WHITE PAPER

Leveraging Flow Chemistry

A green solution for efficiency, sustainability and business value in chemical process development and manufacturing

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Flow chemistry has been transforming pharmaceutical manufacturing by offering a safer, greener and more efficient approach for pharmaceutical industries. By embracing the flow technology, we empower our clients to achieve unprecedented efficiency, sustainability and scalability in the production of RSM, chemical intermediates and APIs, while positioning ourselves as a trusted partner in the pharmaceutical landscape.

FLOW CHEMISTRY:

Redefining sustainability and efficiency

Flow chemistry embodies the core principles of green chemistry, minimizing environmental impact while addressing the evolving demands of modern pharmaceutical manufacturing. As global regulations tighten and cost pressures mount, flow chemistry stands out as an indispensable solution.

At Asymchem, we leverage continuous reactions in compact, controlled reactor volumes to enhance precision, safety and scalability—even for hazardous reactions and complex API manufacturing. This advanced approach delivers a manufacturing process that is both environmentally sustainable and economically advantageous for our clients:

- **Reduced waste:** Higher yields minimize byproducts, thereby cutting waste.
- **Energy efficiency:** Continuous steady-state operations eliminate energy-intensive heating and cooling cycles typical to batch processes, significantly lowering both energy and water consumption.

By adopting flow chemistry, our clients not only comply with regulatory standards but also enhance operational efficiency, gaining a competitive edge in the pharmaceutical industry.

TRANSFORMING MANUFACTURING WITH FLOW CHEMISTRY

Unlike traditional batch processes, flow chemistry accelerates cycle times, reduces manual intervention and enables efficient scaling from small-scale development to full-scale industrial production. This transformative approach allows pharmaceutical companies to tailor processes for specific products while maintaining operational flexibility.

Why partner with Asymchem?

- **Faster development:** Shortened cycle times and reduced lead times accelerate time-to-market.
- **Sustainability:** Resource-efficient processes align with green manufacturing goals.
- **Scalability:** Tailored solutions ensure seamless scaling across all production levels.

REAL-WORLD IMPACT:

A success story in carbapenem synthesis

One of Asymchem's breakthroughs involved transitioning carbapenem synthesis from batch to flow processes. By employing advanced flow chemistry techniques, we achieved:

- **Reduced production time:** Shortened from **20 days** to just **1.5 days.**
- **Improved sustainability:** Decreased process mass intensity by **50%**.

This achievement highlights our ability to deliver transformative results, combining speed, efficiency and environmental responsibility.

ENHANCING SAFETY AND PRECISION

Flow chemistry's inherent advantages extend beyond efficiency to offer significant safety benefits:

- **Minimized risk:** Small reaction volumes mitigate the hazards associated with exothermic or explosive reactions.
- **Enhanced stability:** Precise control over temperature and mixing ensures stable and safe processes.
- **Safe scale-up:** Flow reactors maintain consistent performance, enabling a smooth transition from lab-scale to industrial production.

At Asymchem, we harness these safety advantages to execute complex reactions previously deemed unsafe for scaling. Our advanced methodologies empower clients to achieve reliable, high-quality results without compromising safety.

VERSATILITY AND ADVANCED CAPABILITIES

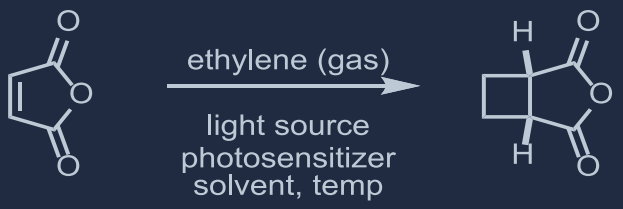
Flow chemistry's versatility allows it to address a wide range of pharmaceutical manufacturing challenges. Our expertise includes:

- High-pressure reactions
- Electrochemical reactions
- Photochemical reactions
- Biotransformations

This extensive range of capabilities enables us to deliver tailored solutions for even the most complex production needs, enabling our clients to overcome significant manufacturing hurdles.

