BioPACIFIC MIP

The Flow Chemistry Platform

Technical Data Sheet

Continuous-flow synthesis with integrated in-line analytics for scalable, automated, data-rich reaction development

The Flow Chemistry Platform performs continuous-flow synthesis of monomers and polymers with precise reagent control, efficient mixing and heat transfer, and the safety and scalability advantages of flow over batch. A fully integrated in-line analytics suite monitors reactions in real time, generating on the order of 10,000 data points per run and supporting both discovery-scale screening and production-scale synthesis within a Design–Build–Test–Learn (DBTL) materials pipeline.



Key Specifications

Parameter	Specification
Reactor modules	Four interchangeable modules — high-temperature, photochemical, electrochemical, sub-ambient; operated individually or coupled in series
Temperature range	−40°C to 250°C, spanning the module set
Photochemical range	~ 220–700 nm via interchangeable mercury-lamp / LED sources
In-line analytics	FT-IR, benchtop NMR, UV-Vis, SEC-MALS
Data throughput	On the order of 10,000 data points per reaction
Scale range	Milligram screening to multi-hundred-gram production; monomer scale-up demonstrated to the kilogram scale
Automation & control	Remote operation; ELN/LIMS capture of run conditions and analytical data; robotic solution-preparation integration in progress

Reactor Modules

Reactor modules share common pumping, mixing, and residence-time control and can be coupled for multi-step sequences.

Reactor Module	Capability
High-temperature reactor	Heated tubular reactor for 25–250°C continuous transformations with precise residence-time and temperature control
Photochemical reactor	Interchangeable mercury-lamp and LED sources; wavelength selection across ~ 220–700 nm
Electrochemical reactor	Standalone or sequentially coupled module; heating/cooling from −10°C to +100°C
Sub-ambient (cold) reactor	Low-temperature module for reactions requiring cooled conditions down to −40°C

Integrated In-Line Analytics

Simultaneous, in-line reaction monitoring from the reaction stream eliminates the bottleneck of off-line characterization and enables closed-loop control.

Technique	Function
FT-IR	Real-time tracking of functional-group conversion and reaction progress
Benchtop NMR	Structural confirmation and quantitative, time-resolved kinetics directly from the reaction stream; no deuterated solvent required
UV-Vis	Monitoring of chromophore formation and conversion (e.g., characteristic monomer absorbance bands)
SEC-MALS	Real-time weight-average and peak molecular weight, and dispersity, directly from the reaction stream

Representative Chemistries & Workflows

Core Flow-Synthesis Modalities

- **Continuous-flow polymerization —** controlled radical and other chain-growth systems with precise control of residence time, temperature, flow rate, molar ratios, and comonomer identity
- **Photochemical and electrochemical synthesis —** wavelength-selective and continuous electrochemical transformations, standalone or coupled in sequence
- **Monomer synthesis and scale-up —** continuous production of bio-derived building blocks (e.g., heterocyclic and disulfide-containing monomers), demonstrated to the kilogram scale
- **Click and tolerant functionalization chemistries —** water- and oxygen-tolerant schemes (e.g., thiol-ene) for biodegradable and biologically active polymers

Real-Time Monitoring & Kinetics Protocols

- **In-line kinetic profiling —** simultaneous NMR/FT-IR/UV-Vis monitoring of binary and ternary copolymerizations, capturing thousands of data points per run
- **Residence-time and parameter optimization —** systematic variation of residence time, molar ratios, flow rates, and temperature with immediate analytical feedback
- **In-line molecular-weight determination —** real-time weight-average molecular weight and dispersity via coupled SEC/MALS

Data-Driven & Closed-Loop Optimization

- **Kinetic parameter estimation —** across wide condition ranges (e.g., via Bayesian inference and Markov Chain Monte Carlo sampling)
- **Predictive modeling —** of monomer reactivity ratios, sequence distributions, and material properties such as degradability
- **Standard outputs —** scalable monomer/polymer product; time-resolved conversion, kinetic, and molecular-weight data; fully captured run metadata linking each run to its conditions (ELN/LIMS)