

efficient processing

Manufacturing Concepts for Microreactors and Continuous Flow Chemistry

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content


- **microinnova** overview
- **efficient** flow processing
- **flow** miniplant systems
- **manufacturing** systems



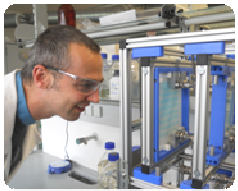
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microinnova overview



aim of microinnova




make chemical processing more efficient

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specialists in process intensification

process development



engineering & plant





Microinnova combines process knowledge with plant competence

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process intensification step by step

evaluation		verification		development		realization	
step 1	milestone	step 2	milestone	step 3	milestone	step 4	milestone
plant check	potential proof	basic feasibility	basic proof	technical feasibility	parameter optimization	engineering & plants	industrial plant
↓		↓		↓		↓	
plant check report		preliminary study lab-scale plant test matrix		device screening critical parameters parameter optimization data for engineering		scale up plant design engineering construction	

turn-key-plant
product

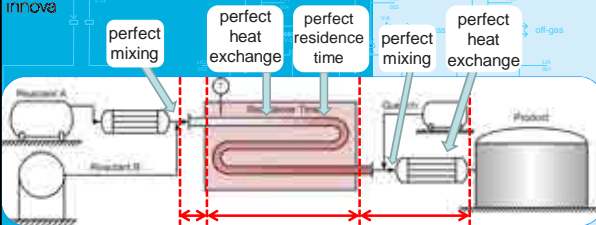
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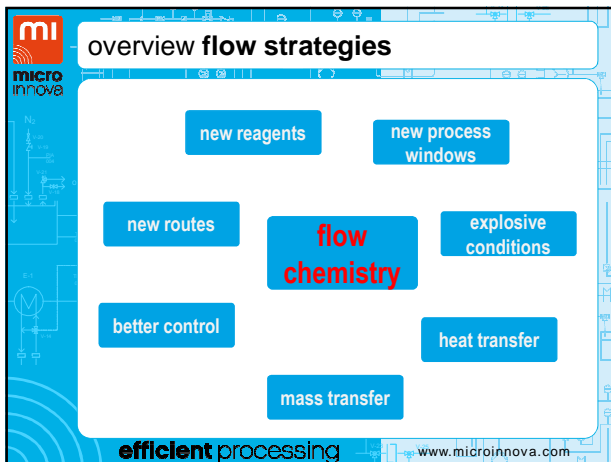
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towards perfect processing



- narrow residence time distribution
- ideal stoichiometry
- no backmixing
- no high concentration spots
- no hot spots
- no dead zones

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drivers for microreactors & flow

drivers	target
development speed	development costs
reduction of process spread	product quality/quality costs
better mixing	mixing sensitive reactions
better heatexchange	exothermic reactions
high pressure, high temperature	new operation windows
complex reactions	yield optimization
small reaction volumes	safety
reduction of reaction steps	new synthesis routes

Only for a group of processes significant benefits !

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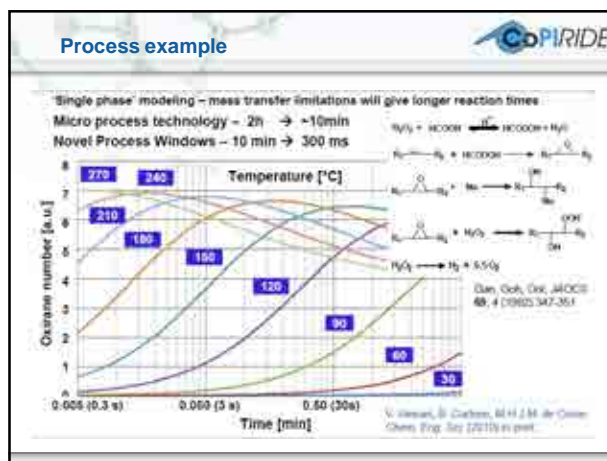
strategy example: avoiding by-products