REAL-WORLD IMPACT:

A success story in scalable photochemical manufacturing



cyclobutane **1**

At Asymchem, we partnered with Amgen to successfully scale the [2+2] photocycloaddition of maleic anhydride and ethylene, delivering over 250 kg of cyclobutane derivatives.

Key achievements included:

- **Efficiency:** Reduced synthesis from six steps to one.
- **Sustainability:** Eliminated hazardous reagents and cut waste by 72%, achieving a PMI of 41.2 kg/kg.
- **Innovation:** Developed a custom flow reactor with an appropriate light source for scalable and safe production.
- **Industry First:** Pioneered the first large-scale application of this photochemical process in pharmaceutical industry.

This groundbreaking achievement exemplifies our commitment to innovation and sustainability, earning us the prestigious **ACS CDMO Green Chemistry Award in 2022.**

ADDRESSING REGULATORY CHALLENGES

Despite its many advantages of flow chemistry, its adoption requires navigating complex regulatory landscapes. Limited guidance from regulatory bodies presents challenges that demand specialized expertise. At Asymchem, we bridge this gap through:

- **Proven compliance:** Successfully validated high-pressure hydrogenation and multiple flow reaction processes.
- **Regulatory excellence:** Over 30 successful inspections/audits by the FDA, NMPA and TGA have been conducted at Asymchem manufacturing sites, including the flow facilities.

We simplify compliance for our clients, ensuring their processes meet global regulatory standards while delivering high-quality products.

ASYMCHEM:

Your strategic partner in flow chemistry

Since 2008, Asymchem has been at the forefront of flow chemistry innovation, setting the standard for excellence in continuous manufacturing. Our commitment to cutting-edge technology and seamless integration empowers pharmaceutical companies to achieve unparalleled efficiency and scalability.

KEY HIGHLIGHTS:

Production capacity

Capable of producing up to **1,000 metric tons** of RSMs, intermediates, and APIs.

Specialized cryogenic production capacity of **500 metric tons.**

Unmatched expertise

15+ years of applied flow chemistry knowledge and experience.

25 years of excellence in chemical-pharmaceutical service.

Integrated teams

A dedicated team of **over 300 professionals** in the Center for Process Science ensures streamlined coordination and efficient project execution.

Advanced in-house fabrication

Custom-built flow reactors are **ready within 1-2 weeks,** eliminating the typical 3-6 month delays associated with outsourcing.

PARTNER WITH ASYMCHEM TODAY

Asymchem is more than a service provider—we are a strategic partner dedicated to empowering our clients with transformative solutions. By leveraging our expertise, state-of-the-art equipment and commitment to sustainability, we help pharmaceutical companies achieve their goals while gaining a decisive edge in a competitive industry.

Let Asymchem guide you through the future of pharmaceutical manufacturing. Contact us today to discover how flow chemistry can revolutionize your chemical process development and meet your needs in the pharmaceutical industry.

ASYMCHEM

As a prominent leader in the CDMO sector, Asymchem (Stock Code: 002821.SZ/6821.HK) has been at the forefront of providing comprehensive R&D and integrated production solutions across the pharmaceutical value chain for over 25 years.

Building on a strong foundation in small molecule CDMO services, we have expanded our expertise to encompass peptides, oligonucleotides, biologics, drug product, and clinical research services. Our business model continues to evolve through technology transfer initiatives, with a strategic focus on continuous flow production and synthetic biology.

With state-of-the-art R&D and manufacturing facilities strategically located in key regions such as China, the United States, and the United Kingdom, our global footprint reflects our commitment to excellence. With a dedicated workforce of over 9,000 professionals— 45% of whom are exclusively focused on R&D — we proudly partner with leading pharmaceutical and biotech companies worldwide. Operating in full compliance with rigorous cGMP and EHS regulations, we address client needs by offering high-quality and cost-effective solutions that expedite clinical trial timelines and deliver customized strategies to meet the diverse requirements of the global landscape of drug development.