Advanced in vitro exposure systems

Inhalation Toxicology
Skin Exposure
Auxiliary Equipment
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VITROCELL® Exposure Systems for Inhalation Toxicology

In vitro characterization of the effects of airborne substances

When you require a specific solution for your in vitro studies in the field of inhalation toxicology, talk to us with confidence. We have over a decade of experience in designing, producing and installing customized exposure systems specifically for your research needs.

VITROCELL® equipment offers you flexible solutions using biological systems for the accurate analysis of these airborne substances:

- Gases
- Complex mixtures
- Nanoparticles
- Fibers

Application Areas

- Combustion exhaust
- Cosmetics
- Household chemicals
- Indoor / outdoor air analysis
- Viruses
- Industrial chemicals
- Pesticides
- Pharmaceuticals
- Tobacco smoke (whole smoke and gas phase)
- E-cigarette aerosols

Direct Exposure Technology at Air/Liquid Interface

Primary cultures and cell lines, e.g. from the respiratory tract, can be observed in modules specifically designed for direct contact between cells and components of the test atmosphere at the air/liquid interface.

Features

- Direct exposure to monolayer cell cultures, tissue constructs, suspension cells or bacteria
- Dose-dependent results
- Highest levels of design and manufacturing quality
- Tailor-made solutions
- Installation and application support
**In vitro Inhalation Toxicology**

A typical system flow chart
In response to the scientific need to expose in physiologically relevant conditions, VITROCELL® exposure modules have been specifically designed and engineered to enable direct exposure of mammalian cells or tissue at the air/liquid interface where the cell systems are not covered with culture media. Researchers can thus use all cell types cultivated on microporous membranes. This approach allows for more credible and authentic results than by submerged exposure due to a closer replication of the human physiology.

The advantages:
- No losses
- No dissolution
- No reaction of constituents with culture media
- High sensitivity
The exposure of mammalian cells or tissues to airborne substances is frequently performed under submerged conditions. In doing so, the test substances are dosed into the culture media. This procedure results in an undesired interaction of the formerly airborne substances with the media, causing limitations for authentic analysis. Therefore VITROCELL® recommends the air/liquid interface exposure technology.
The culture media supply may be static (gravimetric/syringe method) or intermittent/continuous („CF“ type modules).

**VITROCELL® 12**
Static culture media supply

**VITROCELL® 12 CF**
Static, intermittent or continuous culture media supply

**VITROCELL® 6**
Static culture media supply

**VITROCELL® 6 CF**
Static, intermittent or continuous culture media supply
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**Legend:**  
- `x` = well suited  
- `xx` = particularly well suited
System Options for 6-well insert sizes

VITROCELL® 6 system setup with a number of different module options

A

**VITROCELL® 6/4 CF and 6/3 CF**

In one module 4 compartments are used for exposure to the substances and in another module 3 compartments for clean air control.

1–4 compartments of the exposure module may be equipped with Quartz Crystal Microbalance sensors for validation or monitoring purposes.

B

C

**VITROCELL® 6/6**

In this configuration there is the option to assess 3 different doses @ 3 replicates plus one row of compartments @ 3 replicates for clean air control. One compartment for each row for exposure may be equipped with a Quartz Crystal Microbalance sensors for validation or monitoring purposes.

**VITROCELL® 6/3 CF**

In this configuration 2 VITROCELL® 6/3 CF modules are used: One module houses 3 compartments for exposure, a second VITROCELL® 6/3 module takes care with it’s 3 compartments for clean air control.
Delivery Content

1. **Vacuum Pump**
   The vacuum diaphragm pumps supplied by VITROCELL® have been developed and manufactured to be chemically resistant. Thus, they are suitable for aggressive or corrosive gases and vapors alike. The dry-running devices are specifically developed for laboratory applications and are maintenance-free. The pump exhaust line must be guided to a laboratory hood for proper extraction.

2. **Vacuum Calibration Valve**
   VITROCELL® flow calibration valves regulate the flow of the aerosol through the modules in the ml range. The valves are located between the vacuum pump and the aerosol exposure top. Mass flow meters enable accurate valve read-outs. The consistent and adjustable flow rate ranges from 0...20 ml/min. Alternative flow rate ranges are available upon request. The valves enable fast control of the flow rates prior to the experiment. They are manufactured from Teflon/stainless steel and can be easily cleaned. If the aerosol contains particles, we recommend installing disposable microfiber filters in front of the valves.

3. **Flow Meter**
   Mass flow meters are required to adjust the vacuum flow by means of vacuum calibration valves and to accurately set dilution and aerosol generator air flows. They are available in various ranges.

4. **Flow Controller**
   Mass flow controllers have been specifically designed to regulate dilution and aerosol generator airflow precisely. They are available various l/min. ranges.

5. **Water Bath**
   VITROCELL® uses water baths to efficiently heat and pump water through the circuit of the exposure modules, ensuring accuracy in temperature control with a modern state-of-the-art design. These units provide best-in-class economical performance while remaining user-friendly by reducing unnecessary functions and focusing on reliability. Engineered from highest-quality components and materials, such as stainless steel for the baths, durable heating thermostats with a long operation life are guaranteed.

6. **Option: Quartz Crystal Microbalance Sensor System**
   VITROCELL® Microbalance Sensor – optimal for dose-response measurement. With the advanced VITROCELL® software, deposition data in ng/cm² is attainable online.
Option: High voltage charging for enhanced particle deposition

The VITROCELL® 6/3, 6/4 and 6/6 CF modules can be equipped with electrodes for high voltage charging to increase particle deposition efficiency significantly.

Features

- Suitable for COSTAR®, FALCON® and ThinCert® 6-well sized cell culture inserts
- Adaptors for 12 and 24-well sized inserts
- Individual media inlets and outlets for each cell culture insert compartment
- Special inlet geometry of the aerosol exposure top for optimal particle deposition
- Inlets made of stainless steel with a unique VITROGLIDE surface treatment
- Base module made of electropolished stainless steel
- Base module and aerosol exposure top with integrated water heating circuit
- Control window for monitoring culture media levels
- Autoclavability of all components
- Suitable for VITROCELL® Quartz Crystal Microbalance
The VITROCELL® 6 CF module system has been specifically designed and engineered to facilitate the research of mammalian cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control. The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile is obtained in one experiment.

The cells are exposed at the air/liquid interface on cell culture inserts using low flow rates of the aerosol.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply
The media is supplied to the module by gravimetric method, syringe or using a media pump for intermittent/continuous media exchange.
Base module

The base module is made of electropolished stainless steel for maximum durability and is fully autoclavable for 20 min. at 120 °C and higher temperatures. A constant temperature within the unit (37 °C / 99 °F) is assured via water circuit heating. Therefore, an additional incubator is not required during exposure.

The media are supplied individually to each well compartment.

Optionally, media exchange can be carried out on a continuous basis using a precision media pump.

This module is renowned in scientific circles for its reliability and durability.

Aerosol exposure top

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlet-stream flows through specifically shaped inlets. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nanoparticles.

The aerosol inlets are connected to the distribution or dilution systems.

Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively.

The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum.

Universal Module with optional adaptor sets for:
- 12-well sized inserts
- Snapwell® inserts
- 24-well sized inserts
- 35 mm Petri dishes (AMES test)

Optional media inserts for media volume reduction units (10.8 ml) (static supply only for easier maintenance)

Optional microbalance sensor for dose monitoring

Cell culture insert (6-well size)
Options for 3, 4 and 6 cell culture compartments

VITROCELL® 6/3 CF  VITROCELL® 6/4 CF  VITROCELL® 6/6 CF

Option: High voltage charging for enhanced deposition

The VITROCELL® 6/3, 6/4 and 6/6 CF modules can be equipped with electrodes for high voltage charging to increase deposition efficiency significantly.

Features

- Suitable for COSTAR®, FALCON® and ThinCert® 6-well sized cell culture inserts
- Adaptors for 12 and 24-well sized inserts
- Individual media inlets and outlets for each cell culture insert compartment
- Special inlet geometry of the aerosol exposure top for optimal particle deposition
- Inlets made of stainless steel with a unique VITROGLIDE surface treatment
- Base module made of electropolished stainless steel
- Base module and aerosol exposure top with integrated water heating circuit
- Control window for monitoring culture media levels
- Autoclavability of all components
- Suitable for VITROCELL® Quartz Crystal Microbalance
The VITROCELL® 6 modules can be equipped with microbalance sensors.
VITROCELL® 6/6
Exposure Module

For 6 cell culture inserts (6-well size)

The VITROCELL® 6/6 module system has been specifically designed and engineered to facilitate the research of mammalian cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Normally only one system is required: 1 dilution with 3 inserts is used for exposure to the substances and 3 inserts in the same system for clean air control.

The cells are exposed at the air/liquid interface on 6 cell culture inserts using low flow rates of the aerosol.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply
The media is supplied to the module by gravimetric method, syringe or using a media pump for intermittent/continuous media exchange.
**Base module**

The base module has been designed for 6 cell culture inserts.

The media are supplied individually to each well compartment. Optionally, media exchange can be carried out on a continuous basis using a precision media pump.

Temperature is electronically controlled at 37°C (99°F) by means of a heated base plate. Therefore, an additional incubator is not required while using this module. The base module is made of electropolished stainless steel. It is autoclavable at 121°C (250°F) for 20 min. This module is renowned in scientific circles for its reliability and durability.

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlet-stream flows through specifically shaped inlets. They are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nanoparticles.

The aerosol inlets are connected to the distribution or dilution systems. Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively. The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum.

**Features**

- Suitable for COSTAR®, FALCON® and ThinCert® 6-well sized cell culture inserts
- Individual media inlets for each row of 3 insert compartments
- Base module made of stainless steel for maximum durability
- Control window for monitoring culture media levels
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Available inlet materials: Stainless steel, stainless steel with unique VITROGLIDE surface treatment
- Heating base plate with electronic control
- An additional incubator is not required while using this module
- Autoclavable at 121°C (250°F)
VITROCELL® 6/48 Climatic Chamber Exposure Module

For 48 cell culture inserts (6-well size)

The cells are exposed at the air/liquid interface on 48 cell culture inserts using low flow rates of the aerosol. A complete dose/response profile can be obtained in one experiment.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

The VITROCELL® 6/48 module system has been specifically designed and engineered to facilitate the research of mammalian cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Only one system is required: 7 dilutions with 6 inserts are used for exposure to the substances and 6 inserts in the same system for clean air control.
**Base module**

The base module has been designed for 48 cell culture inserts.

The media is supplied individually to each well compartment.

Temperature is electronically controlled at 37° C (99° F) by means of a heated base plate. Therefore, an additional incubator is not required while using this module. The base module is made of aluminum with media compartments of stainless steel. It is autoclavable at 121° C (250° F) for 20 min.

This module is renowned in scientific circles for its reliability and durability.

**Aerosol exposure top**

The docking station with special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlet-stream flows through specifically shaped inlets. They are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nanoparticles.

The aerosol inlets are connected to the distribution or dilution systems. Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively. The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum and titanium.

