Anton Paar

Synthesis Reactors
for Research and Development

Microwave Synthesis Reactors

Pushing the Limits for Your Synthesis Needs

Heat is vital in chemical synthesis because it enhances chemical reactions. Sometimes syntheses do not work without heat introduction, or, if they work, it could take days or even weeks at room temperature, compared to hours or minutes at elevated temperatures.

Compared to conventional reflux synthesis, microwave-assisted synthesis in modern microwave reactors enables increasing yields while significantly reducing reaction times down to only a few minutes. Besides that, the convenience of handling, as well as the safety features of modern microwave reactors, are other reasons why more and more chemists are using microwave heating in their daily laboratory routines.

Benefit from Anton Paar's decades of experiences in microwave chemistry. We don't only provide high-performance microwave synthesis reactors, but we also support you with our comprehensive application expertise.

FIND OUT MORE

www.anton-paar.com/apb-microwave-synthesis

Monowave Series:
The Leaders in the Lab

Anton Paar's high-performance Monowave microwave reactors – designed for small- to medium-scale microwave synthesis – boost productivity and enhance product purity across all applications in research and development laboratories.

Rapid, uniform heating is guaranteed:

→ 850 W unpulsed microwave power automatically adjusted for the sample

→ Powerful stirring up to 1,200 rpm

Precise internal temperature measurement:

→ Simultaneous internal temperature measurement with the fiber-optic ruby thermometer (optional accessory) for accurate control of highly exothermic reactions

→ Improved traceability and reproducibility

→ Essential for transfer and scale-up of reaction protocols

The result: Significant increase of yield and purity across the board.

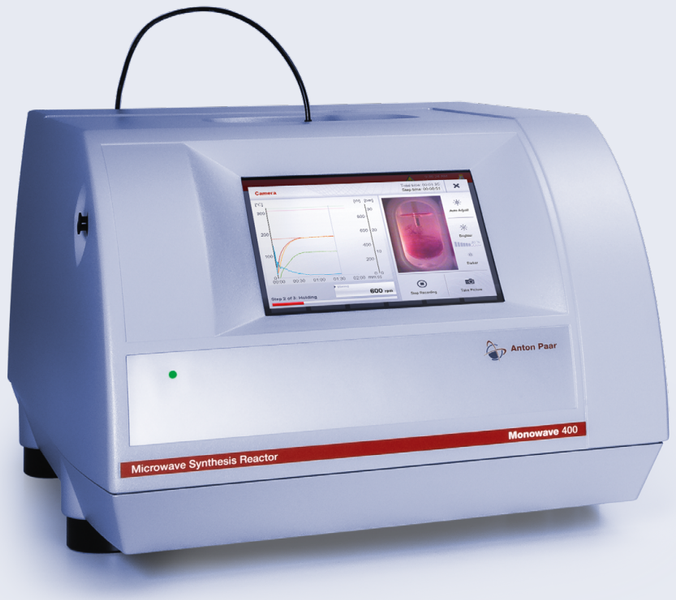
Microwave reactors Monowave 400, Monowave 450, and Monowave 400 R are fully 21 CFR part 11-compliant. And you can perform flawless in situ reaction monitoring of microwave reactions with Monowave 400 R, and its integrated Raman fiber-optic probe.

Vials for any application

→ Vials for reaction scales between 0.5 mL and 20 mL, with tool-free handling

→ Wide-neck vials for bulky samples and extractions

→ Silicon carbide vials for efficient heating of all solvents, and processing of chemicals not suitable for glass vials



Monowave 400: Setting the standard for demanding chemical reactions

→ High-speed, closed-vessel microwave chemistry at temperatures of up to 300 °C, pressures of up to 30 bar, and reaction time up to 100 h

→ Streamline your workflow through real-time observation with a built-in digital camera, and VNC remote control

Monowave 200: A strong foundation

→ Fully upgradable entry level device – operational limits extension, supplementary features, tools and accessories available with a software upgrade