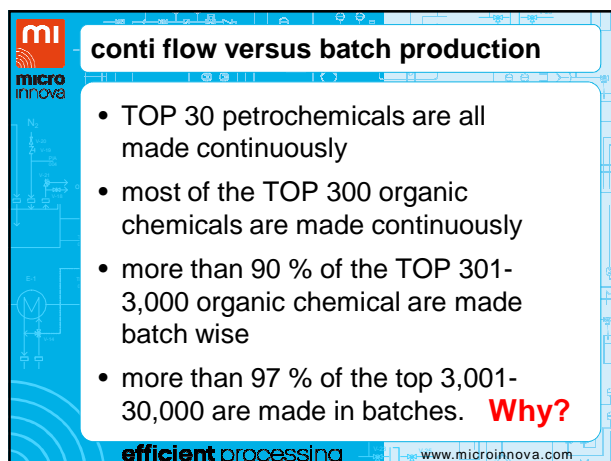
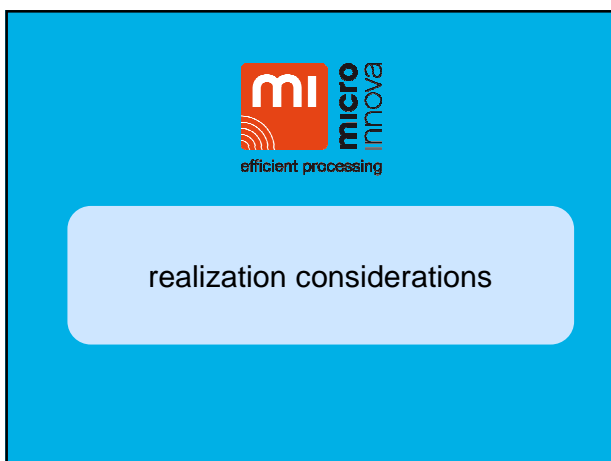
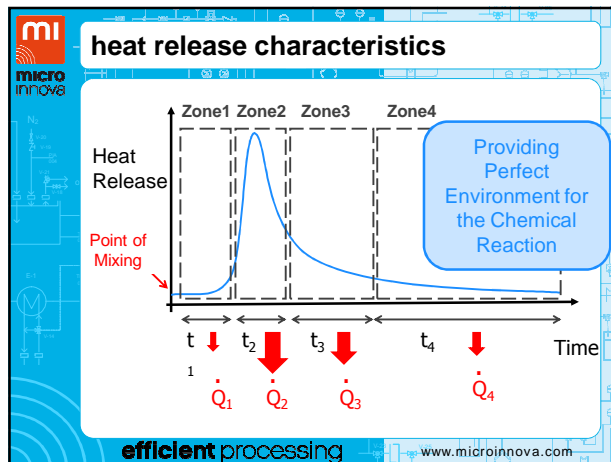
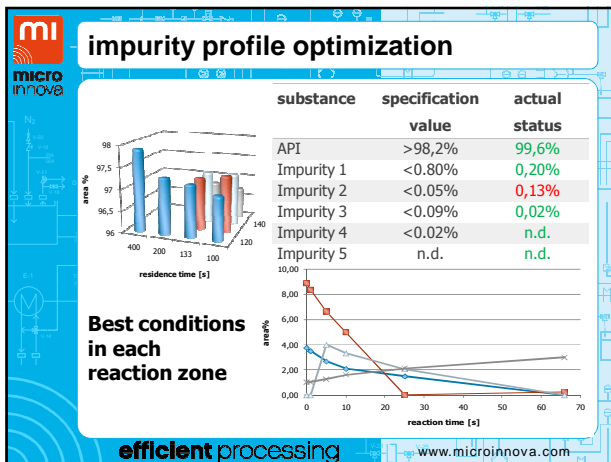
Friedl-Crafts-Alkylation

Yoshida, "Flash Chemistry", Wiley, 2008

tool: plug flow & quench

Gerhard Emig, Elias Klemm, "Technische Chemie", Springer, 2005





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comparison batch versus conti / flow

<p>advantage batch</p> <ul style="list-style-type: none"> • flexibility • multipurpose <p>process is adjusted to the plant</p>	<p>advantage conti/flow</p> <ul style="list-style-type: none"> • process performance • safety <p>plant is adjusted to the process</p>
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↓ ↓

concept necessary, which combines batch flexibility with continuous performance

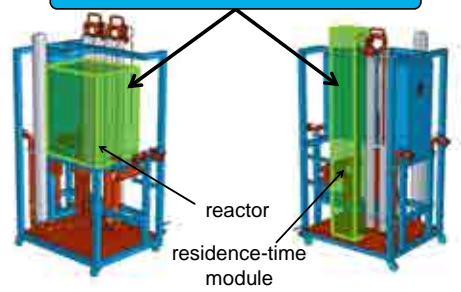
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on-module flexibility

on-module adaption by exchanging specific parts

engineered spaces for adaption



reactor
residence-time module

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inter-module flexibility

module storage

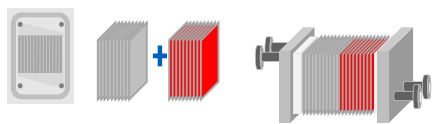
feed 1	feed 2	feed 3	reactor 1	reactor 2	product

