

TECHNICAL DATA SHEET

K1 REACTION SYSTEM

2026

**REVOLUTIONISING ADVANCED
MATERIALS DISCOVERY AND
MANUFACTURE**

WE PARTNER WITH MANUFACTURERS
TO ENABLE SCALABLE PRODUCTION
OF ADVANCED NANOMATERIALS



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OVERVIEW

DESCRIPTION

The K1 reactor system revolutionizes nanomaterial production through its unique combination of speed, safety, precision, and intelligent automation. This innovative system harnesses continuous flow chemistry and modular components to generate high-value nanomaterials in mere seconds. Within a single benchtop, the K1 is capable of generating either millilitres of samples in minutes, or over a kilogram of nanomaterial in a day.

The K1 is built with patented high shear annular flow technology, which eliminates the need for extreme temperatures and pressures in nanoparticle synthesis, creating a safer working environment and minimizing potential hazards. Precise control over the shear rate ensures consistent particle size, morphology, and ultimately, the performance of the nanomaterials across all batches.

Furthermore, the K1 system integrates powerful machine learning algorithms that analyses reaction data and optimize process parameters to achieve your desired nanomaterial specifications. When combined with our fully automated workflows, this intelligent optimization streamlines development by reducing time spent on experimentation and accelerating the path from concept to production.



Schematic of the K1 Start, incorporating annular flow reactor technology with AI-driven optimization and automation

Ultimately, the K1 is easy-to-scale system that allows scale-up without significant reconfiguration and additional optimization, to AM's 10 and 100 kg/day systems (the K10 and K100).

K1 SYSTEM MODELS & FEATURES



FEATURES	START	PRO	MAX
Dosing	Continuous Low Pulsation Pumping	- Continuous Low Pulsation Pumping - Automated Valves	- Continuous Low Pulsation Pumping - Automated Valves
Product Collection	None	None	- Stirrer - Waste & Product Pumps
Max Number of Reagents	2	4	4
Automation Level	- Single Batch Dispensing - Manual Cleaning & Loading	- Continuous Dispensing - Autonomous Reaction & Cleaning	- Continuous Dispensing - Autonomous Reaction & Cleaning - Automated Production Collection with Spray Reduction
Use Cases	Single Batch Synthesis	Multi Sample Synthesis	High Throughput Synthesis
Sensors	Pressure	Pressure	Pressure

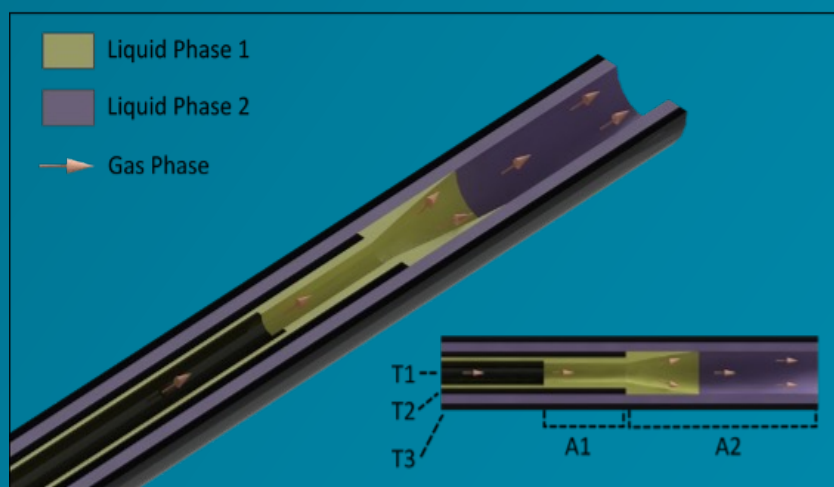
ANNULAR MICROREACTOR MODULE

REACTOR PRINCIPLES

The K1 reactor operates on the principle of high, precision shear rate control. By precisely controlling shear rates at magnitudes as high as 10^6 s^{-1} , the annular flow reactor enables precise manipulation of mixing and nanoparticle formation dynamics. This results in precision synthesis of targeted particle size, crystallinity, morphology and other critical characteristics of nanomaterials.

