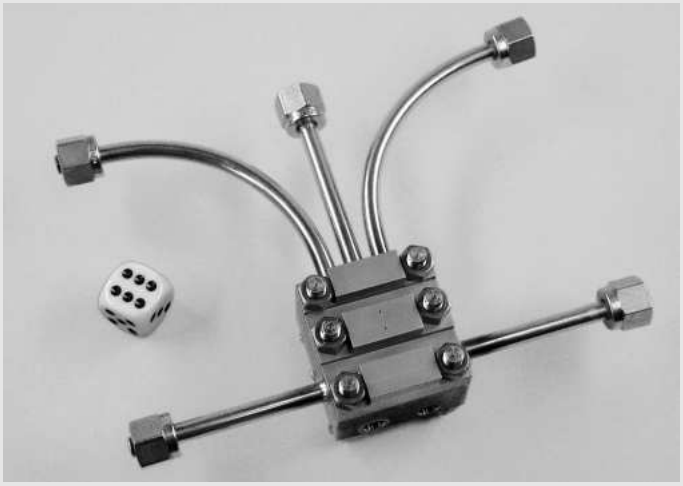
GAS PHASE MICRO REACTOR WITH MIXER AND INTERNAL HEATING/COOLING

GPMR-MIX



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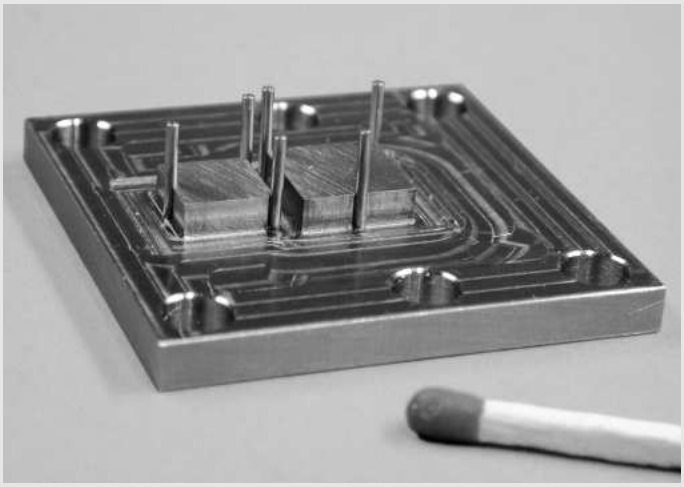


Top housing plate of reactor with mixer and reactor stack

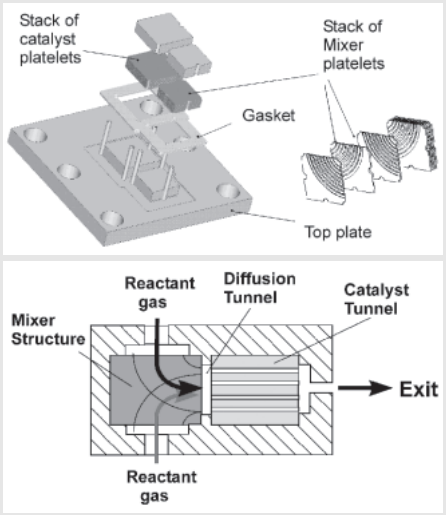
Principle

The Gas Phase Micro Reactor with Mixer and Internal Heating/Cooling GPMR-MIX contains two recesses, each filled with one stack of micro-structured platelets, which are connected via a conduit. Both stacks are connected to welded tubes, serving for feed and fluid withdrawal.

The first stack comprises two types of mirror-imaged platelets with parallel feeding channels which are alternately arranged so that a multi-lamination flow configuration is created for gas mixing. In the conduit attached, forming a flow-through chamber, mixing is completed within short time due to the virtue of decreasing the diffusion path. Hence the mixed reactant gas volume (before reaction) is kept as small as possible. As a result, investigations in the explosive regime are safely amenable, as demonstrated by research with this and similar tools.

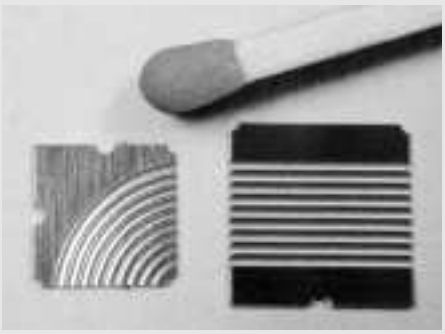
The second stack comprises platelets with parallel channels of small depth so that very good heat transfer is provided. By this means, hot-spots are reduced and near-isothermal operation can be achieved. The platelet construction material itself may act as catalyst or, more preferably, the channels may be coated with a catalyst layer, e.g. wet chemically using the wash-coat route or by means of thin-film deposition. A small total mass of the construction material, hence a compact arrangement of the functional units, and internal large-power heat supply guarantee fast heating up, typically in the range of a few minutes (ca. 100 K/min), even when approaching relatively large temperatures, e.g. up to 600°C. Internal cooling typically of similar time scale is provided by convection flow of a gas stream at high flow rate in a channel which surrounds the functional units.

The mixer-catalyst zone reactor has been extensively studied for its use for ethylene oxide synthesis. Among other results of the parametric study, safe operation in the ex regime (3 vol.-% ethylene, 50 vol.-% oxygen, balance nitrogen; 5 bar; 4 l/h; 277°C), high space-time yields (up to 0.78 tons h^{-1} m^{-3}), a maximum selectivity of 69% (6 vol.-% ethylene, 30 vol.-% oxygen, balance nitrogen; 5 bar; 0.124 s; 5 l/h; 290°C), not far from the industrial benchmark, and higher conversions at comparable selectivity compared to fixed-bed technology (20 vol.-% ethylene, 80 vol.-% oxygen; 0.3 MPa; 3.17 l/h; 230/250°C) were demonstrated.



Schematic of the GPMR-Mix device and details of the functional principle

Individual parts of GMPR-Mix



Mixer and reaction platelet

Laser-cut mixer platelets

Technical Data

Name	Gas Phase Micro Reactor with Mixer and Internal Heating
Order number	GPMR-MIX
Size (L x B x H)	40 x 40 x 30
Connectors (Inlet/Outlet)	1/4″
Standard material	Inconell 600 (2.4816) for housing and top plate 1.4571 for mixing and catalyst plates
Number of mixing plates	10
Size of mixing plates (mm)	7.5 x 7.5
Channel geometry of mixing plates (µm)	180 – 490 x ~ 100
Number of catalayst plates	10
Size of catalyst plate (mm)	9.5 x 9.5
Channel geometry of the catalyst plates (µm)	460 x 125

Operating Conditions

Temperature (°C)	600
Pressure stability (bar)	50
Flowrate (l/h)	5
Residence time (s)	0.025 – 2
Leakage Class	$< L_{0.1}$
Specific surface area (m^2/m^3)	12700
Total inner surface per reaction layer (mm^2)	54
Specific inner surface per reaction layer (m^2/m^3)	3840
Active inner volume per layer (mm^3)	2.5