→ High-speed, closed-vessel microwave chemistry at temperatures of up to 260 °C and pressures of up to 20 bar

Monowave 450: Automation, for increased productivity

→ Autosampler MAS 24 queues and processes up to 24 vials of different sizes

→ Small footprint – no extra lab space required because Autosampler MAS 24 sits on top of the instrument

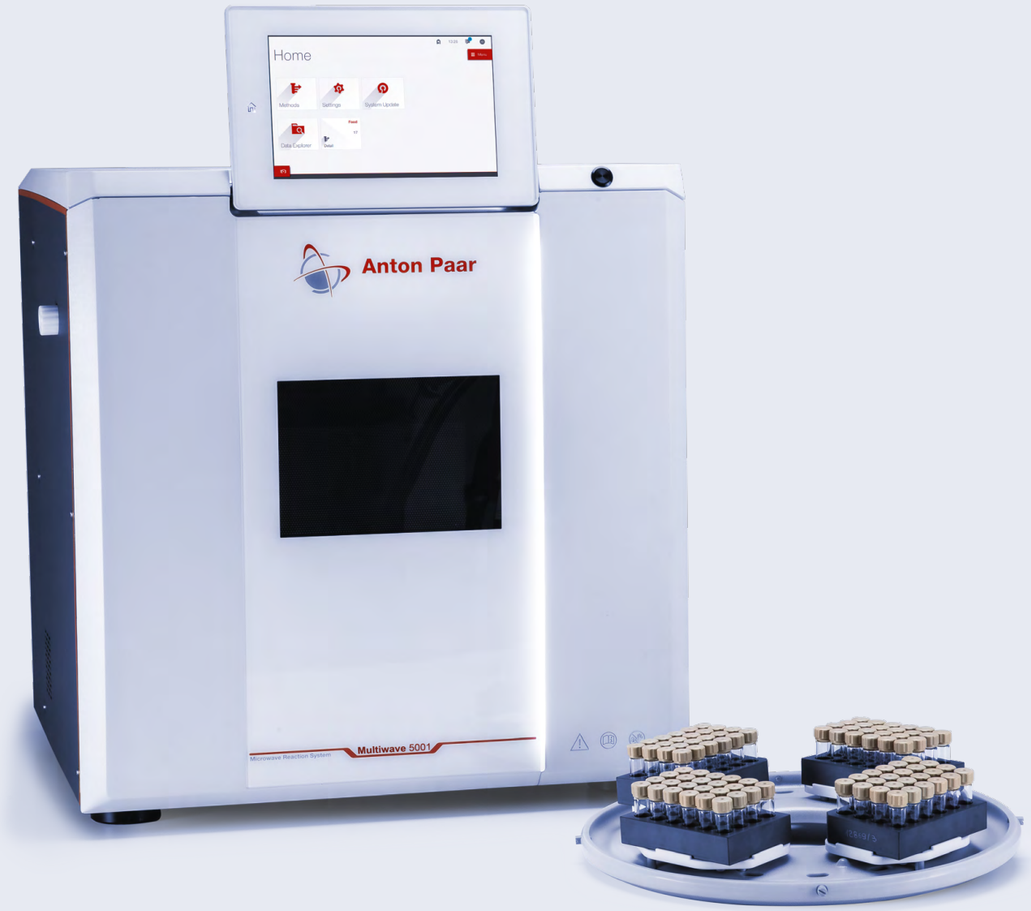
Monowave 400 R:
In Situ Reaction Monitoring

Combine the Monowave 400 R microwave reactor with the Cora 5001 Raman spectrometer, which performs molecular spectroscopy for the characterization of microwave assisted reactions.

Gain a better understanding of reaction mechanisms and kinetics by combining precise temperature profiles with real-time information about the chemical composition of a reaction mixture. As a result, you can optimize reaction conditions based on deeper insights, such as the influence of parameters, the role of different reagents, or detection of the ideal end point of a reaction. The combined setup fulfills the accessible exposure limits (AEL) of laser class 1.

