

## Flow Chemistry

550+  
projects

50+  
reaction types

kilo to metric ton scale



**2023 ACS GCIPR CMO Excellence in Green Chemistry Award Winner**

The award-winning project implemented innovative continuous flow process

### Application in safer, more stable, higher-yield processes

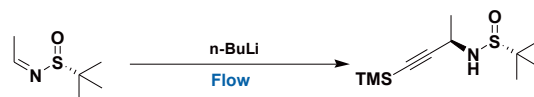
- High temperature/pressure
- Highly energetic
- Cryogenic
- Highly reactive and air-sensitive
- Toxic and/or stinky agents
- Unstable intermediates
- Oxidation and/or ozonization
- Diazotization
- Sulfonation
- Esterification
- Halogenation
- Reduction

### Reactors

- Single-tube
- Static mixer
- Dynamic tubular reactor
- Photo-flow reactor
- Multi-tube
- Fixed/micropacked bed
- Electrochemistry reactor
- CSTR

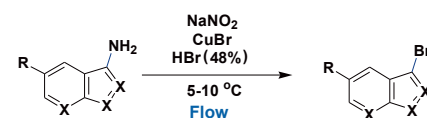
## Cases

### Cryogenic reaction



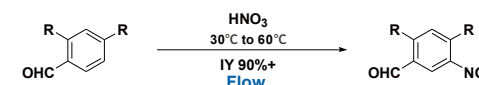
Comparison	Batch	Flow
Feasibility of scaling up	×	√
Temperature	-70 to -60 °C	-40 to 10 °C
Yield	N/A	84%
Scaling-up risk	High	Low
Completed 260 kg product with 240 mL continuous flow reactor in 30 hours		

### Diazotization



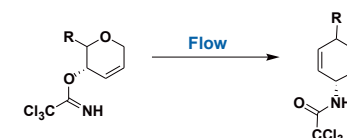
Comparison	Batch	Flow
Feasibility of scaling up	×	√
Temperature	N/A	5 to 10 °C
Yield	N/A	80 - 85%
Scaling-up risk	High	Low
Completed 200 kg product with a set of 100 mL continuous flow reactor in 2-3 days		

### Nitration



Comparison	Batch	Flow
Feasibility of scaling up	×	√
Temperature	20 - 30 °C	30 - 60 °C
Yield	N/A	90 - 93%
Scaling-up risk	High	Low
Automatic leve	Low	High
Over 300 kg of product completed with an integrated continuous tubing reactor		

### High temperature



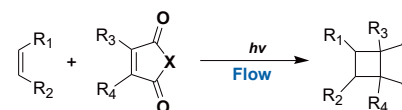
Comparison	Batch	Flow
Feasibility of scaling up	×	√
Temperature	200 °C	220 - 250 °C
Yield	N/A	>94%
Scaling-up risk	High	Low
Automatic leve	Diphenyl ether (BP: 258 °C)	Toluene (BP: 110 °C)
Over 100 kg of product completed		

### Oxidation



Comparison	Batch	Flow
PMI	15	7
Time	> 4 h	10 min
Yield	88 - 90%	95%
Complexity of work-up	High	Low
Over 100 kg of product completed		

