



CEM Academic Solutions

Microwave Synthesis Systems and Teaching Materials
for Graduate Research and Undergraduate Instruction

CEM

Why teach with a laboratory microwave?

Bring real world experience into the teaching laboratory with state-of-the-art tools like the ones your students will encounter in graduate school and the workplace.

Perform reactions 10 – 1,000 times faster than conventional heating

Microwave heating allows students to complete purification and analysis in the same lab period. The shortened reaction time also provides them with the opportunity to perform difficult or multi-step syntheses in the undergraduate lab.

Achieve greater yields and increased purities

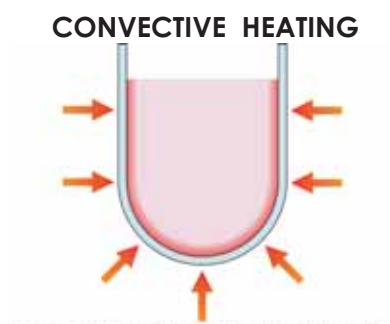
Microwave energy transfers to the reactants rapidly, giving side reactions very little opportunity to form and resulting in greater yields of the target product.

Implement green chemistry principles

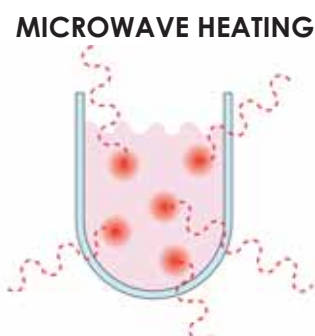
Microwave reactions use less solvent than conventional reactions, and in some chemistries, less hazardous solvents or even water may be used and still produce great results.

Enhance the safety of your lab

Laboratory grade microwave systems provide monitoring and feedback control of temperature, pressure, and stirring to ensure maximum safety and reproducibility in the lab.



Energy is transferred indirectly to the reactants by applying heat to the outside surface of the vessel. This form of heating is very slow and inefficient.



Since the vessel wall is virtually transparent to microwaves, energy is directly absorbed by the reaction, providing instantaneous activation or localized superheating of the molecules in solution. This direct molecular activation limits side reactions and provides a fast and efficient form of heating.

Microwave vs. Conventional Reflux Heating for Organic Experiments

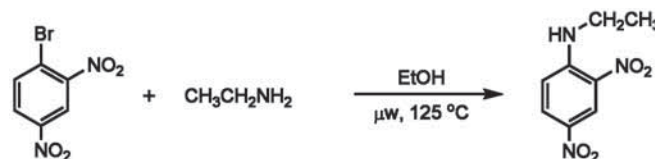
Experiment Type	Reflux conditions	Microwave conditions
Diels-Alder	90 minutes in DMF	10 minutes in H ₂ O
Williamson Ether Synthesis	60 minutes in H ₂ O	10 minutes in H ₂ O
Aldol Condensation	23 hours in H ₂ O	15 minutes in H ₂ O
Bromination	45 minutes in HOAc	8 minutes in HOAc
Nucleophilic Aromatic Substitution	60-90 mins in Toluene	10 minutes in EtOH / H ₂ O
Hydrolysis	34 hours in MeOH / H ₂ O	9-15 minutes in MeOH / H ₂ O

Microwave Solutions for Your Lab

CEM offers two microwave platforms for synthetic chemistry: the **MARS 6** and the **Discover SP**. The MARS 6 is a parallel reactor designed for batch processing of reactions. The ability to run multiple reaction vessels simultaneously is advantageous for large teaching laboratories, as it only takes 30 minutes to complete a set of 24 vessels. The Discover SP is a sequential system, which is best suited for a smaller class size, but can be utilized in a larger lab section where students work in groups. The advantage of the Discover SP for the teaching environment is that sequential processing of reactions minimizes the backlog on other equipment.

Nucleophilic Aromatic Substitution

Complete in 10 minutes or less in the microwave!



Microwave	Reaction Vessels	Solvent	Reagents		Reaction Time	Cool-down Time
		Ethanol	1-Bromo-2,4-dinitrobenzene	Ethylamine (70% aqueous)		
MARS 6	24	5 mL	0.298 g	0.380 mL	10 minutes	20 minutes
Discover SP	12	3 mL	0.298 g	0.380 mL	6 minutes	2 minutes

*Leadbeater, N. E.; McGowan, C. B. Clean, Fast Organic Chemistry: *Microwave-assisted laboratory experiments*. 2006, CEM Publishing.



