



# NEOS-GR

Rapid, Solvent-Free Extraction  
by Microwave Hydrodiffusion  
and Gravity (MHG)

# NEOS-GR

## Microwave Hydrodiffusion and Gravity (MHG) System

The NEOS-GR is the result of a partnership between Milestone and the Université d'Avignon et des Pays de Vaucluse, France, which led to the grant of the European patent EP 1 955 749 A1.

The NEOS-GR is based on the MHG technology (Microwave Hydrodiffusion and Gravity) a new and green technique for the extraction of essential oils from different kinds of aromatic plants.

\*This green extraction is an original "**upside down**" microwave alembic combining microwave heating and earth gravity at atmospheric pressure. Based on a relatively simple principle, this method involved placing plant material in a microwave reactor, **without adding any solvent or water**.

The internal heating of the *in-situ* water within the plant material distends the plant cells and leads to the rupture of glands and oleiferous receptacles.

The physical phenomenon, known as hydrodiffusion, allows the extract (water and essential oil) diffused outside the plant material, to drop by **earth gravity** out of the microwave reactor and fall through a perforated Pyrex disc.

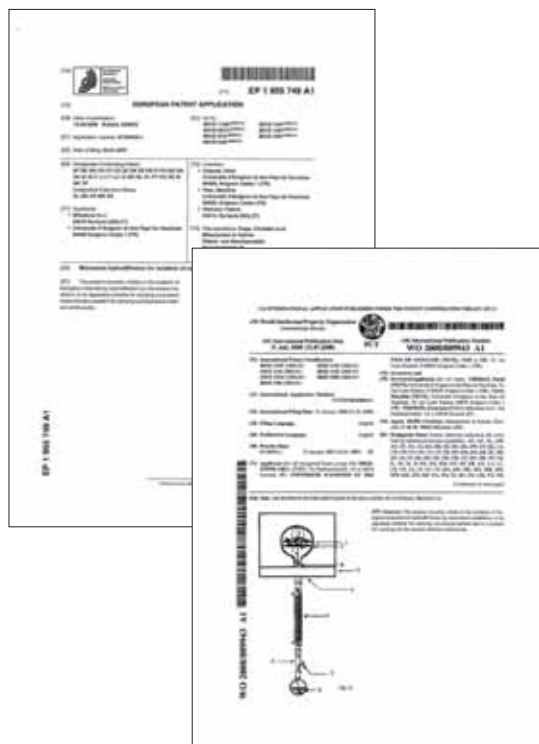
A cooling system outside the microwave oven cools the extract continuously. Water and essential oil are collected and separated in a vessel traditionally called the "Florentine flask".

It is important to note that this green method allows to extract essential oils without distillation and evaporation which are the most energy consuming between the unit operations.

The **distillation step** which can represent **up to 80%** of the total analytical procedure is **no longer required**.

Whereas traditional processes are carried out within **3 hours**, solvent-free microwaves hydrodiffusion plus gravity requires no more than **30 minutes**.

Once the essential oils have been extracted they can be analyzed directly by GC-MS without any preliminary clean-up or solvent exchange steps.



## NEOS-GR

**Extraction without distillation and evaporation**

**Recovery of high boiling point compounds  
(pigments, flavonoids, carotenoids)**

## NEOS-GR: one unit, two technologies

The NEOS-GR system is also suitable, with appropriate glassware, for carrying out extraction of essential oils by rapid distillation and evaporation according to the Solvent-Free Microwave Extraction (SFME) Technology.

See NEOS specific catalog for further information.



\*F. Chemat, M. Abert-Vian, Z. Huma

Chapter 1: Microwave-assisted separations: green chemistry in action.

"Green chemistry research trends". Edited by J.T. Pearlman Nova Science Publishers, New York, 2009. ISBN: 978-1-60692-092-3.

# The NEOS-GR system



High definition video system for visual control of process.



Icon-driven programs provide full control of the extraction method parameters.

Microwave labstation, microprocessor controlled with infrared automatic temperature system.



Samples are located in dedicated easy-to-handle glass modules. Loading/unloading of samples are immediate and easy.

