
		Throughput: 0.1 – 9 l/h
	Mixer-settler (3-stage)	each 250 ml volume
		entirely temperature-controlled (0 up to +150 °C)
		Throughput 0.1 – 9 l/h
	CO_2 extraction	Phase equilibrium cell
		Modular testing unit with co-current or counter-current and co-solvent
		Extractors 50 ml to 250 ml
		Max. CO_2 flow-through: 1 kg/h
	CO_2 mini-plant with co-current or counter-current and co-solvent	Extractors: 2 x 5 l
		2 l extraction column
		Max. CO_2 flow-through: 10 kg/h
Membrane technology	From reverse osmosis and nano-/ ultrafiltration up to micro-filtration	
	Dead-end filtration with flat membranes	
	Cross-flow method with flat membranes, tube- and spiral-wound modules	
	Liquid volumes from 0.5 to 300 l	
	Solvent-resistant plants	
	Ceramic plant with two membrane units	
Crystallization	2-liter-crystallizer	Temperature range – 90 to +200 ° C
		Test facilities from 0.5 to 10 l
		Crystallization: from the melt
		Crystallization: from solution
		Crystallization: by removal of the solvent
		Modular design of the system allows an extension or integration with other installations
		Crytal nucleus can be induced to influence the crystal growth
		Possibility of a rapid switch between sweating and freezing



ENVIRONMENTAL ENGINEERING –
REACTIONS AND SEPARATION TECHNIQUE

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