**Features**

- Suitable for COSTAR®, FALCON® and ThinCert® 6-well sized cell culture inserts
- Base module compartments made of stainless steel for maximum durability
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Available inlet materials: stainless steel, stainless steel with unique VITROGLIDE surface treatment
- Heating base plate with electronic control
- An additional incubator is not required while using this module
- Option: VITROCELL® AMES 6/48 Plus with 7th row for dosimetry (for liquid trapping or microbalance)
- Autoclavable at 121° C (250° F)
Refined detail solutions

Vacuum quick connector strips for fast exchange of exposure tops with alternative inlet sizes

Heavy duty column guided lifting-closing mechanism for precise dosing

VITROCELL® 48 PLUS
with 7th row for liquid trapping or microbalance

Exposure module with 7th row on drawer

Optional microbalance sensor in 7th position

For Dosimetry
7 doses @ 7 replicates
1 control @ 7 replicates

Technical Data

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System Options for 12-well insert sizes

**VITROCELL® 12 system setup with a number of different module options**

1. **VITROCELL® 12/6 CF**
   In this module 3 compartments are used for exposure to the substances and 3 compartments for clean air control. 1-3 compartments for exposure may be equipped with Quartz Crystal Microbalance sensors for validation or monitoring purposes.

2. **VITROCELL® 12/4 CF and 12/3 CF**
   In this configuration 2 separate modules are used: The VITROCELL® 12/4 CF module houses 3 compartments for exposure plus one for the Quartz Crystal Microbalance sensor. A second VITROCELL® 12/3 module takes care with its 3 compartments for clean air control.

3. **VITROCELL® 12/12**
   In this configuration there is the option to assess 3 different doses @ 3 replicates plus one row of compartments @ 3 replicates for clean air control. One compartment for each row for exposure may be equipped with a Quartz Crystal Microbalance sensor for validation or monitoring purposes.
Delivery Content

**1 Vacuum Pump**
The vacuum diaphragm pumps supplied by VITROCELL® have been developed and manufactured to be chemically resistant. Thus, they are suitable for aggressive or corrosive gases and vapors alike.

**2 Vacuum Calibration Valve**
VITROCELL® flow calibration valves regulate the flow of the aerosol through the modules in the ml range. The valves are located between the vacuum pump and the aerosol exposure top. Mass flow meters enable accurate valve read-outs. The consistent and adjustable flow rate ranges from 0…20 ml/min.

**3 Flow Meter**
Mass flow meters are required to adjust the vacuum flow by means of vacuum calibration valves and to accurately set dilution and aerosol generator air flows. They are available in various ranges.

**4 Flow Controller**
Mass flow controllers have been specifically designed to regulate dilution and aerosol generator airflow precisely.

**5 Water Bath**
VITROCELL® uses water baths to efficiently heat and pump water through the circuit of the exposure modules, ensuring accuracy in temperature control with a modern state-of-the-art design. These units provide best-in-class economical performance while remaining user-friendly by reducing unnecessary functions and focusing on reliability. Engineered from highest-quality components and materials, such as stainless steel for the baths, durable heating thermostats with a long operation life are guaranteed.

**6 Option: Quartz Crystal Microbalance Sensor System**
VITROCELL® Microbalance Sensor – optimal for dose-response measurement. With the advanced VITROCELL® software, deposition data in ng/cm² is attainable online.
VITROCELL® 12/3 and 12/4 CF Stainless Steel Exposure Module

For 3 or 4 cell culture inserts (12-well size)

The VITROCELL® 12 CF module system has been specifically designed and engineered to facilitate the research of human cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control.

The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile is obtained in one experiment.

The cells are exposed at the air/liquid interface on 3 cell culture inserts using low flow rates of the aerosol.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply

The media is supplied to the module by gravimetric method, syringe or using a media pump for intermittent/continuous media exchange.
Base module

This module’s casing is made of electropolished stainless steel. It is designed with three or four compartments for 12-well cell culture inserts and is fully autoclavable at 121°C (250°F) for 20 min. Through the employment of a special adapter set, this module can also be flexibly combined for use with 24-well cell culture inserts. A constant unit temperature is guaranteed using a regulated flow of temperature-controlled water through the module.

Available adaptor set for:
- 24-well sized inserts

The media can be supplied individually to each well compartment. Flexible media exchange can be static, intermittent or continuous basis. This flexibility is afforded by use of a precision media pump. This module is renowned in scientific circles for its reliability and durability.

Aerosol exposure top

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlet-stream flows through specifically shaped inlets. They are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nanoparticles.

The aerosol inlets are connected to the distribution or dilution systems. Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively.

The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum.
Option for 4 cell culture compartments

VITROCELL® 12/4 CF

VITROCELL® 12/4 CF base module

Option for microbalance sensor

Media insert for VITROCELL® 12 series

The VITROCELL® 12/3 and 12/4 CF modules can be equipped with microbalance sensors for dose monitoring.

Optional media inserts for easier cleaning.
Media volume 2.5 ml

Features

- Suitable for COSTAR®, FALCON® and ThinCert® 12-well sized cell culture inserts
- Autoclavability of all components
- Base module casing made of electropolished stainless steel for extreme durability
- Base module and aerosol exposure top with integrated heating circuits
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Longer exposure cycles possible due to permanent media supply option
- Control window for monitoring culture media levels
- Option: Quartz Crystal Microbalance
**VITROCELL® 12/6 Stainless Steel Exposure Module for Static Culture Media Supply**

*For 6 cell culture inserts (12-well size)*

The VITROCELL® 12/6 module system has been specifically designed and engineered to facilitate the research of human cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control.

The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile is obtained in one experiment.

The cells are exposed at the air/liquid interface on 6 cell culture inserts using low flow rates of the aerosol. After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

**Culture media supply**

The media is supplied to the module by gravimetric method or syringe.
**Base module**

The VITROCELL® 12/6 modules are made of electropolished stainless steel. They are designed with six compartments for 12-well cell culture inserts and are fully autoclavable at 121°C (250°F) for 20 min. A transparent control window facilitates the external monitoring of media levels. Through the employment of a special adapter set, this module can also be flexibly combined for use with 24-well cell culture inserts. A constant unit temperature is guaranteed using a regulated flow of temperature-controlled water through the module.

The media can be supplied gravimetrically using a bottle or syringe. This module is renowned in scientific circles for its reliability and durability.

**Aerosol exposure top with central aerosol supply**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlet-stream flows through specifically shaped inlets. They are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nanoparticles.

The aerosol inlets are connected to the distribution or dilution systems. Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively. The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum.

**Features**

- Suitable for COSTAR®, FALCON® and ThinCert® 12-well sized cell culture inserts
- For higher throughput
- Autoclavability of all components
- Base modules’ casing made of electropolished stainless steel for extreme durability
- Base module with water heated base plate
- Integration of the hyperboloid geometry of inlets into the aerosol exposure top
- Dynamic dilution system part of delivery
- Option: Control window for monitoring culture media levels
VITROCELL® 12/6 CF Stainless Steel Exposure Module
For 6 cell culture inserts (12-well size)

The VITROCELL® 12/6 CF module system has been specifically designed and engineered to facilitate the research of human cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure. Normally 3 compartments are used for exposure to the substances and 3 compartments for clean air control. The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile is obtained in one experiment.

The cells are exposed at the air/liquid interface on 6 cell culture inserts using low flow rates of the aerosol. After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply
The media is supplied to the module by gravimetric method, syringe or using a media pump for intermittent/continuous media exchange.

VITROCELL® 12/6 CF Dynamic Dilution System and rack
**Base module**

The VITROCELL® 12/6 CF modules casing is made of electropolished stainless steel. It is designed with six compartments for 12-well cell culture inserts and is fully autoclavable at 121° C (250° F) for 20 min. Through the employment of a special adapter set, this module can also be flexibly combined for use with 24-well cell culture inserts. A constant unit temperature is guaranteed using a regulated flow of temperature-controlled water through the module. The media are supplied individually to each well compartment. Optionally, media exchange can be carried out on a continuous basis using a precision media pump.

This module is renowned in scientific circles for its reliability and durability.

**Aerosol exposure top with individual aerosol inlets**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlet-stream flows through specifically shaped inlets. They are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nano-particles.

The aerosol inlets are connected to the distribution or dilution systems. Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively. The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum.

The module can easily be locked hermetically with the two levers attached to the base.
Option for microbalance sensor

The QCM sensor can be integrated in the VITROCELL® 12/6 CF exposure module. It is capable of measuring the deposited mass at a resolution of 10 nanogram/cm² per second. Results are reported online by the VITROCELL® Monitor software. Data is presented in graphs and stored in MS Excel®.

System available in different setups for dosimetry

The system can be combined with a separate single module for dosimetry. The dosimetry module can accommodate a stainless steel insert for trapping constituents of the aerosol in liquids. Alternatively it can be equipped with a microbalance sensor.

A photometer can be added either directly in the aerosol flow of the Exposure Module or at a separate port of the main aerosol flow.

Features

- Suitable for COSTAR®, FALCON®, and ThinCert®
- 12-well sized cell culture inserts
- For higher throughput
- Autoclavability of all components
- Base module made of electropolished stainless steel for extreme durability
- Base module with water heating base plate
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Option: Quartz Crystal Microbalance
The VITROCELL® 12/12 module system has been specifically designed and engineered to facilitate the research of human cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Normally only one system is required: 3 dilutions with 3 inserts each are used for exposure to the substances and 3 inserts in the same system for clean air control. Each dilution represents a different dose concentration, so that a complete dose/response profile can be obtained in one experiment.

The cells are exposed at the air/liquid interface on 12 cell culture inserts using low flow rates of the aerosol.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply
The media is supplied to the module by gravimetric method or syringe.
**Base module**

The VITROCELL® 12/12 modules’ casing is made of electropolished stainless steel. It is designed with 12 (4x3) compartments for 12-well cell culture inserts and is fully autoclavable at 121°C (250°F) for 20 min. The capability to expose with up to 4 dilutions or 3 dilutions plus 1 clean-air control in a compact module is its outstanding feature. A transparent control window facilitates the external monitoring of media levels. Through the employment of a special adapter set, this module can also be flexibly combined for use with 24-well cell culture inserts. A constant unit temperature is guaranteed using an electronic temperature control. The media can be supplied individually for each row of 3 compartments. This module is renowned in scientific circles for its reliability and durability.

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top. The aerosol inlet-stream flows through specifically shaped inlets. They are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The stainless steel / VITROGLIDE inlets are specifically designed for aerosols containing nanoparticles. The aerosol inlets are connected to the distribution or dilution systems. Extraction from the module takes place via small holes using a controlled vacuum flow. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates effectively. The aerosol exposure top features an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module. It is made of high-quality anodized aluminum.

**Features**

- Suitable for COSTAR®, FALCON® and ThinCert® 12-well sized cell culture inserts
- Autoclavability of all components
- Base module made of electropolished stainless steel for extreme durability
- Electronic heating system
- Base module and aerosol exposure top with integrated heating circuit
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Control window for monitoring culture media levels
VITROCELL® 12/12 Docking Station
Easy connection to distribution and dilution systems

VITROCELL® 12/12 quick connect system replaces the mounting of tubing material.

Quick connectors engage to inlets of Exposure Top.

Vitrocell 12/12 Base Module

Features
- Complete rack system for fixation of components
- Docking station with sliding base for fast and safe connections
- Quick-connect system for distribution/distribution system
VITROCELL® 12/12 Climatic Chamber

The professional solution to avoid condensation during the exposure to liquid aerosols

System includes rack, docking station, quick-connect system, dilution systems and optional flow controllers for dilution air.

Features

- Dimensions (L x W x H): 1280 x 900 x 870 (open 1350) mm
- Supplied with dynamic double-jet dilution system for 4 dilutions with 3 replicates
- Integrated aerosol distribution system made of stainless steel / VITROGLIDE surface
- Climatic Chamber with temperature monitoring
- Unique quick-connect system for easier handling

Easy access to all components. Components can be separated with ease.
**VITROCELL® 12/12**  
**Isokinetic Sampling System**  
For uniform particle distribution – optional dilution systems

The aerosol is guided from the central duct to the modules via isokinetic sampling probes enabling high reproducibility and uniformity of results.