Water cooled condenser.

Lab-grade water chiller for optimal extraction performance. (option)

Mobile module for flexibility of use.



Collected specimens.



# Typical applications

## \* Extraction of essential oils from rosemary: MHG vs Hydrodistillation

	MHG	HD
Sample amount (gram)	500	500
Time (min)	15	180
Yield (%)	0,33 ± 0,09%	0,35 ± 0,07%



## Extraction of essential oil from *Rosmarinus officinalis*

Compounds	MHG (%)	HD (%)
Monoterpene hydrocarbons	68.60	68.56
Oxygenated Monoterpenes	28.10	24.87
Sesquiterpene hydrocarbons	1.41	1.91
Oxygenate sesquiterpenes	0.25	0.26
Other oxygenated compounds	1.19	1.03
Extraction time (min)	15	180
Yield (%)	0.33±0.09	0.35±0.07
Total oxygenated compounds	29.54	26.16
Total non-oxygenated compounds	70.01	70.47

## \* Properties and activities of rosemary essential oils obtained by MHG and HD

	MHG	HD
Specific gravity	0,9	0,9
Refractive index	+1.468	+1.470
Optical rotation in degree	+2	+3
Colour	Pale yellow	Pale yellow
Odour	Fresh, light, freshly camphorated with a slight note of citrus, odour closed to fresh aromatic herbs	Freshly camphorated and citrus, boiled odour, different from fresh fruit
Anti-microbial activity	Inhibition zone diameter (mm +/- standard deviation) for tested micro-organism	
Staphylococcus aureus (Staphylococcaceae) Gram-positive bacteria (ATCC 6538)	17±0.5	12.5±0.4
Escherichia coli (Enterobacteriaceae) Gram-negative bacteria (ATCC 4157)	19.0±0.5	15.5±0.5
Saccharomyces cerevisia (Saccharomycetaceae) Yeast (ATCC 2601)	24.0±0.6	20.0±0.6
Antioxidant activity	Photochemiluminescence expressed as mmol equivalents of trolox per litre of sample standard deviation	
mmol Trolox/l	4.53±0.02	3.68±0.06

## Microwave hydrodiffusion and gravity vs. hydrodistillation\*\*

	<i>Mentha spicata</i> L.		<i>Mentha pulegium</i> L.	
	MHG	HD	MHG	HD
Extraction Time (min)	20	90	20	90
Yield (%)	0.60	0.59	0.95	0.90
Environmental impact (g CO <sub>2</sub> rejected)	160	2400	160	2400



## Citrus peels\*\*\*

Technique	MHG	HD
Sample amount (gram)	500	500
Time (min)	15	180
Yield (%)	1,0 ± 0,1%	1,1 ± 0,1%

\*Comparison of two isolation methods for essential oil from rosemary leaves: Hydrodistillation and microwave hydrodiffusion and gravity. *Food Chemistry* 114 (2009) 355-362.

\*\*Microwave hydrodiffusion and gravity, a new technique for extraction of essential oils. *Journal of Chromatography A* 1190 (2008) 14-17.

\*\*\*A new process for extraction of essential oil from Citrus peels: Microwave hydrodiffusion and gravity. *Journal of Food Engineering* 90 (2009) 409-413.

# Scientific papers on the NEOS-GR technology

## Microwave hydrodiffusion and gravity:

a new technique for extraction of essential oils. *Journal of Chromatography A* 1190 (2008) 14-17

A new process design and operation for the extraction of essential oils was developed. Microwave hydrodiffusion and gravity (MHG) is a combination of microwaves for hydrodiffusion of essential oils from the inside to the exterior of biological material and earth gravity to collect and separate. MHG is performed at atmospheric pressure without adding any solvent or water. MHG has been compared with a conventional technique, hydrodistillation (HD), for the extraction of essential oil from two aromatic herbs: spearmint (*Mentha spicata* L.) and pennyroyal (*Mentha pulegium* L.) belonging to the Labiatae family. The essential oils extracted by MHG for **15 min** were quantitatively (yield) and qualitatively (aromatic profile) similar to those obtained by conventional hydrodistillation for **90 min**. MHG also prevents pollution through potential **90% of energy saved** which can lead to greenhouse gas emission benefits.



