Dekati® Oxidation Flow Reactor DOFR™

- Compact oxidation flow reactor for secondary aerosol formation studies
- Ideal for transient emission studies
- Adjustable oxidation parameters for PAM studies
- Constant reactor residence time and high outlet sample flow for multiple instruments

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Excellence in Particle Measurements

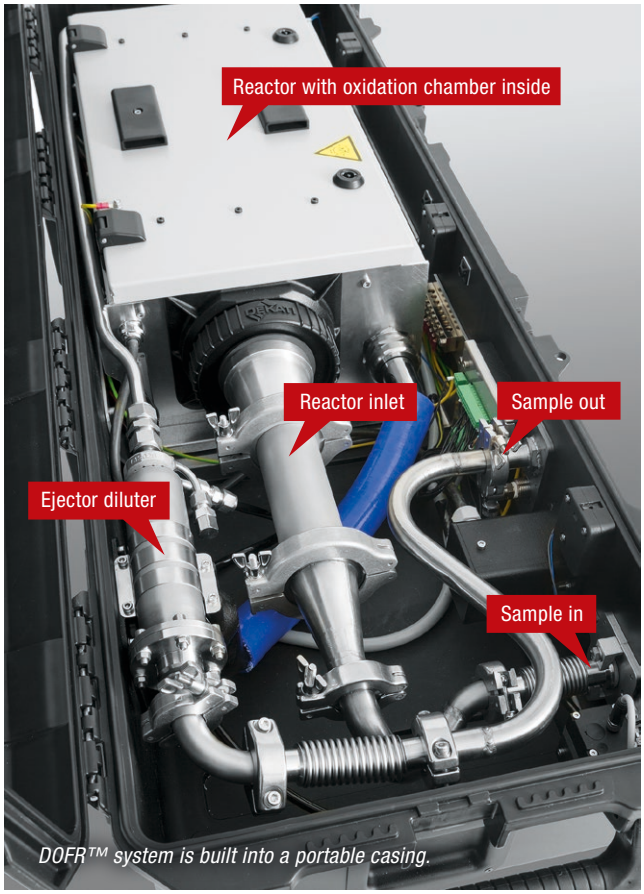
Dekati®
Oxidation Flow Reactor
DOFR™

Description

Dekati® Oxidation Flow Reactor, DOFR™, is a constant flow oxidation flow reactor for secondary aerosol (SA) formation studies. The formation of secondary aerosols can take several days in the atmosphere and the purpose of the oxidation flow reactor is to speed up these processes. In the Dekati® DOFR™, the formation processes are accelerated by creating highly oxidative conditions for the aerosol sample and the time-scale is reduced from days to less than one minute. The flow through the oxidation chamber is kept constant and laminar, resulting in minimal particle losses. All these features make the DOFR an ideal tool for PAM (Potential Aerosol Mass) measurements and SA formation research.

In the DOFR™, the aerosol sample passes through a laminar flow reactor where it is exposed to high intensity UV radiation. The UVC radiation together with water molecules and ozone in the sample* create highly oxidative conditions inside the reactor speeding up the formation of secondary aerosols. The size, concentration and mass of the aerosol is then monitored with a particle measurement instrument connected at the outlet of the reactor. For example, the Dekati® ELPI®+ (Electrical Low Pressure Impactor) is well suited for monitoring the particle size distribution and concentration in real time after the reactor. The key advantage of the Dekati® DOFR™ is its very low aerosol sample residence time. This short residence time together with the laminar flow profile inside the reactor make the DOFR™ an ideal tool to study even transient emission sources such as engine tailpipe emissions in variable driving conditions.

* Humidifier and O_3 generator not included in the DOFR™



DOFR™ system is built into a portable casing.

Operating principle

The Dekati® DOFR™ design and operation is based on the TSAR system** (Tampere Secondary Aerosol Reactor) designed in the Tampere University of Technology (nowadays Tampere University) in 2015. The system consists of a sample inlet, a reactor chamber with 12 UVC-lamps and an ejector diluter. The sample first passes through the reactor inlet that is designed to ensure laminar flow through the reactor itself. After the inlet part, the sample enters the oxidation chamber that is made of clear glass and surrounded by 12 UVC-lamps operating at 254 nm. Each of the lamps can be switched ON/OFF to change the intensity of the UVC light which is then measured with a built in UV-sensor inside the unit. An ejector diluter placed right after the oxidation chamber acts as a pump and generates a constant flow through the inlet and the reactor chamber. The ejector diluter additionally dilutes the sample that is then lead to particle measurement instruments such as the ELPI®+ to determine particle size distribution and concentration.

The complete DOFR™ system is built into a portable and robust casing that can easily be transported between measurement locations. The system has a modular design making it easy to detach different components of the unit for maintenance and cleaning. A separate pre-conditioning unit with e.g. ozone production will be available at a later date and it is fully compatible with the DOFR™.