MARS 6

The best-selling MARS 6 is a multimode microwave system that provides parallel reaction processing, making it ideally suited for teaching laboratories. With the ability to accommodate up to 36 pressurized vessels or up to a 5 L open flask, the MARS 6 offers both high-throughput for larger lab sections and flexibility to run batch syntheses.

In addition to accommodating synthetic chemistry, the MARS 6 can also be used for solvent extraction and acid digestion for metals analysis.



Discover SP

The Discover SP is a single mode, sequential microwave system which allows significant flexibility in the teaching lab, as students can explore different reaction parameters and work with various substrates and solvents. The sequential format is ideal for classes of 12 students or less, but also fits in classes with a larger number of students who work in groups.

The Discover SP is the system of choice for research laboratories performing initial investigative syntheses and chemistry optimization with a variety of accessories available, including automation decks.

Teaching

A State of the Art Microwave Synthesis System for Your Laboratory

Features

1800 WATTS DELIVERED ENERGY

Highest available power for rapid heating of reactions regardless of the number of vessels in the cavity

LARGEST MICROWAVE CAVITY

Allows for the greatest range of reaction vessels

- Up to 36 pressurized vessels
- Up to a 5 L open flask

RUGGED, HIGH-GRADE 316 SOLID-STEEL CAVITY

Multi-layer Teflon® coating provides maximum protection against corrosion

HEAVY-DUTY, SPRING-MOUNTED, PRESSURE RELIEVING DOOR WITH SAFETY INTERLOCKS

SOLVENT- AND IMPACT-RESISTANT COMPOSITE SHELL

Superior system protection from a laboratory environment than painted metal wraps

SPECIALLY DESIGNED CAVITY & WAVEGUIDES

Ensures uniform distribution of microwave energy without need of a mode stirrer

HIGH-RESOLUTION, FULL COLOR TOUCHSCREEN WITH SPEAKERS

No need for a laptop or external controller

INTUITIVE SOFTWARE CONTROL

Quickly program new methods, load existing methods, and recall run data

FIBER OPTIC AND IR TEMPERATURE CONTROL AVAILABLE

SAFETY CONTROLS

Sensor and feedback monitoring to prevent vessel events for maximum operator safety

8 GIGABYTE MEMORY

Ample data storage space

CONNECTIVITY

Available ports: 5 USB, 1 USB-B, 2 Ethernet, and 1 RS-232

ONBOARD TRAINING VIDEOS

Learn how to properly assemble vessels and operate a MARS 6



Vessel Options for the MARS 6 Synthesis System

Vessel Type	Max. number of vessels per run	Volume	Max. Temp. (°C)	Materials of Construction
Open flask	1	Up to 5 L	Reflux	Glass
GlassChem™	24 or 36	20 mL	180	Glass
GreenChem™	14	100 mL	200	Teflon or Glass
EasyPrep™	12	100 mL	300	Teflon

Enhanced stirring for homogenous sample mixing.



Atmospheric Pressure Vessel Kit

Each kit includes a 3 L and a 5 L vessel. Also included are extenders, adapters (specific to each vessel) and a vessel stand. The adapters' side port allows for placement of the temperature probe in the reaction vessel to control the reaction conditions.



GlassChem Vessels

The **GlassChem™** vessels are engineered with a simple screw cap design for ease of use while still providing the temperature and pressure capabilities necessary to perform a full range of experiments in the teaching lab.

Reinforced composite sleeves surround each individual vessel, protecting the cavity and user for maximum safety. A Teflon® turntable shield ensures the vessels are properly seated and secured throughout the run.

This simple to use vessel permits reaction conditions of up to 180 °C and 200 psi. It is designed for undergraduate teaching as well as research. These vessels are available in starter kits of 8, 16, 24, or 36 vessels. Each kit includes a control vessel to provide precise control of reaction conditions.