The inlets aspirate directly from the constant flow of test substance. The isokinetic distribution system is made of stainless steel. The optional dilution systems are equipped with air jets for dynamic dilution to obtain different dose / response results per row @ 3 replicates.
Back view – Isokinetic Sampling and Dilution System and optional Microbalance Modules

- Small flange connections for easy disassembly and cleaning.
- Isokinetic Sampling probes made of stainless steel.
- Dynamic dilution system with air jets featuring a constant flow rate over the entire system.

Features

- Distribution from the source of the test substances to the module inlets
- High reproducibility
- Optional dynamic dilution system

The optional microbalance sensor is capable of measuring the deposited mass in separate VITROCELL® 12/1 Modules at a resolution of 10 nanogram/cm² per second.

VITROCELL® Flow Monitor Software
Integration of the controllers into the VITROCELL® Monitor Software for easy setting of target flows and reporting of actual flows.
The VITROCELL® 24/24 module system has been specifically designed and engineered to facilitate the research of human cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure. 6 dilutions and controlled guidance of the aerosol to 4 wells per dilution make the VITROCELL® an efficient and extremely powerful analysis tool.

Normally only one system is required: 5 dilutions with 4 inserts each are used for exposure to the substances and 4 inserts in the same system for clean air control. Each dilution represents a different dose concentration, so that a complete dose/response profile can be obtained in one experiment.

The cells are exposed at the air/liquid interface on 24 cell culture inserts using low flow rates of the aerosol.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply
The media is supplied to the module by gravimetric method or syringe.
**Base module**

The base module is made of electropolished stainless steel. An optional transparent control window facilitates the external monitoring of media levels and may be easily removed from the integrated heating base. Temperature can be programmed individually. This module is renowned in scientific circles for its reliability and durability.

The base module is made of electropolished stainless steel. It is autoclavable at 20 min./121°C (250°F).

**Features**

- Supplied with dynamic double-jet dilution system for 6 dilutions with 4 replicates
- 24 media compartments for COSTAR®, FALCON® and ThinCert® inserts in 24-well size
- Base module made of electropolished stainless steel for extreme durability
- Individual aerosol supply to each cell culture membrane
- Base module and aerosol exposure top are autoclavable
- Integrated, sensor-controlled heating plate
- Option: Control window for monitoring culture media levels

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlets are already connected to the integrated distribution system. Evacuation from the module takes place via small holes using an individually controlled vacuum flow for each insert.
VITROCELL® 24/48 Exposure Module
For 24 cell culture inserts (24-well size)

The VITROCELL® 24/48 module system has been specifically designed and engineered to facilitate the research of human cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

Normally only one system is required: 7 dilutions with 6 inserts each are used for exposure to the substances and 6 inserts in the same system for clean air control. Each dilution represents a different dose concentration, so that a complete dose/response profile can be obtained in one experiment.

The cells are exposed at the air/liquid interface on 24 cell culture inserts or on a HTS plate using low flow rates of the aerosol.

After exposure, the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation (see also VITROCELL® assay guide).

Culture media supply
The media is supplied to the module by gravimetric method or syringe.

Higher Throughput
7 doses @ 6 replicates
1 control @ 6 replicates
Base module with unique locking device

The base module is made of electropolished stainless steel. Temperature can be programmed individually.

Aerosol exposure top

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The aerosol inlets are already connected to the integrated distribution system. Evacuation from the module takes place via small holes using an individually controlled vacuum flow for each insert.

The flow rate is controlled by the VITROCELL® calibration valves which are connected to a vacuum pump. The aerosol exposure top with the integrated aerosol distribution system is made of stainless steel with VITROGLIDE surface treatment. The dynamic dilution system for up to 8 dilutions is part of the delivery.
VITROCELL® 24/48
Climatic Chamber XT

The new generation of Climatic Chambers is enlarged to accommodate all required components for the operation of the VITROCELL® 24/48 System. More space facilitates the handling of dosimetry tools inside the chamber.

The extended version features an integrated humidification system with pre-heating of dilution air. The flow controllers are moved to the inside of the chamber for constant temperature and increased humidity output.

Features

- Supplied with dynamic double-jet dilution system for 8 dilutions with 6 replicates
- 48 media compartments for COSTAR®, FALCON® and ThinCert® inserts in 24-well size
- Base module made of electropolished stainless steel for extreme durability
- Integrated aerosol distribution system made of stainless steel / VITROGLIDE surface
- Single supply to each cell culture membrane
- Base module and aerosol exposure top are autoclavable
- Integrated, sensor-controlled heating plate
- Optional climatic chamber for liquid aerosols
- Integrated flow controllers
- Space for Humidification Station
The VITROCELL® AMES 3 module system has been specifically designed and engineered to facilitate the research of bacteria in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control. The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile can be obtained in one experiment.

The bacteria are directly exposed using controlled flow rates of the aerosol. After exposure, the cultures are further processed to measure the number of revertants.
**Base module**

This high-quality module’s casing is made of electropolished stainless steel. It has been designed with three compartments for 35 mm Petri dishes.

This module is renowned in scientific circles for its reliability and durability.

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The inlets are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The aerosol inlets are connected to the aerosol generation / dilution system and their respective outlets to the vacuum pump.

**Features**

- Suitable for Petri dishes (diameter 35 mm)
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Direct flow control for each inlet
- Base module made of stainless steel for maximum durability
The VITROCELL® AMES 4 module system has been specifically designed and engineered to facilitate the research of bacteria direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control. The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile can be obtained in one experiment. The bacteria are directly exposed using controlled flow rates of the aerosol.

After exposure, the cultures are further processed to measure the number of revertants.
**Base module**

This high-quality modules’ casing is made of electropolished stainless steel. It has been designed with four compartments for 35 mm Petri dishes. This module is renowned in scientific circles for its reliability and durability.

![35 mm Petri dishes](image)

**Features**

- Suitable for Petri dishes (diameter 35 mm)
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Direct flow control for each inlet
- Base module made of stainless steel for maximum durability
- Option: Quartz Crystal Microbalance

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The inlets are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The aerosol inlets are connected to the aerosol generation / dilution system and their respective outlets to the vacuum pump.

![Optional microbalance sensor for dose monitoring](image)
**VITROCELL® AMES 48**

**Exposure Module Climatic Chamber**

For 48 Petri dishes (35 mm size)

The VITROCELL® AMES 48 module system has been specifically designed and engineered to facilitate the research of bacteria in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers.

Only 1 system is required: 7 dilutions with 6 petri dishes for exposure to the substances and 6 Petri dishes in the same system for clean air control. A complete dose/response profile can be obtained in one experiment. The bacteria are directly exposed using controlled flow rates of the aerosol. After exposure, the cultures are further processed to measure the number of revertants.
Base module

The base module has been designed for 48 Petri dishes.

The base module is made of aluminum with compartments of stainless steel. It is autoclavable at 121° C (250° F) for 20 min. This module is renowned in scientific circles for its reliability and durability.

Features

- Suitable for Petri dishes (diameter 35 mm)
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Direct flow control for each inlet
- Base module compartments made of stainless steel for maximum durability
- Option: VITROCELL® 48 Plus with 7th row for dosimetry (for liquid trapping or microbalance)
- Autoclavable at 121° C (250° F)
Refined detail solutions

Vacuum quick connector strips for fast exchange of exposure tops with alternative inlet sizes

Heavy duty column guided lifting-closing mechanism for precise dosing

VITROCELL® 48 PLUS
with 7th row for liquid trapping or microbalance

Exposure module with 7th row on drawer

Optional microbalance sensor in 7th position

Technical Data

<table>
<thead>
<tr>
<th>Dimensions:</th>
<th>1 280 x 750 x 800 mm (L x W x H), Height opened: 1 115 mm</th>
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<tr>
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<td>1 200 W (max)</td>
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<tr>
<td>Fuse:</td>
<td>2 x 6.3 A</td>
</tr>
</tbody>
</table>
VITROCELL®
SC 3 Exposure Module for Suspension Cells
For 3 Petri dishes (35 mm size)

The VITROCELL® SC 3 module system has been specifically designed and engineered to facilitate the research of suspension cells direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. It has a unique magnetic stirring capability.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control. The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile can be obtained in one experiment. The suspension cells are directly exposed in stirred media using controlled flow rates of the aerosol. After exposure, the cultures are further processed.
**Base module**

The modules’ casing is made of high-quality stainless steel. It has been specifically designed with 3 compartments for 35 mm Petri dishes. This module is renowned in scientific circles for its reliability and durability.

35 mm Petri dishes

![Controller for magnetic stirrers](image)

**Features**

- Suitable for Petri dishes (diameter 35 mm)
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Direct flow control for each inlet
- Base module made of stainless steel for maximum durability
- Magnetic stirring capability

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure top.

The inlets are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results. The aerosol inlets are connected to the aerosol generation / dilution system and their respective outlets to the vacuum pump.

![Aerosol exposure top](image)
The VITROCELL® SC 4 module system has been specifically designed and engineered to facilitate the research of suspension cells direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. It has a unique magnetic stirring capability.

Normally two modules are required: one module for exposure to the substances and a second module for clean air control. The capacity can be easily increased by adding more modules. Each module can receive a different dose concentration, so that a complete dose/response profile can be obtained in one experiment. The suspension cells are directly exposed in stirred media using controlled flow rates of the aerosol. After exposure, the cultures are further processed.
**Base module**

The module is made of high-quality stainless steel. It has been specifically designed with 4 compartments for 35 mm Petri dishes.

This module is renowned in scientific circles for its reliability and durability.

![Controller for magnetic stirrers](image)

Optional microbalance sensor for dose monitoring

**Aerosol exposure top**

Special sealing and connection mechanisms guarantee a hermetic connection of the base module with the aerosol exposure unit.

The aerosol inlets are connected to the aerosol generation / dilution system and the respective outlets to the vacuum pump.

The inlets are available in stainless steel or stainless steel with unique VITROGLIDE surface treatment for lowest adhesion results.

**Features**

- Suitable for Petri dishes (diameter 35 mm)
- Hyperboloid geometry of inlets for optimized particle deposition and distribution
- Direct flow control for each inlet
- Base module made of stainless steel for maximum durability
- Magnetic stirring capability
- Option: Quartz Crystal Microbalance
VITROCELL® Cloud 6
For exposure of cell cultures to liquid aerosols at the Air/Liquid Interface

The VITROCELL® Cloud Alpha 6 is our new innovation in the Cloud family and presents a great leap forward in automated exposure of cell cultures. It combines high deposition efficiency with ease of use. The development is based on the well-known and frequently published VITROCELL® Cloud formats (6-, 12- and 24-well) of the first generation. It’s functionality enables fully automated processes with an all-in-one control unit. Everyday experiments at the Air/Liquid Interface have never been easier.

The new Cloud Alpha 6 was developed as a result of numerous customer requests and is capable to expose mammalian cell cultures in 6-, 12- or 24-well sized cell culture inserts. All commercial brands are supported.

The Cloud system is suitable for nebulization of solutions and suspensions. Fields of application are virus research, screening of inhaled drugs and toxicity testing of inhaled substances such as chemicals or nanoparticles.

The system has an integrated controller for the aerosol generator, adjustable via touchscreen.