## Comparison of two isolation methods for essential oil from rosemary leaves:

hydrodistillation and microwave hydrodiffusion and gravity. *Food Chemistry* 114 (2009) 355-362



Traditional Hydrodistillation (HD) and innovative Microwave Hydrodiffusion and Gravity (MHG) methods have been compared and evaluated for their effectiveness in the isolation of essential oil from fresh *Rosmarinus officinalis* leaves. The microwave method offers important advantages over traditional alternatives, namely: shorter isolation times (**15 minutes against 3 h** for hydrodistillation), environmental impact (energy cost is fairly higher to perform HD than that required for rapid MHG isolation), cleaner features (as no residue generation and no water or solvent used), increases antioxidant activity and provides a **more valuable essential oil** (with high amount of oxygenated compounds).

It offers also the possibility for a **better reproduction of natural aroma** of the essential oil from rosemary leaves than the HD essential oil. Moreover, microwave procedure yielded essential oils that could be analysed or used **without any clean-up**, solvent exchange or centrifugation steps. Scanning electron microscopy shows important structural changes for MHG extraction in contrast to those obtained by HD.

## A new process for extraction of essential oil from Citrus peels:

microwave hydrodiffusion and gravity. *Journal of Food Engineering* 90 (2009) 409-413

The process uses the hydrodiffusion phenomenon generated by microwaves to extract essential oil from the inside of the biological material and gravity to collect and separate them. The present apparatus permits fast and efficient extraction, reduces waste, avoids water and solvent consumption, and allows substantial energy savings.



A microwave irradiation power of 500 W for 500 g of plant material was chosen as an optimum and permits in only 15 minutes to extract the essential oil completely.

MHG is clearly quicker than conventional HD, an extraction time of **15 min** with MHG provides yields comparable to those obtained after **180 min** by means of HD, which is the one of the reference methods in essential oil extraction. The overall yield of essential oil obtained from lime peels was 1.0 +/- 0.1% and 1.1 +/- 0.1% by MHG and HD, respectively. The essential oils of lime peels extracted either by **MHG, HD or CP are rather similar in their composition and contains the same dominant components**.

## Clean recovery of antioxidant flavonoids from onions:

optimising solvent free microwave extraction method. *Journal of Chromatography A* 1216 (2009) 7700-7707



A solvent free microwave hydrodiffusion and gravity extraction (MHG) of flavonol content from onion (*Allium cepa* L.) was studied. Effectiveness of this innovative method in extraction of onion total phenolic content, total quercetin (TQ), quercetin aglycon (QA), quercetin-3,4'-diglucoside (QDG), quercetin-4'-monoglucoside (Q4G), quercetin-3-monoglucoside (Q3G), kaempferol (KMF) and myricetin (MRT) have been evaluated and compared with conventional solvent extraction.

Microwave extraction offers important advantages like **shorter extraction time (23 min)**, cleaner feature (no solvent or water used) and extraction of valuable onion crude juice retaining fresh organoleptic properties with higher phenolic content (58.29 mg GAE/ gDW) at optimized power (500 W). Microwave extraction resulted **significant yield (81.5%) with 41.9% of flavonol** contents, with better retain of remaining flavonoids (55.9%) in residues of onions.

## The simplicity of the NEOS-GR



T/T Programs



Power/Time Programs



Favorites



User Programs



Notes

Through a touch screen, the icon-driven NEOS-GR, can run any protocols both for time-at-temperature or for microwave power and time.

## Documenting NEOS-GR protocols

Through a USB port, programs can be easily uploaded and downloaded for documentation and QC purposes.



## The advantages of NEOS-GR

- No Solvents – Green Chemistry
- Shorter extraction time (minutes)
- Recovery of high boiling point compounds
- Less work-up. Absence of solvents.
- Higher purity of extracts



## More about NEOS-GR ?

Just log-in at [www.milestonesrl.com/essential](http://www.milestonesrl.com/essential) for scientific papers published in major journals using the technologies of the NEOS and NEOS-GR System.



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