Multiwave 5001:
Microwave Reaction Platform

One system, endless possibilities. From high-performance chemistry suited for materials synthesis and nanotechnology, high-throughput screening and compound library generation, to parallel scale-up and solvent extraction, there's a configuration fit for any task. The Multiwave 5001 microwave reaction platform provides unmatched operational parameters of up to 300 °C and 60 bar, and facilitates up to 96 chemical reactions in parallel.



R&D Results in Microwave Synthesis

1 Rapid one-step synthesis of battery materials (Monowave 400)
A rapid, one-step hydrothermal method successfully produced high-purity $LiFePO_4$ (LFP) in just 10 minutes at 200 °C, eliminating the need for additional thermal treatment. This efficient process yields LFP with excellent structural integrity and ensures electrochemical performance, making it a viable cathode material for Li-ion batteries, while saving both time and energy.

→ *High-purity $LiFePO_4$ prepared by a rapid one-step microwave-assisted hydrothermal synthesis*, C. A. G. Bezerra et al., *J. Mater. Sci*. **2021**, *56*, 10018–10029.

2 In-situ Raman monitoring of chemical reactions (Monowave 400 R, Cora 5001)
A series of polyfunctionalized 4H-chromenes was synthesized through a microwave-assisted, catalyst-free reaction. Coupled with real-time Raman spectroscopy monitoring, it allowed for efficient parameter optimization, demonstrating the system's ability to handle sustainable solvents, with ethanol proving most effective for this complex synthesis.

→ *Monitoring of catalyst-free microwave-assisted MCR-type synthesis of 2-amino-3-cyano-4H-chromene derivatives using Raman spectrometry*, O. Hebert et al., *Synthesis* **2022**, *53*, 5215–5225.

3 Synthesis of functional polymers (Monowave 400)
Researchers synthesized an Iridium-loaded polymer photocatalyst (P10) that facilitates overall water splitting, producing hydrogen and oxygen in stoichiometric amounts for over 60 hours. This study shows the potential of conjugated polymers as single-component photocatalytic systems for sustainable hydrogen production.

→ *Photocatalytic overall water splitting under visible light enabled by a particulate conjugated polymer loaded with palladium and iridium*, Y. Bai et al., *Angew. Chem. Int. Ed*. **2022**, *61*, e202201299.

4 Precision synthesis of magnetic nanocrystals (Monowave 400)
Researchers synthesized HfO_2 nanoparticles via a microwave-assisted hydrothermal method, forming the basis of an innovative Fe_3O_4@HfO_2 nanoreactor. This advanced composite combines chemodynamic therapy and radiotherapy, offering a synergistic approach that enhances tumor treatment efficacy, paving the way for future cancer therapies.

→ *Camouflaged Nanoreactors Mediated Radiotherapy-Adjuvant Chemodynamic Synergistic Therapy*, M. Lu et al. *ACS Nano* **2023**, *17*, 24170–24186.

5 High throughput synthesis of MOFs (Multiwave 5001, 2x24MG5)
Using a microwave-assisted method, multiple Ce(IV)-MOF (metal-organic framework) samples were synthesized simultaneously in just 30 minutes. This efficient, high-throughput process allowed for the rapid production of diverse MOFs with different topologies by incorporating chiral and achiral C4-acids as linkers, demonstrating the capability to generate a wide variety of materials in a single run under mild, water-based conditions.

→ *The first water-based synthesis of Ce(IV)-MOFs with saturated chiral and achiral C4-dicarboxylate linkers,* J. Jacobsen, et al. *Dalton Trans*. **2019**, *48*, 8433–8441.

6 Hydrothermal modification of graphene (Multiwave 5001)
A microwave-hydrothermal method was optimized to produce reduced graphene oxide (M-rGO) with an interconnected 3D porous structure. This rapid process, requiring no reducing agents, yielded M-rGO with exceptional energy storage properties, including high capacitance and energy density – ideal for scalable production of advanced supercapacitors.