High yet precise shear rate is achieved by accessing a fluid dynamic regime known as “multiphase annular flow”. In this regime, liquids and gases flow through a pipe with high differences in relative velocity. A high velocity gas forces liquids to the very edges of the pipe, leaving a gaseous annulus core. In the thin film that the liquids occupy ($10 - 200 \mu\text{m}$), there is a very high yet uniform distribution of shear rates. Chaotic mixing also occurs at the gas and liquid interface due to a phenomenon known as “Kelvin-Helmholtz instabilities”.

An example schematic of a two-reagent flow is given below, where three tubes (T1, T2, T3) create two annular flow zones (A1, A2). In section A1, air flow through T1 forces Liquid Phase 1 into a thin film at the inner walls of T2. In A2, the thin film of Liquid Phase 1 from A1 is then contacted with a thin film of Liquid Phase 2. In T3, mixing and reaction occur.



Schematic Cross Section of Annular Flow Reactor. Not to scale.

LABEL	LEGEND
A1	Annular Region 1
A2	Annular Region 2
T1	Tube 1 (Gas)
T2	Tube 2 (Liquid 1)
T3	Tube 3 (Liquid 1 + Liquid 2 Mixing Zone)

REACTOR SPECIFICATIONS

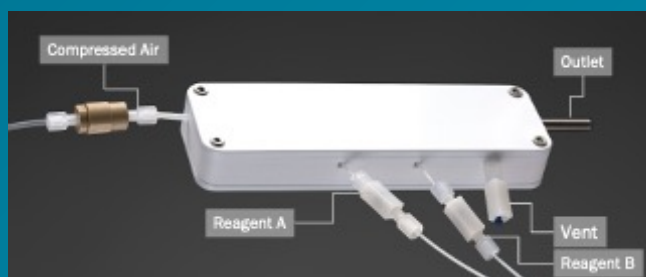
The K1's patented design and proprietary assembly process enables precision alignment of microcapillaries in a coaxial manner.

The K1 can be purchased in three different configurations to enable different chemistries. For a single step reaction of two reagents, the 2T is a simple yet versatile solution. For multi-step reactions involving 3 or 4 reagents, the 3T or 4T may be used. This capability opens doors to multistep processes or the incorporation of quenching agents, expanding the versatility and applicability of the reactor system. Please note that only two reagents lines can be mixed simultaneously with the current K1.

K1-2T TECHNICAL SPECIFICATIONS

Dimensions	21.5 x 5.8 x 2.6cm
Weight	200g
Wetted Materials Selection	ETFE, PEEK, PP, Quartz,
Minimum Micromixing Time	0.5ms
Maximum Shear Rate	10^6 s^{-1}
Maximum Liquid Flowrate (Total)	20 mL/min
Maximum Air Flowrate	5 L/min
Maximum Pressure	7 bar
Reaction Length	50 mm

Each K1 also comes equipped with a vent line which can be used for quenching, tip cleaning, or as a vent port.