Insert holder system

Insert holders for 6-, 12- and 24-well sized inserts are part of the delivery. All commercial brands are supported.
How the Vitrocell® Cloud works

After pipetting the suspension, exposure to the cell cultures takes place in three phases:

Phase 1
Emission Of Cloud

Phase 2
Homogeneous Mixing

Phase 3
Gravitational Settling

Dosimetry using Quartz Crystal Microbalance (QCM)

The QCM sensor is integrated in the Cloud Alpha 6 exposure module. It is capable of measuring the deposited mass at a resolution of 10 nanogram/cm² per second.

Results are reported online by the VITROCELL® Monitor software. Data is presented in graphs and stored in MS Excel®.

Different choices of nebulizers

The system comes with a choice of 3 types of vibrating mesh nebulizers having droplet MMAD ranges of 2.5 – 6.0 µm, 2.5 – 4.0 µm and 4.0 – 6.0 µm.

Recommended nebulisation volumes are 200 µl. So the device is particularly suitable for testing whenever small quantities of testing materials are available.

Features

- Integrated controller for aerosol generator
- Optional integrated microbalance controller
- Defined experiment recipes
- Automatisation of the experiment by nebulization time or by user-defined volume
- Output rate database for nebulizers
- Heating system
- Optional PowerVent function: evacuation of potentially residual aerosols via vacuum pump
- Designed for virus research, screening of inhaled drugs and toxicity testing of inhaled substances such as chemicals or nanoparticles
**VITROCELL® Cloud 12**

For exposure of cell cultures to liquid aerosols at the Air/Liquid Interface

The VITROCELL® Cloud Alpha 12 is our new innovation in the Cloud family and presents a great leap forward in automated exposure of cell cultures. It combines high deposition efficiency with ease of use. The development is based on the well-known and frequently published VITROCELL® Cloud formats (6-, 12- and 24-well) of the first generation. It’s functionality enables fully automated processes with an all-in-one control unit. Everyday experiments at the Air/Liquid Interface have never been easier.

The new Cloud Alpha 12 was developed as a result of numerous customer requests and is capable to expose mammalian cell cultures in 12- or 24-well sized cell culture inserts. All commercial brands are supported.

The Cloud system is suitable for nebulization of solutions and suspensions. Fields of application are virus research, screening of inhaled drugs and toxicity testing of inhaled substances such as chemicals or nanoparticles.

The system has an integrated controller for the aerosol generator, adjustable via touchscreen.

**Insert holder system**

Insert holders for 12- and 24-well sized inserts are part of the delivery. All commercial brands are supported.

**Dosimetry using Quartz Crystal Microbalance (QCM)**

The QCM sensor is integrated in the Cloud Alpha 12 exposure module. It is capable of measuring the deposited mass at a resolution of 10 nanogram/cm² per second.

Results are reported online by the VITROCELL® Monitor software. Data is presented in graphs and stored in MS Excel®.
How the Vitrocell® Cloud works

After pipetting the suspension, exposure to the cell cultures takes place in two steps, each with three phases:

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission Of Cloud</td>
<td>Homogeneous Mixing</td>
<td>Gravitational Settling</td>
</tr>
</tbody>
</table>

**Step 1**
Clean Air Control

**Step 2**
Test Aerosol

Different choices of nebulizers

The system comes with a choice of 3 types of vibrating mesh nebulizers having droplet MMAD ranges of 2.5 – 6.0 µm, 2.5 – 4.0 µm and 4.0 – 6.0 µm. Recommended nebulisation volumes are 200 µl. So the device is particularly suitable for testing whenever small quantities of testing materials are available.

Features

- Integrated controller for aerosol generator
- Optional integrated microbalance controller
- Defined experiment recipes
- Automatisation of the experiment by nebulization time or by user-defined volume
- Output rate database for nebulizers
- Heating system
- Optional PowerVent function: evacuation of potentially residual aerosols via vacuum pump
- Designed for virus research, screening of inhaled drugs and toxicity testing of inhaled substances such as chemicals or nanoparticles
VITROCELL® Cloud SEQ 24
For sequential and multiple exposures to liquid aerosols

This system is specifically designed for dose-controlled and spatially uniform deposition of liquid aerosols on cells cultured at the air/liquid interface. The aerosol is applied for a short time of approx. 3 – 4 minutes.

The VITROCELL® Cloud can be used for aerosols generated from liquids and suspensions. Possible fields of application are screening for inhaled drugs and toxicity testing of inhaled substances including nanoparticle suspensions.

There is a choice among 4 options of Aeroneb® nebulizers:
- 4.0 – 6.0 µm
- 2.5 – 6.0 µm
- 2.5 – 4.0 µm
- 10 µm (special version)

The Cloud aerosol chamber is made of Polycarbonate. The VITROCELL® Cloud SEQ represents another evolution of the well-known Cloud system. Keeping functional process parameters according to established devices like the VITROCELL® Cloud 6, 12 or 24 it enhances these devices even further. It offers the possibility to sequentially expose rows of inserts to create dose-response effects via multiple exposures in one experiment. The concentration of nebulized liquid is kept at the same level for each nebulisation and the cell-cultures under comparable conditions.

Please download the VITROCELL® Cloud demonstration video from our website.

VITROCELL® Cloud SEQ 24
for 24 inserts (24-well size) allowing sequential and multiple exposures of individual rows for quick dose-response curve measurements
Up to 6 doses @ 4 replicates for 24-well sized inserts

New exposure system for liquid aerosols

High droplet output rate – cloud dynamics

No external air-flow required (simple)

No humidity control required

Dose-controlled and spatially uniform aerosol deposition

Features

- Up to 6 doses @ 4 replicates for 24-well sized inserts
- New exposure system for liquid aerosols
- High droplet output rate – cloud dynamics
- No external air-flow required (simple)
- No humidity control required
- Dose-controlled and spatially uniform aerosol deposition
- Small residual volume in nebulizer reservoir
- Low insert-to-insert variabilities
- Easy handling
- Clinically relevant
VITROCELL® Cloud 96+
For exposure to liquid aerosols – high throughput

The VITROCELL® Cloud Alpha 96 is our newest innovation in the Cloud family and presents a great leap forward in automated exposure of cell cultures. It combines high throughput testing with ease of use. The development is based on the well-known and frequently published VITROCELL® Cloud formats (6-, 12- and 24-well). It's functionality enables fully automated processes with an all-in-one control unit. Everyday experiments at the air/liquid interface have never been easier.

The new Cloud Alpha 96 series was developed as a result of numerous customer requests and is now capable to expose mammalian cell cultures in Corning® HTS Transwell® 96-Well Permeable Support Systems.

The Cloud system is suitable for nebulization of solutions and suspensions. Possible fields of application are screening of inhaled drugs, toxicity testing of inhaled substances such as chemicals or nanoparticles and virus research.

The system has an integrated controller for the aerosol generator, adjustable via touchscreen.

Two Versions available

Cloud Alpha 96

Cloud Alpha 96 + with integrated Quartz Crystal Microbalance (QCM)

The system is available as Cloud Alpha 96 and Cloud Alpha 96+. The latter features an integrated Quartz Crystal Microbalance for online assessment of the deposited mass.
How the Vitrocell® Cloud works

After pipetting the suspension, exposure to the cell cultures takes place in three phases:

**Phase 1**
Emission Of Cloud

**Phase 2**
Homogeneous Mixing

**Phase 3**
Gravitational Settling

Dosimetry using Quartz Crystal Microbalance (QCM)

The QCM sensor is integrated in the Cloud Alpha 96 + exposure module. It is capable of measuring the deposited mass at a resolution of 10 nanogram/cm² per second.

Results are reported online by the VITROCELL® Monitor software. Data is presented in graphs and stored in MS Excel®.

Choice of three types of nebulizers

The system comes with a choice of 3 types of vibrating mesh nebulizers having droplet MMAD ranges of 2.5 – 6.0 µm, 2.5 – 4.0 µm and 4.0 – 6.0 µm.

Recommended nebulisation volumes are 200 µl (Cloud Alpha 96) and 300 µl (Cloud Alpha 96 +). So the device is particularly suitable for testing whenever small quantities of testing materials are available.

Features

- Integrated controller for aerosol generator
- Optional integrated microbalance controller
- Defined experiment recipes
- Automatisation of the experiment by nebulization time or by user-defined volume
- Output rate database for nebulizers
- Heating system
- Optional PowerVent function: evacuation of potentially residual aerosols via vacuum pump
- Designed for screening of inhaled drugs, toxicity testing of inhaled substances such as chemicals or nanoparticles and virus research
This feature for the Cloud family is designed for the work with hazardous compounds. The Cloud exposure chamber is connected airtight to the base module. After nebulisation and sedimentation, the vacuum pump is activated and potentially remaining gaseous substances are evacuated.

**Features**

- Available for CLOUD 6, 12 and 24
- Tight connection of exposure chamber to base module
- Fast removal of residual gaseous compounds

**Option: VITROCELL® Cloud PowerVent**

Evacuation of residual gaseous compounds

1. Tube to vacuum pump
2. Bypass for switching off venting function
3. Switch for venting function
4. HEPA Filter
5. Liquid trap
6. PowerVent Adapter for Clean Air
7. PowerVent Adapter for Exposure Chamber
8. HEPA Filters for filtered Air
9. Switch for venting function of Exposure and Clean Air Chambers
VITROCELL® Cloud α MAX
Smallest nebulization volumes and high deposition efficiency

The VITROCELL® Cloud Alpha MAX is our newest innovation in the Cloud family and presents a great leap forward in automated exposure of cell cultures. It combines high throughput testing with ease of use. The development is based on the well-known and frequently published VITROCELL® Cloud formats (6-, 12- and 24-well). It's functionality enables fully automated processes with an all-in-one control unit. Everyday experiments at the air/liquid interface have never been easier.

The new Cloud Alpha MAX series was developed as a result of numerous customer requests and is now capable to expose mammalian cell cultures in 6-, 12- or 24-well sized cell culture inserts. All commercial brands are supported.

The Cloud system is suitable for nebulization of solutions and suspensions. Possible fields of application are screening of inhaled drugs, toxicity testing of inhaled substances such as chemicals or nanoparticles and virus research.

Ideal for small quantities of test substance

The VITROCELL® Cloud Alpha MAX is designed for lower nebulization volumes and very high deposition efficiency.

This is important when only small quantities of material are available or when expensive test substances need to be tested. The non-cell exposed area is reduced significantly by direct nebulization into exposure chambers with reduced chamber volume.

A set of 3 nebulizers allows for simultaneous testing of 3 concentrations, or a combination of Microbalance, control liquid and suspension of the test substance.

3 positions can be exposed while 3 positions are prepared. Different chamber volumes available. Picture shows the Quartz Crystal Microbalance Sensor in right position.
How the Vitrocell® Cloud works

After pipetting the suspension, exposure to the cell cultures takes place in three phases:

- **Phase 1** Emission Of Cloud
- **Phase 2** Homogeneous Mixing
- **Phase 3** Gravitational Settling

Choice of three types of nebulizers

The system comes with a choice of 3 types of vibrating mesh nebulizers having droplet MMAD ranges of 2.5 – 6.0 µm, 2.5 – 4.0 µm and 4.0 – 6.0 µm.

Recommended nebulisation volumes are 10 – 40 µl. So the device is particularly suitable for testing whenever small quantities of testing materials are available.

Dosimetry using Quartz Crystal Microbalance (QCM)

The QCM sensor is integrated in the Cloud Alpha MAX exposure module. It is capable of measuring the deposited mass at a resolution of 10 nanogram/cm² per second.