→ *Effective microwave-hydrothermal reduction of graphene oxide for efficient energy storage,* A. R. Thiruppathi, et al., J. *Energy Storage* **2022**, *48*, 103962.

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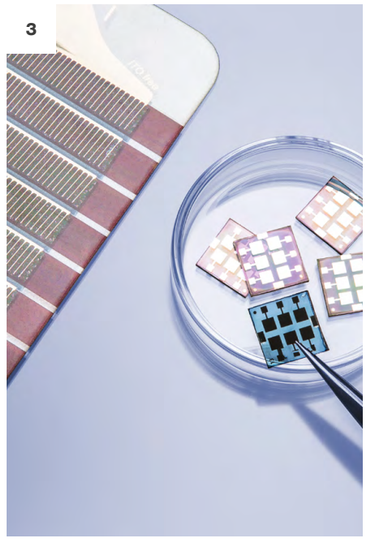

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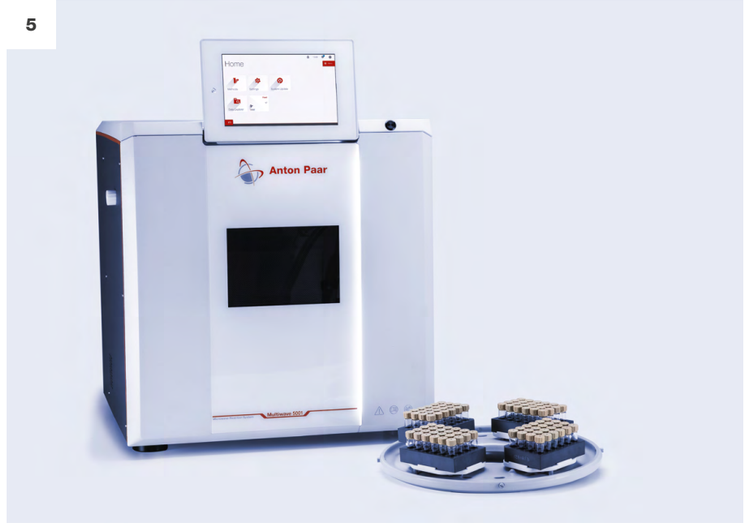

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Still Looking for Your Perfect Application?

Discover the world of microwave synthesis:
www.anton-paar.com/synthesis

Find the right reaction conditions in our application database. Explore our collection of over 3,500 chemical reactions that have been successfully performed in our reactors.

For a quick start with sealed-vessel synthesis, use our protocol converter and find the right reactor with the help of our configuration finder.

FIND OUT MORE

www.anton-paar.com/apb-application-database

	Monowave 200	Monowave 400	Monowave 450	Monowave 400 R	Multiwave 5001
	↓	↓	↓	↓	↓
Max. MW power	850 W				2,000 W
Max temp.	260 °C (upgradable)	300 °C			260 °C
Max. pressure	20 bar (upgradable)	30 bar			60 bar
Vessels	-				100 mL
Glass vials	4/10/30 mL	4/10/30 mL 30mL Wide-neck			5 mL
SiC vials*	10 mL	10 mL 30 mL Wide-neck			-
Operation volume	0.5 mL to 20 mL				0.3 mL to 60 mL
Camera	No	Yes	Yes	No	Optional
Fiber optic sensor	Optional				No
Automation	No (upgradable)	Optional	Yes	Optional	n.a.
Raman connectivity	No	No	No	Yes	No
Stirring	0 rpm to 1,200 rpm				Low / High

* SiC vials cannot be used simultaneously with Raman probe in Monowave 400 R

Reliable.
Compliant.
Qualified.

FIND OUT MORE

www.anton-paar.com/service

Our well-trained and certified technicians are ready to keep your instrument running smoothly.

Maximum uptime

Warranty program

Short response times

A global service network

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