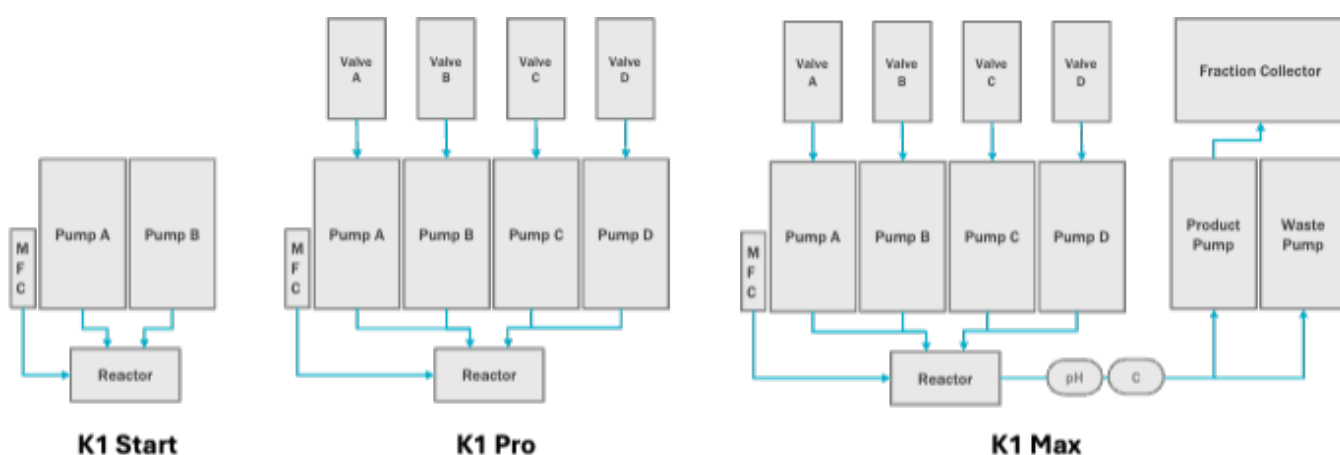


ANNULAR MICROREACTOR MODELS

CAPABILITIES	-2T	-3T	-4T
Number of Reagents	Up to 2	Up to 3	Up to 4
Use Case	• Single step process • Manual quenching • Manual tip cleaning	• Multistep processes • Automated quenching • Automated tip cleaning	• Multistep processes • Automated, simultaneous quenching & tip cleaning

DOSING MODULES

K1 Dosing Modules consist of continuous, medium-pressure low pulsation pumps for liquid reagents, mass flow controllers for compressed air, peristaltic pumps and fraction collectors for product collection, and sensors for monitoring reaction pressure and product pH and conductivity. Additional options are available upon request, such as temperature regulation and additional analytical equipment. Max systems are made to customer specifications.



K1 Configuration Schematics. Reagent and compressed gas not shown.

START

The Entry level model of the K1 reactors equipped with a continuous low-pulsation pumping system, enabling high-volume production with precision and speed. Pump pressure sensors provide basic monitoring capabilities. Changing between reagents and cleaning solvents is done manually. The K1 Start is ideal for laboratories that are starting out in nanoparticle synthesis, with low sample generation frequency (<10/day).

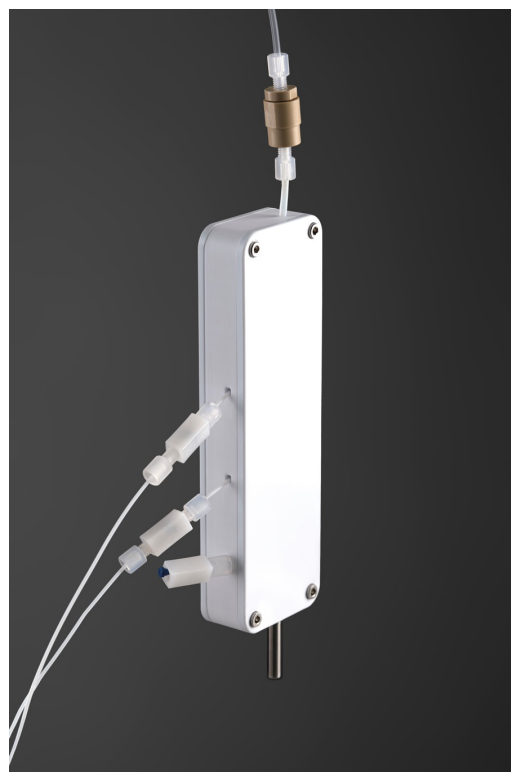
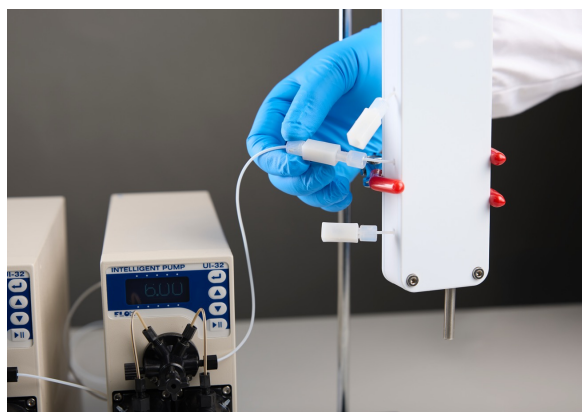
PRO

The K1 Pro expands on the K1 Start, enabling more complex nanomaterial syntheses. It features four continuous low pulsation pumps allowing for more intricate reagent combinations. The autonomous valves provide automated cleaning between reactions, enhancing workflow efficiency. High-precision pressure sensors provide in-depth process data and facilitate semiautonomous process optimization. This makes the K1 Pro ideal for generating multiple samples (>10/day) and optimizing workflows swiftly.