Results are reported online by the VITROCELL® Monitor software. Data is presented in graphs and stored in MS Excel®.

Features

- Lowest nebulization volumes: ≤ 40 µl per exposure and well
- High deposition efficiency
- Cloud dynamics by vibrating mesh nebulizers
- Easy handling with no external air-flow required
- High reproducibility
- Air Liquid Interface (ALI) exposure
- Direct and efficient guidance of substance exposure to the cells
- 80, 40, 10 mm tube length
VITROCELL® Cloud ALI Starter Kit
For exposure to liquid aerosols

This system is specifically designed for dose-controlled and spatially uniform deposition of liquid aerosols on cells cultured at the air-liquid interface. The aerosol is applied during a short time of approx. 3 minutes. The setup is designed for 6, 12 and 24-well sized inserts. The cultivation module is made of electropolished stainless steel. It can be heated by water circuit with an optional water bath.

The VITROCELL® Cloud ALI Starter Kit can be used for aerosols generated from liquids and suspensions. Possible fields of application are screening for inhaled drugs and toxicity testing of inhaled substances including nanoparticle suspensions. There is a choice among 4 options of Aeroneb® nebulizers:
- 4.0 – 6.0 µm
- 2.5 – 6.0 µm
- 2.5 – 4.0 µm
- 10 µm (special version)

The Cloud aerosol chamber is made of Polycarbonate.

Please download the VITROCELL® Cloud demonstration video from our website.

Adaptor sets included for:
- 12-well sized inserts
- 24-well sized inserts

VITROCELL® Cloud ALI Starter Kit QCM
for 1 insert (6/12/24-well size)
and optional microbalance sensor
**Features**

- Exposure system for liquid aerosols
- High droplet output rate – cloud dynamics
- No external air-flow required (simple)
- No humidity control required
- Dose-controlled and spatially uniform aerosol deposition
- Small residual volume in nebulizer reservoir
- Easy handling
- Clinically relevant

*Optional microbalance sensor for dose monitoring*
VITROCELL® Cloud Quartz Crystal Microbalance Sensor

The microbalance sensor can be fitted in the VITROCELL® Cloud ALI Starter Kit QCM, VITROCELL® Cloud MAX, VITROCELL® Cloud 6, and VITROCELL® Cloud 12 (12-well version).

It is capable of measuring the deposition in the module at a resolution of 10 nanogram/cm² and second.

The VITROCELL® Monitor software shows the deposition in ng/cm² online for max. 9 microbalances. The data is logged into a .csv file which can be opened with Excel®.

VITROCELL® Monitor Software
**VITROCELL® Powder Chamber**

For exposure to smallest quantities of dry powders

This system is specifically designed for dose-controlled and uniform deposition of dry powder aerosols on cells cultured at the air/liquid interface.

The dry powder can be applied from all commercially available inhalers or via direct dosing.

A typical powder quantity for exposure is 20 mg per experiment.

**Exposure Process**

Duration for a single experiment lasts approx. 20 minutes. The powder is transported via negative pressure from the inhaler or direct dosing device to 4 independent sedimentation tubes. After these are filled, the 4 cell culture insert compartments are moved under the sedimentation tubes for exposure.

The entire process is sequenced automatically by editing the VITROCELL® Powder Chamber Controller.

**Process Parameters**

The following process parameters can be varied to optimize the results:

- Sedimentation tube length (10 – 30 cm)
- Flow rate (l/min)
- Sedimentation time (s)
- Exposure time (min)
- Filling time (ms)

Adaptors for all commercially available dry powder inhalers

1 Party release
2 Sedimentation tubes
3 Exposure tray
4 Controller
Process Steps

1 | Insert loading
The exposure tray houses 4 compartments for 12-well sized cell culture inserts or optional Quartz Crystal Microbalances. The tray is shown in the loading position.

2 | Filling of sedimentation tubes
Filling of the sedimentation tubes is performed by a controlled air flow. Subsequent sedimentation takes place via gravity and without active flow. Filling and sedimentation times are edited in the controller unit. The tray is shown in the sedimentation position.

3 | Exposure to inserts
After filling and sedimentation, the tray is moved to connect the sedimentation tubes with the cell culture insert compartments. The desired exposure duration time is edited in the controller unit. The tray is shown in the exposure position. After exposure the tray is moved back to position 1 to access the exposed inserts.

Dose Monitoring
All 4 cell culture insert compartments can be equipped with Quartz Crystal Microbalances for evaluation and monitoring of the dose.

Features
- Deposition of small particles
- For 12-well sized inserts
- Exposure to 4 wells
- Controlled dry powder release
- Deposition by sedimentation and diffusion
- Flexible flow rates
- Easy handling
- Physiological air/liquid interface conditions
VITROCELL® Automated Exposure Station
User friendly solution with high tech features

The VITROCELL® Automated Exposure Station has been specifically designed and engineered to facilitate the research of mammalian cell cultures in direct exposure to airborne substances such as gases, complex mixtures, nanoparticles and fibers. The system authentically simulates the conditions of human physiological exposure.

It offers a capacity of up to 18 cell culture compartments for exposure and 6 compartments for clean air control.

All key functions for successful exposure such as, aerosol flow rates, humidity, temperature and leak test are edited by touch-screen prior to the experiment. The respective data is shown on live graphs and stored for further analysis. The cells are exposed at the air/liquid interface on 6/12/24-well sized cell culture inserts.

The isokinetic sampling system enables a uniform and reproducible delivery of the test substance to the cells. Applying an electrical field increases deposition efficiency.

Post-exposure the cells are further processed to measure a wide range of endpoints, e.g. cytotoxicity, genotoxicity, proliferation, cellular and oxidative stress as well as inflammation. See also the VITROCELL® assay guide for further information.
VITROCELL® Automated Exposure Station
Standard Version

Automated Exposure Station for up to 4 VITROCELL® 6 modules (pictures showing version with 3 modules). For other exposure module options see page on available configurations.

Features

- Direct aerosol sampling
- Size selective inlet
- Automated process
- Temperature controlled system
- Integrated humidification of aerosol
- Aerosol flow control by mass flow controllers
- Touch-screen display
- Analytical modules for TEM evaluation
- Central data management system
- Online dose measurement
- Electrostatic deposition enhancement
- Integrated vacuum pump
VITROCELL® Automated Exposure Station
Extended Version
Optional External or Integrated Dilution System
Optional Abrasive Dust Generator

The picture shows the setup for C³ Carbon Concrete Composite project. It contains the VITROCELL® Abrasive Dust Generator, the VITROCELL® external dilution system and the extended VITROCELL® Automated Exposure Station. The Abrasive Dust Generator provides an aerosol to the dilution system derived from the cutting process of e.g. carbon concrete. It is suitable to generate an aerosol from cutting and grinding processes of a range of different materials and workpieces. Individual dilution ratios can be adjusted at the external dilution system. In the following step the aerosol is guided the Automated Exposure Station where cells are exposed at the air/liquid interface. Additional analytical modules for dose determination via Quartz Crystal Microbalances, TEM analysis as well as online mass spectrometry of the gas phase can be integrated.
Automated Exposure Station, Extended Version, with compartment for analytical equipment

Features

- Direct aerosol sampling
- Size selective inlet
- Automated process
- Temperature controlled system
- Integrated humidification of aerosol
- Aerosol flow control by mass flow controllers
- Touch-screen display
- Analytical modules for TEM and mass spectrometry
- Optional external or integrated dilution system
- Central data management system
- Online dose measurement
- Electrostatic deposition enhancement
- Integrated vacuum pump
Application Examples

Tobacco Smoke/E-Cigarette Vapors: whole aerosol and gas phase

Environmental Aerosol: industrial emissions, exhaust gas form combustion processes, viruses, environmental pollutants in general, allergens

HICE: combustion derived aerosols from ship diesel and automotive engines as well as from wood stoves

Aerosol Sources

Test Results

Basic Assays: cell viability, cytotoxicity see also VITROCELL® Assay Guide

Omics-Analysis: metabolomics, transcriptomics, proteomics, micro-RNA

Dose monitoring: online dose determination

1 HICE® Aerosols and Health

References:


3. © panalot - Fotolia_6974298
C³: aerosol generated from cutting process of carbon concrete composite

ProCycle: aerosol derived from recycling processes of nanocomposites

NanoMILE: investigation of nanoparticles

Physical Aerosol Characterization: ¹
number size distribution, morphology

Chemical Characterization: mass spectrometry
**Inlet with particle separation**
A size selective inlet separates different fractions of aerosol according to the installed nozzle plate. The Inlet is adjustable to PM₁, PM₁.₅, and PM₁₀.

**Exposure modules**
The base module accepts up to 6 cell culture inserts. Each cell culture compartment has an independent media reservoir. A transparent control window facilitates the external monitoring of media levels. The temperature is controlled by means of a water bath; therefore an additional incubator is not required during the experiment. The temperature for each module is individually monitored. The base module is made of electropolished stainless steel. It is autoclavable at 121° C (250° F) for 20 min.

**Aerosol exposure top**
The aerosol inlet stream flows through specifically shaped inlets which are optimized for electrostatic deposition. They are made of stainless steel with VITROGLIDE surface treatment. The stainless steel / VITROGLIDE inlets are specifically designed for the work with nanoparticles. The aerosol flow rate is controlled by mass flow controllers with data recording by the central data management system.

**Isokinetic sampling system**
The aerosol is guided into the central reactor of the system where it is humidified if needed. Distribution to the modules via isokinetic sampling probes enables high reproducibility and uniformity of results.
Electrostatic deposition enhancement

A significant increase in deposition efficiency is achieved by applying an adjustable electrical field between aerosol inlet and cell culture.

Integrated Quartz Crystal Microbalance

The microbalance sensor is capable of measuring the deposition in the module at a resolution of 10 nanogram/cm² per second. The sensors can be placed in all media compartments to validate the mass deposition in the module. After validation they can be removed so that the experiment can be carried out using the cell culture inserts. One microbalance sensor can remain in the module to monitor the dose during exposure. The data is displayed online using the VITROCELL® Monitor software.

Touch-screen operation

All functions such as aerosol and vacuum flows, temperature, humidity automatic leak test, applied voltage for electrostatic deposition enhancement, start/end of the experiment can be edited using a large 15” touch-screen display. The central data management system provides valuable information on experiment parameters with user-friendly charts. The system can be networked and has a remote service module.

Keyboard

The keyboard can be used alternatively to the touch screen.
**Dilution System**

To provide different aerosol concentrations, a dilution system can be integrated into the station. The dilution ratios can be adjusted between 1:2 to 1:10.

**Analytic Modules**

To analyze the aerosol at the same location than cell cultures, separate analytical modules can be integrated. They feature special inserts for TEM-Imaging, mass spectrometry of the gas phase as well as measurements of particle deposition via Quartz Crystal Microbalances.

**Time based Shut Down**

The time based shut down feature offers the possibility to adjust dose by switching off the different levels at different time points. Defining dose by different exposure times is a valuable alternative if a dilution system can not be integrated.
## Available Configurations

<table>
<thead>
<tr>
<th>Level</th>
<th>Exposure System</th>
<th>Microbalance</th>
<th>High Voltage</th>
<th>TEM Analysis</th>
<th>Mass Spectrometry</th>
</tr>
</thead>
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*Available configurations for different levels of exposure systems, including clean air control modules, microbalances, high voltage systems, TEM analysis, and mass spectrometry.*
## Technical Data

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<td><strong>Main Aerosol Flow:</strong></td>
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* depending on configuration

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Nozzles for connection to external equipment
VITROCELL® Gas Supply Systems
For the exposure of gases, particle-free mixtures and direct samples from the environment

Possible sources of gases or particle-free mixtures:

- **Gas cylinder**
  Gases and mixtures in various concentrations and specifications can be purchased from gas supply companies. The cylinders must have pressure and flow regulators. They can be connected to the VITROCELL® distribution system which then delivers the gases or mixtures to the VITROCELL® module.