** Simonen, P., Saukko, E., Karjalainen, P., Timonen, H., Bloss, M., Aakko-Saksa, P., Rönkkö T., Keskinen J. & Dal Maso, M. 2017. A new oxidation flow reactor for measuring secondary aerosol formation of rapidly changing emission sources. Atmospheric Measurement Techniques, 10, 1519-1537, doi:10.5194/atm-10-1519-2017

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Applications

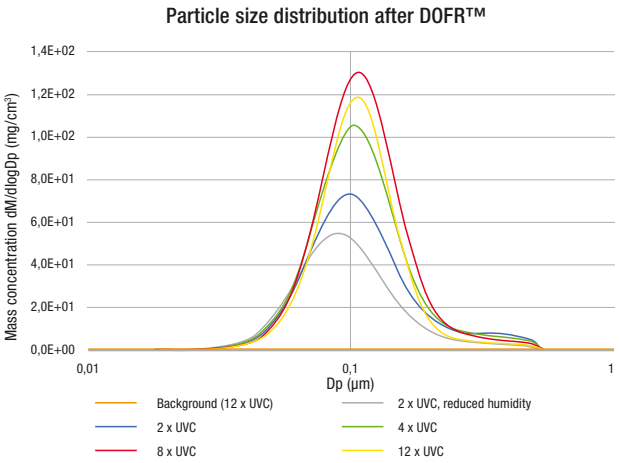
- Secondary aerosol formation research
- PAM measurements
- Transient emission source measurements
- Engine tailpipe emission research
- Marine engine studies
- Aircraft emission research
- Stationary source emissions studies

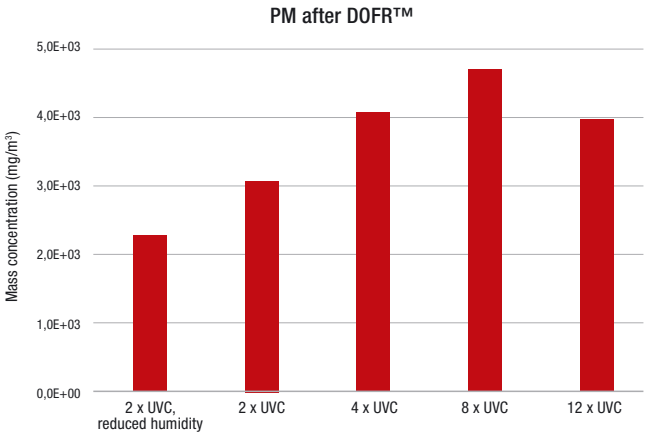
What is secondary aerosol?

Term secondary aerosol is used to refer to the particulate mass that is formed through chemical reactions in the atmosphere, long after the actual emission from the source into the air. Secondary aerosol is formed when volatile compounds originated from the source react in the atmosphere with highly reactive oxidative species and form new compounds. The volatile compounds that have potential to form new compounds are called precursors, and they can be either organic or inorganic molecules. When the precursor compounds and the oxidative species react, they form new compounds that can have lower volatility than the original precursor molecules emitted from the source. These newly formed low volatility compounds can then form new particles via nucleation or grow existing particles via condensation. This process is called aging of the aerosol and the potentially formed aerosol mass is commonly referred to as PAM (Potential Aerosol Mass), and the DOFR™ is designed to determine the maximum PAM for the source aerosol in a matter of minutes by adjusting different oxidation parameters.

Features

- Fast oxidation flow reactor for secondary aerosol formation studies
- Design based on the TSAR reactor developed by Tampere University
- Constant reactor flow with short sample residence time
- Up to 1 month photochemical age for aerosol
- Laminar sample flow with negligible fine particle losses
- High output sample flow for measurement instruments
- Adjustable UV intensity with 12 UVC lamps operating at 254 nm
- Integrated UV sensor for light intensity measurement included
- Integrated cooling for UV lamps included
- Integrated ejector diluter for diluting the sample for measurement instruments and flow control included
- Compact, portable design
- Separate sample conditioning unit with primary dilution, humidity adjustment, ozone generation and RH and O_3 sensors available soon. Sample conditioning unit is fully compatible with the DOFR™ system.





Example of vehicle exhaust measurements: particle size distributions and PAM measured with HR-ELPI®+ after DOFR™ with different UVC intensity settings.

Dekati® Oxidation Flow Reactor DOFR™

Specifications

Sample temperature	0 - 40 °C
Sample pressure	Ambient
Sample residence time	~ 40 s
Photochemical aging time	Adjustable, up to 1 month
Inlet/sample flow rate	Recommended ~ 5 lpm*. Inlet flow can be adjusted by adjusting the ejector diluter operating pressure (also affects dilution factor).
Outlet flow rate	~ 50 lpm*
Dilution factor	~10*
Dilution air	Clean and dry dilution air, 5 bar abs., max 60 slpm
Dilution air connection	G1/4" female, quick connector included
UV source wavelength	254 nm
Power requirements	110 W @ 230 V, 250 W @ 110 V
Weight	32 kg
Dimensions	W120 x L42 x H24 cm
Oxidation chamber volume	~3 ltr
Sample inlet/outlet	NW16 flange, additional tube connectors included

* Each unit is individually calibrated. Instrument specific values can be found in the calibration data sheet provided with the instrument

DOFR™ oxidation chamber is made of clear glass and surrounded with 12 UVC lamps operating at 254 nm.

Recommended accessories

- Humidifier and RH sensor with flow control
- O_3 generator and sensor with flow control
- Primary dilution system. Requirements depend on the conditions, composition and concentration of the sampled emission. For example, the Dekati® eDiluter™ Pro is suitable for sample dilution and conditioning from variable sample conditions.

DOFR™ components

DOFR™ package includes laminar flow OFR, 12 UVC lamps, UV sensor for UVC intensity detection, ejector diluter for diluting the sample for particle measurement instruments and to maintain constant flow through the reactor, control unit for controlling the UVC intensity, logging UV sensor data and adjusting dilution air pressure.

Acknowledgements

The DOFR™ instrument originated through work carried out at the Aerosol Research Group at Tampere University, Tampere, Finland.

For more information, please contact:
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Dekati Ltd. is a world leader in designing and manufacturing innovative fine particle measurement solutions. We have over 25 years of experience in providing measurement instruments and complete measurement solutions to a wide variety of environments and sample conditions. All Dekati® Products are developed and manufactured in Finland and are available with up to five-year warranty.

ISO 9001
BUREAU VERITAS
Certification
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