MAX

The K1 Max is the pinnacle of automation and efficiency in nanomaterial R&D. Equipped with high-precision sensors, including pH and conductivity sensors, the K1 Max supports comprehensive analytical capabilities. It also features an advanced automated sample collection module, enabling fully autonomous workflows and continuous synthesis without manual intervention. The K1 Max is ideal for laboratories needing high-throughput capabilities, with up to 100 samples/day.

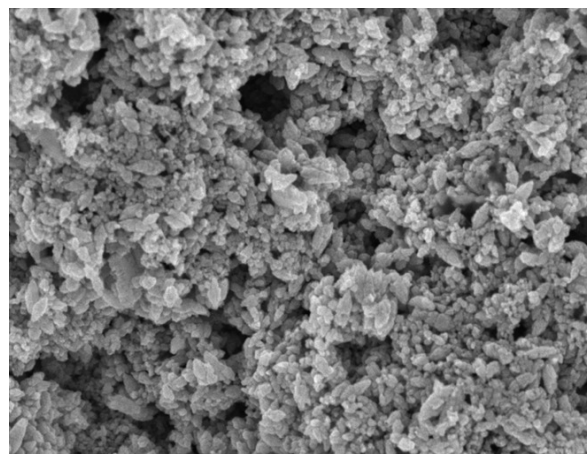
CAPABILITIES – START, PRO & MAX



CAPABILITIES	START	PRO	MAX
Air Dosing	• 1 x Mass Flow Controller • 30 SLPM Max	• 1 x Mass Flow Controller • 30 SLPM Max	• 2 x Mass Flow Controller • 5 SLPM Max
Liquid Dosing	• 2 x Low Pulsation Pumps • 10 bar max • 50 – 250 mL/min max	• 4 x Low Pulsation Pumps • 10 bar max • 50 – 250 mL/min max • 4 x Selector Valves (4 Port)	• 4 x Low Pulsation Pumps • 20 bar max • 0.1 – 50 mL/min • 4 x Selector Valves (4 Port)
Dosing Sensors	• 3 x Pressure Sensors (1 x Gas, 2 x Liquid Sensors) • 0.1 bar accuracy	• 5 x Pressure Sensors (Liquid) (1 x Gas, 4 x Liquid Sensors) • 0.1 bar accuracy	• 5 x Pressure Sensors • (1 x Gas, 4 x Liquid Sensors) • 0.01 bar accuracy
Analytical Sensors	Optional: pH, conductivity	Optional: pH, conductivity	• 1 x pH Sensor • 1 x Conductivity Sensor
Automated Priming & Rinsing	None	Included	• Collection Vessel • Waste & Product Peristaltic Pumps • Fraction collector
Max Number of Reagents	2	4	4

MATERIAL CAPABILITIES

FAMILIES	• 2D Materials • Metals • Metal Oxides • Metal Organic Frameworks • Quantum Dots • Organic Nanoparticles • Ceramics
SIZE RANGE	<5 nm to 5 um
MORPHOLOGIES	Spheres, Flakes, Rods, Stars and more
THROUGHPUT (DRY BASIS)	10 kg/day



ZnO morphologies synthesized with K1

TYPE	2D MATERIALS	METALS	METAL OXIDES	METAL ORGANIC FRAMEWORKS	QUANTUM DOTS	ORGANIC NANOPARTICLES
Bonding type	Multiple	Metallic	Ionic	Covalent/ Coordination/Ionic	Ionic/Covalent	Covalent
Reaction Mechanism	Multiple	Reduction	Co-precipitation	Co-precipitation	Co-precipitation Solvothermal	Anti-solvent precipitation
Examples	• Hydrotalcite • Graphene	• Silver • Gold	• Zinc Oxide • Iron Oxide	• Copper BDC • ZIF-8	• ZnO • Graphene Quantum dots	Curcumin
Applications	• Sensors • Optics • Battery electrodes • Construction additives	• Conductives • Sensors • Antimicrobials • Catalysts	• Coatings • Catalysts • Antimicrobials	• Carbon capture • Industrial-Adsorbents	• Optoelectronics • Biosensors • Security inks	• Drug delivery • Pharma