GlassChem
20 mL vessel
with Stir Bar



GlassChem
20 mL control
vessel

Teaching & Research

Advanced Microwave Technology for Greater Flexibility

Features

300 WATTS OF FOCUSED ENERGY

Efficient power delivery for maximum reaction control

SELF-TUNING WAVEGUIDE

Adjust for changing chemical properties to optimally heat sample

ACTIVENT™ PRESSURE RELIEF

Programmable reaction venting to release gaseous byproducts and reduce vessel failures

VOLUME-INDEPENDENT TEMPERATURE MEASUREMENT

Reduces the number of vessels needed to accommodate a large working volume

300 mL MICROWAVE CAVITY

Large cavity provides unprecedented access and vessel flexibility

WORKING VOLUME

- 0.2 – 50 mL pressurized
- 0.2 – 75 mL reflux

POST-REACTION COOLING

Rapidly quench reactions upon completion

SOFTWARE & KEYPAD CONTROL

Intuitive Synergy™ software and backup control

AUTOMATION

Allows unattended operation and prevents down-time between reactions

EASIEST-TO-USE VESSELS

Snap-on caps
No tools needed for assembly

ACCESSORIES

Provides the utmost flexibility in chemistry exploration

- 80 mL pressurized glass vessel for scale up
- Continuous flow cells
- Camera for real-time reaction viewing
- Gas addition for reactions with gaseous reagents
- Low temperature reactions (as low as -80 °C)
- Automation decks
- Fiber optic temperature monitoring



10 mL



35 mL

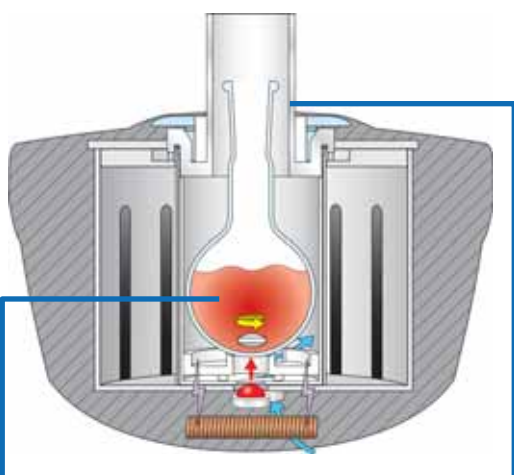


Fiber Optic Temperature Control

Fiber Optic Temperature Control provides the most precise temperature measurement available by directly measuring the temperature inside the reaction vessel. It can be used with 10 mL or 80 mL reaction vessels designed for this purpose, as well as with the 80 mL vessel. Other accessories, including the CoolMate™ and Gas Addition Kit use this type of temperature measurement.

Open Vessel Reactions

Discover SP is the only single-mode microwave synthesis system capable of also performing open vessel reactions using standard laboratory glassware and condensers. Discover SP accepts up to a 125 mL round-bottom flask and allows reagent addition and overhead stirring. It can be used with or without a reflux condenser. Temperature can be measured using either the built-in IR sensor or the optional Fiber Optic Temperature Control.



Use round-bottom flask up to 125 mL

Open Vessel Attenuator

Advantages of Open Vessel:

- Use standard glassware
- Work on a larger scale
- No risk of pressure build-up
- Easy access to reaction for reagent addition or reaction sampling
- Use of overhead stirring for viscous mixtures



Resources at Your Fingertips

Whether you're teaching general chemistry, organic, inorganic, quantitative analysis, or an advanced course, we have the resources to help you every step of the way.

- Teaching Manuals
- Microwave Experiments
- Books on Microwave Chemistry
- Application Notes
- Reference Lists
- And more!



Visit us online today at www.cem.com/academic.



Scan to visit our Academic Resource Center.

Why choose CEM?



We can help

As the leading provider of microwave laboratory systems in the world, we have more than 35 years of experience designing and manufacturing products of superior quality, performance, and reliability. Our applications chemists and service engineers are well known for their expert and timely assistance, ensuring that laboratories using CEM instruments are always running the chemistry needed to get results, fast.

Your partner in academic research and teaching

CEM is a company driven by scientists and their vision. We understand the challenges facing today's academic community and we are committed to supporting educational initiatives aimed at helping students and professors achieve outstanding results in their laboratory.

Resources at your fingertips

Whether you're teaching general chemistry, organic, inorganic, quantitative analysis or an advanced majors' course, we have the microwave system and resources you need to get started today.

Have questions?

Contact us!

We can help you determine which system would be right for your research.

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