- **Sampling bag/samples from indoor/outdoor environment**
  A sampling bag is easily and directly connected to the module using the VITROCELL® SPIDER. The bag can be filled from various sources. If samples must be taken from the indoor/outdoor environment, VITROCELL® offers a special vacuum filling system for the sampling bag which is then transferred to the laboratory. This procedure is not suitable if the test atmosphere contains particles. If the collection of complex mixtures containing particles is required, contact us directly for an individual solution.

- **Dynamic Gas Mixing System**
  There are various options to create individual mixtures with different dose levels. With the VITROCELL® Dynamic Gas Mixing System, it is possible to generate different dilutions of the test aerosol.

Features

- Easy supply of gases and particle-free mixtures
- Sampling directly in the indoor/outdoor environment
- Doses can be varied by creation of different concentrations
The VITROCELL® Spiking System (VSS) has been specifically designed to provide optimal results when exposing gas mixtures from solvents, gases and vapors.

It is the perfect solution when the required concentrations are not available in cylinders. The gas mixture is produced dynamically by means of a digital syringe pump allowing injections of less than 0.1 μl with high accuracy. The component is introduced into a zero gas.

The programmable heating steps, mass flow controllers and the secondary dilution system allow the production of mixtures in various ppm and ppb concentration ranges.

Features

- Suitable for solvents, gases and vapors
- Reliable supply of mixtures in the ppm and ppb range
- Tailor-made system with calculation program
- Accuracy of injection within less than 0.1 μl
- Microprocessor controlled syringe drive for syringes from 10 μl to 140 ml
- Standard max. evaporation temperature 180° C (356° F)
- Optional high temperature version up to 400° C (752° F)
**Calculation Program**

Part of the delivery is a calculation program to choose the syringe type as a function of component, concentration and exposure time.

**Controller**

The controller adjusts the zero gas flow and controls the temperature of the injector block and heating line.

**Digital Syringe Drive**

The microprocessor controlled syringe drive is compatible with a large range of commercially available syringes from 10 µl to 140 ml. The selection is made out of an internal syringe library. The flow rate and operation time can be defined. The injector block can be easily adjusted to fit for the diameters of different syringe types. The injector is heated in function of the dew point of the component. Further heating takes place in the subsequent heating line.

**Dilution / Distribution System**

The system dilutes the mixture to arrive in the ppb range. It works using the proven VITROCELL® double jet technology. It also acts as a distribution system as it is directly connected to the VITROCELL® exposure module.
VITROCELL® BioAerosol Nebulizing Generator

For liquids, proteins, bacteria and microorganisms with minimal sample volume and low flow rates

The VITROCELL® BioAerosol generator has been specifically developed and engineered for applications where the test substance must be dosed in smallest quantities.

It works at low flows of e.g. 2-6 l/min. and has a low dead space.

The BioAerosol Nebulizing Generator can be connected to the Isokinetic Distribution System for the uniform transport of the aerosol to the exposure chambers.

Two operation modes

- **Direct feed single mode** where the test substance is dosed by a precision pump (e.g. peristaltic pump). This permits adjustment of the aerosol concentration without altering the airflow rate.

- **Recirculated flow mode** using a small reservoir (standard size 15 ml). The airflow rate can be individually adjusted based on the desired aerosol concentration. This permits adjustment of the aerosol concentration without altering the airflow rate.

Features

- Nebulizing clean liquids, solutions and suspensions
- Ideal for proteins, bacteria and microorganisms
- Particle diameter approx. 0.7 to 2.5 µm
- Low flow rates of 2-6 l/min
- Exact dosing via direct feed with optional precision pump
- Distribution system designed for VITROCELL® modules
- Optional drying system
VITROCELL® VAGF Nebulizing Generator

For liquids, suspensions and solutions with defined particle size < 2 µm

This VITROCELL® aerosol generator has been specifically developed and engineered for the generation of aerosols from liquids, suspensions and solutions with a defined particle size < 2 micron.

The VAGF Nebulizing Generator can be connected to the HD Distribution System for the uniform transport of the aerosol to the exposure chambers.

The aerosol is dried within the optional drying-path before submission to the exposure modules.

Features

- Known and reproducible particle size < 2 micron by cyclone
- Nebulizing clean liquids
- Nebulizing suspensions and solutions
- Great variability by different concentrated solutions
- Long dosing time
- Distribution system designed for VITROCELL® modules
VITROCELL® VAGK Nebulizing Generator
For liquids, suspensions and solutions

This VITROCELL® aerosol generator has been specifically designed and engineered for the generation of aerosols from liquids, suspensions and solutions.

The VAGK Nebulizing Generator can be connected to the HD Distribution System for the uniform transport of the aerosol to the exposure chambers.

The aerosol is dried within the optional drying-path before submission to the exposure modules.

Features

- Nebulizing clean liquids
- Nebulizing suspensions and solutions
- Known and reproducible particle size by cyclone
- Great variability with different concentrated solutions
- Long dosing time
- Optional HD Distribution System designed for VITROCELL® modules
VITROCELL® VRGB Generator
For the generation of polydisperse solid aerosols from bulk powder material

This VITROCELL® aerosol generator has been specifically designed and engineered for the constant, continuous and reproducible generation of polydisperse solid aerosols from bulk powder material.

The VRGB Generator can be connected to the HD Distribution System for the uniform transport of the aerosol to the exposure chambers.

Features

- Dispersion of non-cohesive powders and dusts
- Particle sizes < 0.1 micron to 100 micron
- Optional cyclone for particle sizes < 5 micron
- Very constant output
- Good reproducibility
- Variable mass flow
- HD Distribution System designed for VITROCELL® modules
VITROCELL® Abrasive Dust Generator
For the generation of aerosols from grinding, cutting or other abrasive processes

Abrasive Dust Generator incl. housing and control panel
The VITROCELL® Abrasive Dust Generator generates dust particles which occur in grinding, cutting or other abrasive processes.

Aerosols containing particles from the following materials can be produced to evaluate their impact on human health:
- Synthetic materials
- Metals
- Ceramics
- Glass-fiber reinforced plastics
- Carbon-fiber reinforced plastics

Cutting speed, feed rate and operation mode can be adjusted to generate an aerosol with different concentrations and aerosol properties. The aerosol is directly removed after the cutting process and guided to the exposure system where 1 m³/h of aerosol will be available for further investigation. Depending on feed rate and aerosol concentration the generator is capable of continuous delivery up to 6 h.

Features
- Aerosol generation made of cutting process
- Automated process
- Touch screen display
- Isokinetic sampling
- Control of cutting speed and feed rate
- Treatment of different materials possible

Technical Data

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VITROCELL® VC 1 SMOKING MACHINE
Manual smoking machine with high tech features

Objective

The manual smoking machine VC 1 is specifically designed and manufactured to fulfill the requirements of in vitro experiments. Suitable for conventional and electronic cigarettes.

Optimal when researching side- and mainstream smoke, it offers significant advantages over other commercial smoking machines.

Generation of smoke with the shortest distance to cell cultures
For the success of an experiment with mainstream tobacco smoke it is vital that the distance between the smoke generation (cigarette holders) and the VITROCELL® cell exposure system is as short as possible to avoid aging and to guarantee authentic smoke composition.

Open and flexible system / incorporation of other analytical tools
The VC 1 machine is designed to allow easy access to all tubes, filters and the pumping system. Additional analytical equipment relevant to the experiment can be easily and individually installed.

Freely programmable parameters
The computer system facilitates highly flexible programming of the smoking process. All parameters of the smoking process like puff duration, puff volume, puff frequency and exhaust duration can be defined according to experiment requirements.

High flexibility for all smoking regimes
ISO, Health Canada Intense, Massachusetts, Square and Human Puff Profile regimes (option) can be smoked. An upgrade for Shisha smoking is available.

Options for e-cigarettes
- square puff profiles
- higher puff volumes
- button actuator
Compliance with Health Canada / CRM 81 Conditions
The VC 1 machine meets the requirements of 55 ml/30 sec puff frequency for smoking combustion as well as electronic cigarettes.

Quality
The VC 1 machine is built to the highest standards using reliable and durable components. Precision of the process is ensured by a linear motor drive for the piston.

Service
All VC 1 machines are specifically designed to be exceptionally service-friendly and have a secure internet-based remote servicing module.

Software Control
Input is communicated via PC with flat screen monitor or laptop (part of delivery).

Scalability
Pooling to multiple machines possible.

Statistics
Smoking process data are logged into an Excel® sheet for further processing.

Machine dimensions are suitable for constrained lab workplaces
The VC 1 machine is divided into 2 major components: computer, control box with smoking platform.

All components are easy to clean
In particular the work with unfiltered mainstream smoke demands frequent cleaning of all machine parts which come into contact with smoke. Cleaning must take place after each experiment to avoid any residual product contamination with subsequent experiments. Easy access to all component parts ensures quick and efficient cleaning.

Components Top View

Human puff profile capability
This optional feature offers the possibility to upload human puff-profile data registered by Smoking Puff Analyzers to the machine controls.

Compatibility with existing lab systems
The VC 1 machine can be integrated with and connected to other lab systems, e.g. analytical systems.

Compliance with ISO 3308:2012
The VC 1 machine meets the requirements of ISO 3308:2012, which assures compatibility with data generated for quality assurance purposes on other smoking machines.

Statistics
Smoking process data are logged into an Excel® sheet for further processing.

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Components Top View

Human puff profile capability
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Statistics
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The VC 1 machine is divided into 2 major components: computer, control box with smoking platform.

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Components Top View

Human puff profile capability
This optional feature offers the possibility to upload human puff-profile data registered by Smoking Puff Analyzers to the machine controls.

Compatibility with existing lab systems
The VC 1 machine can be integrated with and connected to other lab systems, e.g. analytical systems.

Compliance with ISO 3308:2012
The VC 1 machine meets the requirements of ISO 3308:2012, which assures compatibility with data generated for quality assurance purposes on other smoking machines.
State of the art controls for highest precision

Software & Controls

The operation is controlled by Beckhoff software in conjunction with Microsoft Windows 10®. This setup offers extensive possibilities for integration with common Microsoft Office® applications and the exchange of data with Excel®-sheets.

Smoking parameters

The following parameters can be adjusted according to the needs of the experiment:

- Puff and exhaust duration
- Puff frequency
- Puff volume
- Puff profile
- Flow rate
- Clearing puff number
- Puff duration hold time
- Butt length via sensor
VITROCELL® Holder System for e-cigarettes
Secure and tight connection of any puff-actuated device to Smoking Machine

New designs of ENDS (Electronic Nicotine Delivery Systems) products lead to a large variety of different shapes which make the insertion into conventional holders with labyrinth seals impossible. VITROCELL® has developed a new holder system which is flexible to adjust to different shapes. It is compatible with all VITROCELL® Smoking Machines & Robots. In most cases the exchange of the inner sealing is sufficient to adjust for a specific shape.