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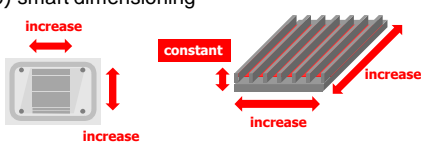
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scale out concept

a) internal numbering up



b) smart dimensioning

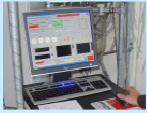



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plant automation solutions



Quick & Easy

High End Development

Manufacturing Professional


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flow mini-plant technology

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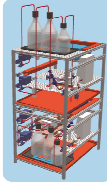
flow mini-plant



Development orientated:
S-Class 1-10 l/h

Manufacturing orientated:
M-Class 10-100 l/h

- link between development and manufacturing
- maximum flexibility by ready modular units
- simple adjustment to new processes
- easy operation
- freely selectable level of automation
- GMP or non-GMP kilo laboratory use
- applicable for small scale manufacturing



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target area


area of application

total flow rate [l/hour]

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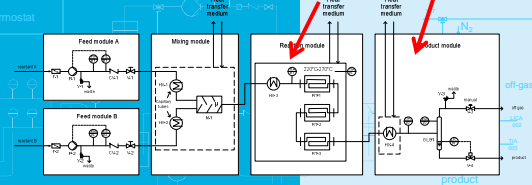
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flow mini-plant example



product module with gas release

endothermic reactions 200 -270°C



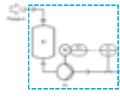
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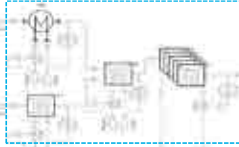
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flow mini-plant module examples


module examples:



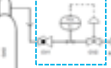
liquid feed module with buffer tank




reaction module with plate-reactor



reaction module for 2 step reaction and multi injection



gas feed module



heating/cooling module

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development process

traditional batch-process development



laboratory-phase



pilot-phase

time & cost savings due to shortening the pilot phase and cancellation of the pilot plant



benchtop-system



flow mini-plant

flow chemistry-development

savings

flow chemistry-manufacturing

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manufacturing solution
plant redesign

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plant redesign-concept



- starting point: one single process step
- integration of microreactors or micro-structured components
- interventions as small as possible

case study example:

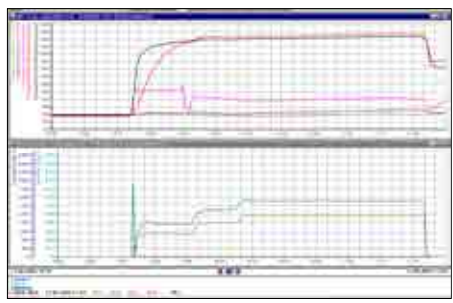
- capacity: 3 tons/hour
- effect
 - double plant capacity
 - energy savings
- investment costs: 1/10 compared to conventional

Kirschneck et al., Chem. Eng. Technol. 2007, 30(3), 305-308

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first test run



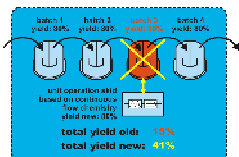
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manufacturing solution
unit operation

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unit operation - solution



- typical for one process step
- typical solution for inefficient or difficult process steps
- implements individual reaction steps in a continuous process
- no modification of remaining process steps
- dedicated or limited multipurpose
- on-module flexibility
- savings:
 - higher yields
 - less energy consumption
 - less raw material input

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case study unit operation-concept

one of the biggest cGMP plants with microreactor

case study example:

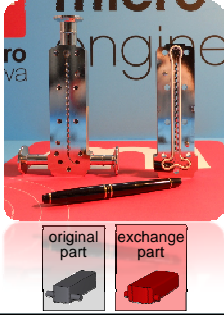

- mixing-sensitive reaction
- barely feasible in batch mode
- microreactor plant results: 30 % higher yield compared to batch
- total throughput is 200 l/hour
- the pilot/production plant has been started up successfully in May 2010
- yield difference (lab-manufacturing): 0.1%

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case study unit operation-concept

on-module adaption by exchanging specific parts of the module (configuration)

original part **exchange part**

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fast track realization

time scale 7 months



case study example

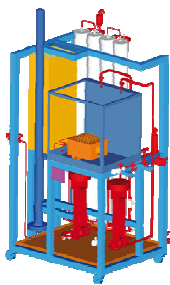
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**manufacturing solution
modular multipurpose**