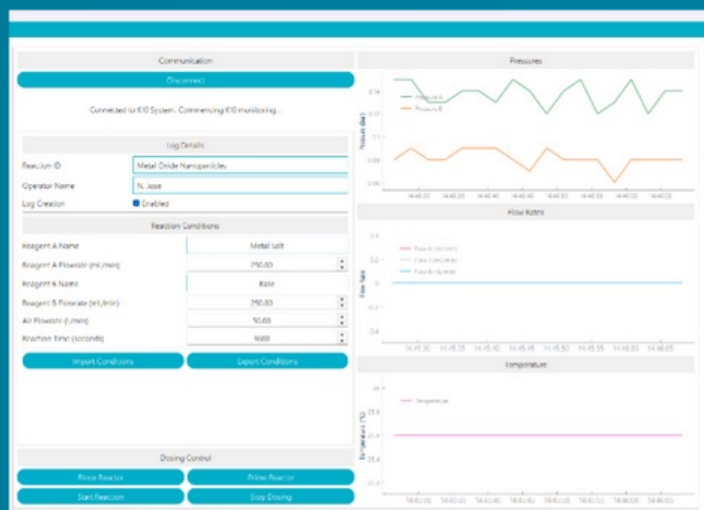
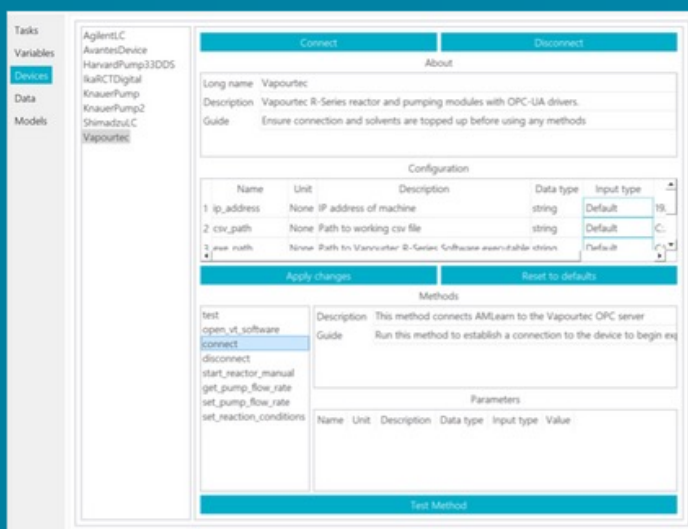
To see relevant publications, please visit <https://acceleratedmaterials.co/nanomaterials/>

K1 reaction systems are easily operated with AMLearn, an operating system for advanced equipment control, automation and machine learning integration. AM Learn contains apps for AM's equipment as well as our proprietary machine learning methods for data analysis and optimisation. These capabilities significantly reduce the time, expense and error of manual experimentation.

K1 reaction systems are bundled with Dash, Optima and K1 applications (K1 Start, K1 Pro and K1 Max). Combining the two, users can rapidly create reliable and scalable synthetic protocols in as little as 20 experiments, varying up to 25 variables and 4 objectives simultaneously.

DASH

- Precision Dosing: Control flow rates and reaction times with exceptional accuracy for consistent, reproducible results.
- Automated Workflows: Schedule experiments, automate repetitive tasks, and free up your time for characterization and development.
- Real-time process monitoring: Monitor reaction conditions to ensure safety and optimize process parameters.



K10

- Precision Dosing: Control flow rates and reaction times with exceptional accuracy for consistent, reproducible results.
- Automated Workflows: Schedule experiments, automate repetitive tasks, and free up your time for characterization and development.
- Real-time process monitoring: Monitor reaction conditions to ensure safety and optimize process parameters.
- Data Management: Import/export reaction recipes seamlessly and generate detailed data reports for comprehensive analysis.