VITROCELL® Vapestarter
For automatic button activation of e-cigarettes

This automated solution is designed to press the button in a precise manner and synchronized with the puff regime. The trigger function is controlled by the software of the smoking machine.

The system consists of an e-cigarette holder and different Vapestarter units which are tailor-made to fit tank products having different diameters as well as square shapes.

Features
- Integration into software of VC 1
- Vapestarters available for all sizes of tank products
- Inclination angle from 0-90°
- Quick-change mechanism for easy exchange of test products

Technical Data

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<td>Remote service module</td>
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**VITROCELL® Shisha Testing Device**

**Testing of water pipe tobacco according to ISO 22486**

The new device is designed for machine smoking of water pipe tobacco. It is used in combination with the renowned VC 1 Smoking Machine featuring an increased puff volume.

Emissions of water pipe tobacco may be used for chemical analysis or in vitro exposure. The device can be combined with any VITROCELL® Exposure System. All parameters such as puff volume, frequency, puff duration and puff profiles are set according to ISO. The water pipe head is made of ceramics and can be operated either with charcoal or electrical heating.

- **Integrated electrical heating device**
- **Heating via charcoal**
- **Useful tools for charcoal operation**

**Features**

- Puff duration: 2.6 s ± 0.1 s
- Puff volume: 530 ml ± 10 ml
- Puff frequency: 20 s ± 0.5 s
- Square puff profile
- Electrical heating: 280 °C ± 10 °C
- User-friendly temperature control unit
The manual smoking machine VC 1 is specifically designed to fulfill the requirements of in vitro experiments and analytical testing. The machine is suitable for conventional and electronic cigarettes as well as for testing of water pipes (shishas). For higher puff volumes it is possible to equip the machine with different cylinder sizes (200, 300 and 600 ml) without compromising the accuracy of the puff profile. The essential requirement for the “Shisha smoking” application is a significant larger puff volume of up to 600 ml.

The conversion procedure to the higher/smaller cylinder size is possible within less than 10 minutes. The Shisha option is designed for an easy upgrade of an already existing VC 1 smoking machine.

**Technical Data**

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VITROCELL® VC 1 S-TYPE SMOKING MACHINE

Manual smoking machine for chemical analysis and *in vitro* experiments

Objective

The manual smoking machine VC 1 S-TYPE is specifically designed and manufactured to fulfill the requirements of chemical characterization and *in vitro* experiments. Suitable for conventional and electronic cigarettes.

Optimal when researching whole aerosol, it offers significant advantages over other commercial smoking machines.

Generation of aerosol with the shortest distance to cell cultures or analysing equipment

For the success of an experiment with whole aerosol it is vital that the distance between the aerosol generation (product holders) and the VITROCELL® cell exposure system or to e.g. impingers is as short as possible to guarantee authentic aerosol-composition.

Open and flexible system / incorporation of other analytical tools

The VC 1 S-TYPE machine is designed to allow easy access to all tubing, filters and the pump system. Additional analytical equipment relevant to the experiment can be easily and individually installed.

Freely programmable parameters

The control system facilitates highly flexible programming of the puffing process. All parameters like puff duration, puff volume, puff frequency and exhaust duration can be defined according to experiment requirements.

High flexibility for all smoking regimes

ISO, Health Canada Intense, Massachusetts, Square and Human Puff

- square puff profiles
- higher puff volumes
- button actuator
- up to 5 channels

Optimized for e-cigarettes and NGP’s

- square puff profiles
- higher puff volumes
- button actuator
- up to 5 channels

1 Control Box with Syringe Drive
2 Filter Holders
3 Examples of e-cigarettes
4 Integrated Button Actuators
5 Laptop or computer/monitor
The VC 1 S-TYPE machine is built to the highest standards using reliable and durable components. Precision of the process is ensured by a linear motor drive for the piston.

All VC 1 S-TYPE machines are designed to be exceptionally service-friendly and have a secure internet-based remote servicing module.

Input is communicated via PC with monitor or laptop (part of delivery).

Max. of 5 ports for e-cigarettes, NGP’s and conventional cigarettes
○ For chemical analysis and in vitro applications
○ No cross-contamination in product change due to change parts and very easy cleaning
○ Capable of all current regimes ISO, HCI, CRM 81 and up to 300 ml puff volume
○ Small dead volumes
○ Integrated button actuators

Human puff profile capability
This optional feature offers the possibility to upload human puff-profile data registered by Smoking Puff Analyzers to the machine controls.

Compatibility with existing lab systems
The VC 1 S-TYPE machine can be integrated with and connected to other lab systems, e.g. analytical instruments.

Compliance with ISO 3308:2012
The VC 1 S-TYPE machine meets the requirements of ISO 3308:2012 which assures compatibility with data generated for quality assurance purposes on other smoking machines.

Compliance with Health Canada / CRM 81 Conditions
The VC 1 S-TYPE machine meets the requirements of 55 ml/30 sec puff frequency for puffing combustion as well as electronic cigarettes.

Quality
The VC 1 S-TYPE machine is built to the highest standards using reliable and durable components. Precision of the process is ensured by a linear motor drive for the piston.

Statistics
Smoking process data are logged into an Excel® sheet for further processing.

Machine dimensions are suitable for constrained lab workplaces
The VC 1 S-TYPE machine is divided into 4 major components: computer, control box with syringe drive platform, impinger and device rack.

All components are easy to clean
In particular the work with unfiltered whole aerosol demands frequent cleaning of all machine parts which come into contact with aerosol. Cleaning must take place after each experiment to avoid any residual product contamination to subsequent experiments. Easy access to all component parts ensures quick and efficient cleaning.

Human puff profile capability
This optional feature offers the possibility to upload human puff-profile data registered by Smoking Puff Analyzers to the machine controls.

Compatibility with existing lab systems
The VC 1 S-TYPE machine can be integrated with and connected to other lab systems, e.g. analytical instruments.

Compliance with ISO 3308:2012
The VC 1 S-TYPE machine meets the requirements of ISO 3308:2012 which assures compatibility with data generated for quality assurance purposes on other smoking machines.

Compliance with Health Canada / CRM 81 Conditions
The VC 1 S-TYPE machine meets the requirements of 55 ml/30 sec puff frequency for puffing combustion as well as electronic cigarettes.

Quality
The VC 1 S-TYPE machine is built to the highest standards using reliable and durable components. Precision of the process is ensured by a linear motor drive for the piston.

Service
All VC 1 S-TYPE machines are designed to be exceptionally service-friendly and have a secure internet-based remote servicing module.

Software Controls
Input is communicated via PC with monitor or laptop (part of delivery).

Features

Components Top View

1 Piston Pump Unit
2 Aerosol Exhaust
3 Manometer
4 Smoking Start Button
5 System off Button
6 Emergency Stop
7 Laptop or computer/monitor
Configuration 1: chemical analysis „e-cigarettes / NGP’s“

1 Control Box with Syringe Drive  
2 Impinger Rack  
3 Filter Holders  
4 Examples of e-cigarettes / NGP’s  
5 Integrated Button Actuators

Configuration 2: in vitro „e-cigarettes / NGP’s“

Special Holder System
Secure and tight connection of any puff-actuated device.

1 Control Box with Syringe Drive  
2 Examples of e-cigarettes / NGP’s  
3 In vitro Exposure System  
4 Integrated Button Actuators

Integrated VITROCELL® Vapestarter
For automatic button activation of e-cigarettes

The Vapestarter unit for different dimensions of tank products

Features
- Integration into software of VC 1 S-TYPE  
- Vapestarters available for all sizes of tank products  
- Inclination angle from 0-90°  
- Quick-change mechanism for easy exchange of test products

This automated solution is designed to press the button in a precise manner and synchronized with the puff regime. The trigger function is controlled by the software of the smoking machine. The system consists of an e-cigarette holder and different Vapestarter units which are tailor-made to fit tank products having different diameters as well as square shapes.
Configuration 3: chemical analysis „Conventional Cigarettes“

1. Control Box with Syringe Drive
2. Impinger Rack
3. Filter Holders
4. Smoking Box
5. Sidestream Exhaust Tubes

Configuration 4: in vitro „Conventional Cigarettes“

1. Control Box with Syringe Drive
2. Smoking Box
3. Sidestream Exhaust Tubes
4. In vitro Exposure System

Option: VITROCELL® FTIR

On-line gas analysis of electronic cigarettes

Gasmet™ FTIR – Analytics – Calcmet™ Software

Application library can be customized:
- Add flavor components
- Proprietary ingredients
Key features

Standardized holder system for ENDS products

Unique 6-port valve system. Freely programmable for configurations 1-4.

Powerful linear motor syringe drive

- Proven linear motor drive
- Software platform from VC 1 / VC 1 S-TYPE / VC 10® / VC 10® S-TYPE
State of the art controls for highest precision

Software & Controls

The operation is controlled by Beckhoff software in conjunction with Microsoft Windows 10®. This setup offers extensive possibilities for integration with common Microsoft Office® applications and the exchange of data with Excel®-sheets.

Smoking parameters

The following parameters can be adjusted according to the needs of the experiment:

- Puff and exhaust duration
- Puff frequency
- Puff volume
- Puff profile
- Flow rate
- Clearing puff number
- Puff duration hold time
- Butt length via sensor

Technical Data

<table>
<thead>
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<th>Dimensions without racks:</th>
<th>605 x 455 x 533 mm (L x W x H)</th>
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<tr>
<td>Voltage:</td>
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<td>Compressed air:</td>
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<tr>
<td>Remote service module:</td>
<td>Included / Internet access mandatory</td>
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</table>
VITROCELL® VC 1/7
SMOKING MACHINE

Linear smoking machine with high tech features

Objective

The linear smoking machine VC 1/7 is specifically designed and manufactured to fulfill the requirements of in vitro experiments. Suitable for conventional and electronic cigarettes. This new concept for a smoking machine offers significant advantages over other commercial smoking machines.

Generation of smoke with the shortest distance to cell cultures

For the success of an experiment with whole aerosol it is vital that the distance between the aerosol generation (cigarette holders) and the VITROCELL® cell exposure system is as short as possible to guarantee authentic aerosol-composition.

Open and flexible system / incorporation of other analytical tools

The VC 1/7 machine is designed to allow easy access to all tubes, filters and the pumping system. Additional analytical equipment relevant to the experiment can be easily and individually installed.

Freely programmable parameters

The computer system facilitates highly flexible programming of the smoking process. All parameters of the smoking process like puff duration, puff volume, puff frequency and exhaust duration can be defined according to experiment requirements.

High flexibility for all smoking regimes

ISO, Health Canada Intense, Massachusetts, Square and Human Puff Profile regimes (option) can be smoked.

Features for e-cigarettes

- square puff profiles
- higher puff volumes
- button actuator
- 7 individually programmable syringe drives
Statistics
Smoking process data are logged into an Excel® sheet for further processing.

Machine dimensions are suitable for constrained lab workplaces
The VC 1/7 machine is divided into 3 major components: computer, control box, syringe drives and cigarette holder systems.

All components are easy to clean
In particular the work with unfiltered aerosol demands frequent cleaning of all machine parts which come into contact with the constituents. Easy access to all component ensures quick and efficient cleaning.

Human puff profile capability
This optional feature offers the possibility to upload human puff-profile data registered by Smoking Puff Analyzers to the machine controls.

Compatibility with existing lab systems
The VC 1/7 machine can be integrated with and connected to other lab systems, e.g. analytical systems.

Compliance with all current e-cigarette regimes
The VC 1/7 is able to generate aerosol with puff volumes up to 200 ml using square profiles and all relevant time settings.