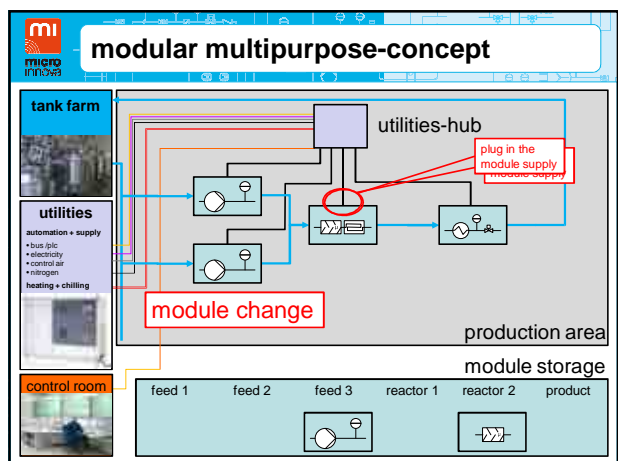
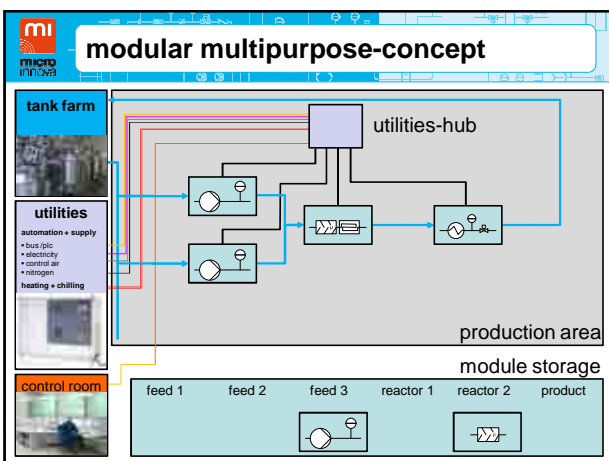
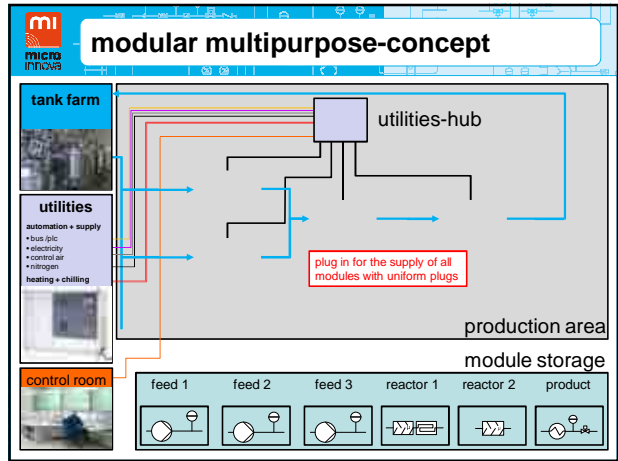
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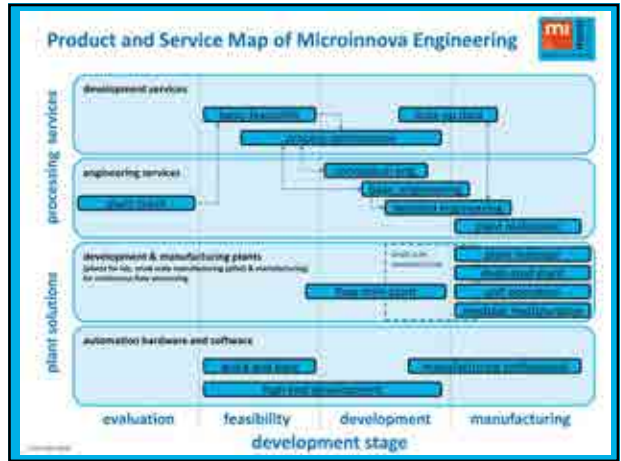
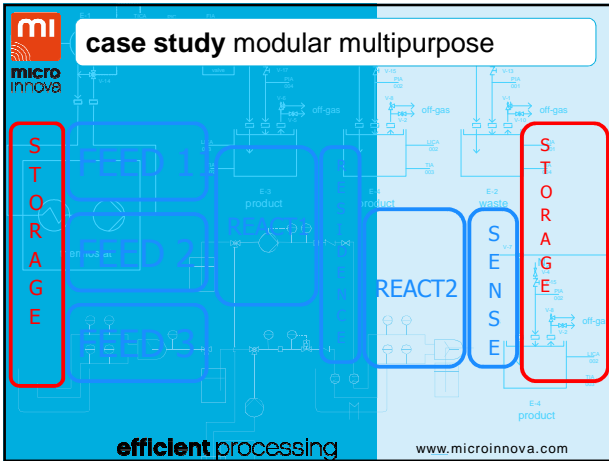
modular multipurpose-concept



- combines advantage of batch technology (**flexibility**) with advantage of continuous processing (**process performance**)
- **interchangeable** modules temporarily assembled and variably combined
- functional units, which can be combined individually according to the process
- **fast adaption** to new processes and easy plant extension
- optimization of plant utilization
- **totally new plant concept** in chemical industry

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summary

turning process performance into money

microinnova solutions

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micro process design engineering manufacturing plant

efficient processing moves forward!