OPTIMA

- Advanced Optimization for Chemical Processes: Employ sophisticated algorithms to intelligently predict optimal reaction conditions, solvent choices, and balance multiple objectives in complex chemical processes.
- Code-Free Workflow Integration: Utilize a user-friendly, graphical interface to design and execute AI-driven optimization protocols without the need for coding expertise.
- Streamlined Automation: Design and execute AI-driven optimization workflows with ease using a code-free, intuitive graphical interface.



Experiment Objectives					
Name	Description	Unit	Target	Upper Bound	Lower Bound
1 Yield	Yield of product	%	Maximize	100.0	0.0

Experiment Parameters				
Name	Description	Unit	Upper Bound	Lower Bound
1 Acetone	concentration of Acetone	mole/dg	10.0	1.0
2 NaOH	concentration of NaOH	mole/dg	0.5	0.05
3 Time	Total reaction time	hrs	20.0	0.0



INDUSTRIAL CASE STUDY: SYNTHESIS OF NANO ZINC OXIDE

Am K1

Am K10

Am K100

Nano zinc oxide is a highly versatile industrial material, with applications ranging from sunscreen to electron transport layers.

Unfortunately, it is a particularly challenging material to efficiently scale-up, due to the wide diversity of morphologies, sizes and crystalline structures it can form.

To demonstrate the industrial viability of our K-series reactors, we have successfully scaled up the manufacture of morphology-controlled nano zinc oxide with the K1, K10, K100 systems in a matter of months.

Compared to conventional batch synthesis methods, the approach exhibited the following benefits:

- Reduced labour in both experimental time and manufacturing personnel, especially useful for constrained R&D timelines
- Reduced space usage – a K1 replaces a 50 L reactor, while a K100 replaces a 10,000 L reactor – saving valuable factory and laboratory space.
- Preservation of product uniformity across 1, 10 and 100 kg/day scales, without the need for additional optimization.

Collectively, these advantages deliver a return on investment improvement of up to 90%.

Detailed specifications for nano zinc oxide and other morphology-controlled materials are available in our Materials Catalogue at <https://acceleratedmaterials.co/materials-catalogue/>



TECHNO-ECONOMIC ANALYSIS RESULTS

	GRAMS – KILO		KILO		KILO – TONNE	
PARAMETERS	K1	50 L Reactor	K10	1,000 L Reactor	K100	10,000 L Reactor
Capacity kg/day	1	1	10	10	100	100
# of experiments per day	10	1	1	0.5	1	0.2
Space Requirement (sqm)	1.5	5	3	25	25	100
Production Cost \$/kg	\$254.00	\$509.00	\$20.00	\$50.00	\$15.00	\$33.00
Total Investment	\$43,185.00	\$126,833.00	\$203,750.00	\$692,387.34	\$576,100.00	\$4,155,871.71

TOTAL COST REDUCTION

CAPACITY (KG/DAY)	1	10	100
CAPEX REDUCTION (\$)	\$ 83,648.00 (66%)	\$ 488,637.34 (71%)	\$3,579,771.71 (86%)
OPEX REDUCTION (\$/KG)	\$ 255.00 (50%)	\$ 30.00 (60%)	\$18.00 (55%)

YEARS TO BREAKEVEN (AT \$50/KG)

~6 months (reduction of 8.47 years)

GET YOUR K1



PACKAGE

AM's standard K1 package consists of:

- The K1 Start, Pro or Max, along with the desired reactor (-2T, -3T or -4T)
- 1 year of customer service, including remote installation guidance, training and troubleshooting
- 1 year warranty on dosing and reaction equipment
- 1 year subscription to AMLearn

PROOF OF CONCEPTS & SERVICES

Unsure if the K1 is right for your application? Need additional services or customization? AM offers proof-of-concept projects, rent-to-own schemes, and R&D services to enhance your K1 purchase.

CONTACT

To request a quotation or get more information, contact AM's team at sales@acceleratedmaterials.co.uk