### Photocatalytic reaction



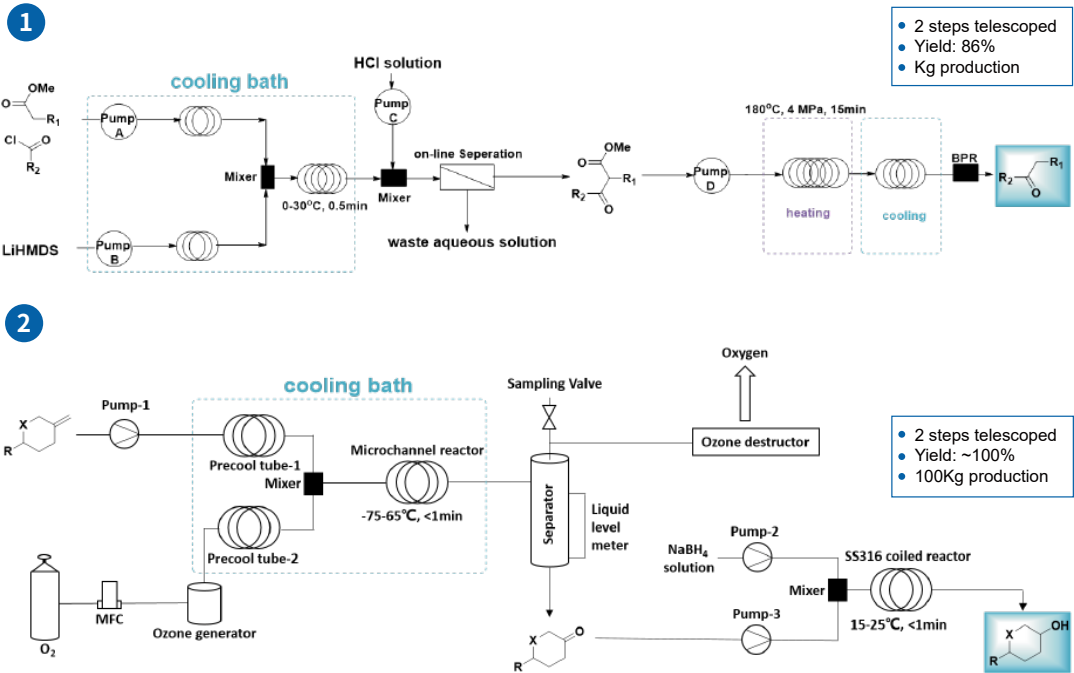
Comparison	Batch	Flow
Feasibility of scaling up	×	√
Time	30 h	40 - 50 min
Light source	Medium pressure mercury lamp	365 nm LED
Scaling-up risk	High	Low
Over 1 MT of product completed		

Electrocatalytic reaction

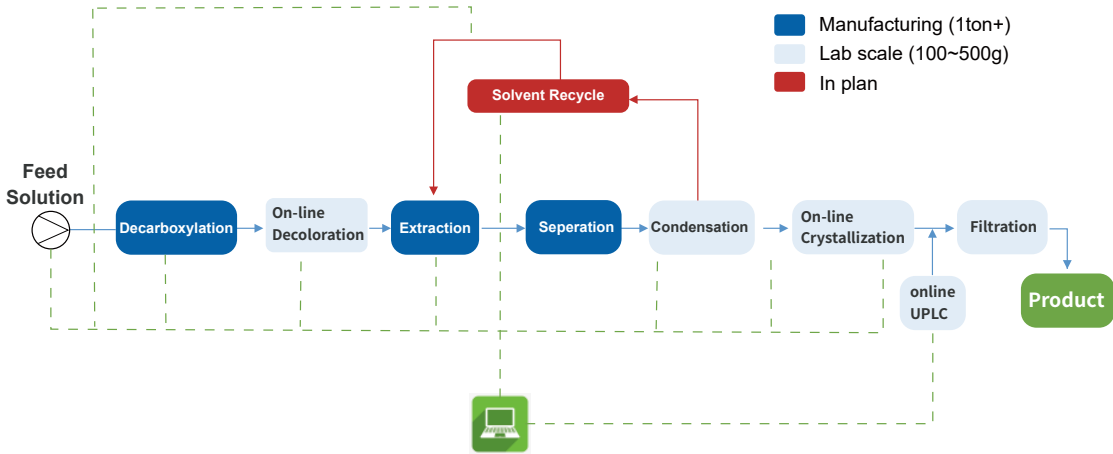


Entry	General Process	Electrochemical Process
Step	3	1
Yield	45%	67%
PMI	135	73
Cost of Material	> 30% cost reduction	
Self-made equipment, Kg scale preparation		

Telescoped flow cases



End-to-end solution



Continuous Manufacturing GMP Workshop at PharmaBlock Zhejiang

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