Compliance with ISO 3308:2012
The VC 1/7 machine meets the requirements of ISO 3308:2012, which assures compatibility with data generated for quality assurance purposes on other smoking machines.

Compliance with Health Canada / CRM 81 Conditions
The VC 1/7 machine meets the requirements of 55 ml/30 sec puff frequency for smoking combustion as well as electronic cigarettes.

Quality
The VC 1/7 machine is built to the highest standards using reliable and durable components. Precision of the process is ensured by linear motor drives for the piston.

Service
All VC 1/7 machines are specifically designed to be exceptionally service-friendly and have a secure internet-based remote servicing module.

Software Control
Input is communicated via PC with flat screen monitor or laptop (part of delivery).

Unique syringe drive system
Linear motor drive system with lowest dead volume and easy cleaning features. Each syringe drive can be programmed with an individual regime.

The linear smoking machine VC 1/7 is specifically designed and manufactured to fulfill the requirements of in vitro experiments. Suitable for conventional and electronic cigarettes.
Highly flexible modes of operation

Mode 1 for e-cigarettes
Direct connection of draw-actuated cigarettes to the syringe drives.

Mode 2 for e-cigarettes
7 individual vapestarter units with button activators for tank products are connected to the syringe drives.

Mode 3 for combustion cigarettes
7 individual smoke boxes allow for smoking of combustion cigarettes. Integrated butt length sensors.

Special Holder System for e-Cigarettes
Secure and tight connection of any puff-actuated device.

VITROCELL® Vapestarter
Innovative solution for smoking machines: automatic button activation of e-cigarettes. For more information see page 137.
State of the art controls for the 7 syringe drives to highest precision

Software & Controls

The operation is controlled by Beckhoff software in conjunction with Microsoft Windows 10®. This setup offers extensive possibilities for integration with common Microsoft Office® applications and the exchange of data with Excel®-sheets.

Smoking parameters

The following parameters can be adjusted according to the needs of the experiment:

- Puff and exhaust duration
- Puff frequency
- Puff volume
- Puff profile
- Flow rate
- Clearing puff number
- Puff duration hold time
- Butt length via sensor

Individual program settings can be allocated to each syringe drive

Technical Data

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VITROCELL VC 10®
SMOKING ROBOT
Specially designed for *in vitro* research and development

Objective

The smoking machine VC 10® is specifically designed and manufactured to fulfill the requirements of whole smoke and aerosol generation for *in vitro* experiments. Suitable for conventional and electronic cigarettes, the VC 10® offers significant advantages over other commercial smoking machines:

**Generation of smoke with the shortest distance to cell cultures**
For the success of an experiment with mainstream tobacco smoke it is vital that the distance between the smoke generation (cigarette holders) and the VITROCELL® cell exposure system is as small as possible to avoid aging and to guarantee authentic smoke-composition.

**Open and flexible system / incorporation of other analytical tools**
The robot is designed to allow easy access to all tubes, filters and the pumping system. Additional analytical equipment relevant to the experiment can be easily installed individually.

**Freely programmable parameters**
The computer system caters for highly flexible programming of the smoking process. Changing from single cigarette smoke to serial smoke mode for a defined number of cigarettes is possible. All parameters of the smoking process such as puff duration, puff volume, puff frequency and exhaust duration can be defined according to experiment requirements.

**Options for e-cigarettes**
- square puff profiles
- higher puff volumes
- lighter off mode
Statistics
Smoking process data are logged into an Excel® sheet for further processing.

Machine dimensions suitable for constrained lab workplaces.
The robot is divided into 3 major components: computer, control box and smoking platform. The smoking platform is the only element that must be placed in the direct area of the experiment; all other components can be located anywhere in the lab.

All components are easy to clean
In particular the work with unfiltered mainstream smoke demands frequent cleaning of all robot parts in contact with smoke. Cleaning must take place after each experiment to avoid any residual product contamination of subsequent experiments. Easy access to all component parts ensures quick and efficient cleaning.

Compatibility with existing lab systems
The robot can be integrated with and connected to other lab systems, e.g. analytical or automation systems.

Compliance with ISO 3308:2012
The robot meets the requirements of ISO 3308:2012, which assures a compatibility with data generated for quality assurance purposes on other smoking machines.

Compliance with Health Canada / CRM 81 Conditions
The robot meets the requirements of 55 ml/30 sec puff frequency for smoking combustion as well as electronic cigarettes when the interchange option is purchased.

Bell shaped and square puff profile capabilities
Human puff profile capability
This optional feature offers the possibility to feed data of human puff profiles registered by Smoking Puff Analyzers to the robot controls.

Quality
The robot is built to the highest standards using reliable and durable components. Precision of the process is ensured by a stepper motor for smoking port rotation and linear drive motor for the pump as well as sensor-controlled and pneumatically-driven components. Compliance with CE standards.

Service
All VC 10® robots are specifically designed to be exceptionally service-friendly and have a secure internet-based remote servicing module.

Multi-port exits (Option)
2, 4 or 5-port exits enable to operate the robot with multiple dilution systems.

Allocation of each cigarette port to a specific piston pump exhaust line and dilution system.
Loading

Magazine

The standard magazine takes up to 20 cigarettes and larger versions are also available. They are suitable for storage in the climatization chamber for pre-conditioning of the cigarettes.

Automatic leak detector

There is the option to activate the leak detector prior to each experiment. The detector confirms the tightness of the system including cigarette holders and pump. The results are logged in the study files.

Loading unit

The loading of the cigarettes into the cigarette holders takes place fully automatically and without damage to the cigarette. The cigarette holders are equipped with labyrinth seals as required by ISO 3308:2012.

VITROCELL® Holder System for e-cigarettes

Secure and tight connection of any puff-actuated device to Smoking Machine

New designs of ENDS (Electronic Nicotine Delivery Systems) products lead to a large variety of different shapes which make the insertion into conventional holders with labyrinth seals impossible.

VITROCELL® has developed a new holder system which is flexible to adjust to different shapes. It is compatible with all VITROCELL® Smoking Machines & Robots.

In most cases the exchange of the inner sealing is sufficient to adjust for a specific shape.
Ignition and smoking

Lighter
The electric lighter ensures the automatic ignition and a safe procedure without cigarette damage.

Syringe drive
The syringe pump is controlled by a linear motor with high precision. The pump can be dismantled for cleaning and refitted again in a few minutes.

Stepper motor for rotation of port holder
The rotation of the port holder is controlled by a stepper motor with highest precision.

Cambridge filter
The Cambridge filter can be mounted easily into the system for analytical purposes.
Smoking and butt extraction

**Hood for sidestream smoke evacuation**

The integrated fan evacuates the sidestream smoke. The air flow at the cigarette holders is adjusted by the fan speed.

**Butt length sensor**

The IR-sensor can be adjusted to a fraction of a millimeter and transmits reliable signals to the pump and butt extractor. If the critical butt length is reached, the pump stops immediately. Alternatively, it is also possible to work with a defined number of puffs.

**Butt extractor**

The cigarette is forwarded to the extraction position and removed from the holder. The ashtray is kept permanently clean with a brush.

---

**VITROCELL® Vapestarter**

*For automatic button activation of e-cigarettes*

This automated solution is designed to press the button in a precise manner and synchronized with the puff regime. The trigger function is controlled by the software of the smoking machine. The system consists of an e-cigarette holder and different Vapestarter units which are tailor-made to fit tank products having different diameters as well as square shapes.

**Features**

- Integration into software of VC 10
- Vapestarters available for all sizes of tank products
- Inclination angle from 0-90°
- Quick-change mechanism for easy exchange of test products
Software & Controls

Smoking parameters

The operation is controlled by Beckhoff software in conjunction with Microsoft Windows 10®. This setup offers extensive possibilities for integration with common Microsoft Office® applications and the exchange of data with Excel®-sheets.

Advanced, user-friendly software with recipe edit functions for favourite smoking / vaping regimes:

- Puff volume: up to 200 ml
- Puff frequency: 4 – 250 s
- Puff duration: 0.1 – 15 s
- Puff exhaust duration: 0.5 – 15 s
- number of cigarettes per run: 300
- number of puffs: 1-250
- smoking modes: single, cycle, serial
- profiles: bell, square, human

Smoking modes

- Single, cycle and serial mode
- Pre-loading mode
- Lighter off mode
- Cycle mode with system purging after each cycle

Technical Data

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tbody>
<tr>
<td>Dimensions electrical control box</td>
<td>600 x 300 x 600 mm (L x W x H); 24 x 12 x 24 inches</td>
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<tr>
<td>Dimensions smoking platform</td>
<td>1000 x 600 x 300 mm (L x W x H) / (height without hood); 40 x 24 x 12 inches</td>
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<tr>
<td>Power supply</td>
<td>1 x 208-240 V, 50/60 Hz, 16 A</td>
</tr>
<tr>
<td>Compressed air</td>
<td>Operating pressure 6 bar (87 psi); system pressure 10 bar (145 psi)</td>
</tr>
<tr>
<td>Remote service module</td>
<td>Included / Internet access mandatory</td>
</tr>
</tbody>
</table>
VITROCELL SMOKING ROBOT VC 10® S-TYPE
Features all special requirements for high-class research

Objective

Cutting edge technologies make the VITROCELL® smoking machine VC 10® S-TYPE a perfect tool for evaluation of conventional and e-cigarettes.

This smoking machine features all special requirements for high-class research: compliance with ISO, Health Canada and square puff profile protocols as well as ease of handling, fast cleaning and high speed product change capabilities. It is suitable for working with side- and mainstream smoke, and offers significant advantages over other smoking machines.

Generation of smoke with the shortest distance to cell cultures
For the success of an experiment with mainstream tobacco smoke it is important that the distance between the smoke generation (cigarette holders) and the VITROCELL® cell exposure system is as short as possible in order to avoid aging and to guarantee a smoke composition matching the real-life situation.

Open and flexible system / incorporation of other analytical tools
The robot is designed to allow easy access to all tubes, filters and the syringe system.

Additional analytical equipment relevant to the experiment can be installed without difficulty by the operator.

Freely programmable parameters
The computer system allows highly flexible programming of the smoking process. Changing from single cigarette smoke to serial smoke mode for a defined number of cigarettes is possible.
All parameters of the smoking process like puff duration, puff volume, puff frequency and exhaust duration can be defined according to the needs of the experiment.

Cleaning must take place after each experiment in order to avoid any influence of residual products on the following experiment. Due to the easy access to all parts the cleaning can be done quickly and efficiently.

Statistics
The data of the smoking process are logged into an Excel® sheet for further processing.

All components are easy to clean
In particular the work with unfiltered mainstream smoke demands frequent cleaning of all parts of the robot which are in contact with the smoke.

Quality
The robot is built to the highest standards using reliable and durable components. Precision of the process is ensured by a stepper motor for smoking port rotation and linear drive motor for the pump as well as sensor-controlled and pneumatically-driven components. Compliance with CE standards.

Service
All VC 10® robots are designed to be very service-friendly and have a secure internet-based remote servicing module.

Special Features

- Platform concept with docking stations
- Large magazine for 300 cigarettes enabling long test runs
- New smoking head with small dead volume and integrated butt ejector
- Quick-lock holder system for all types of conventional and e-cigarettes
- Machine-controlled button actuator for e-cigarettes
- Heated smoke path system
- New multiple 5-port exhaust system
- Scalable to up to 3 syringe drives
- Entire product change cleaning in < 10 min (with a few prepared exchange parts)

VC 10® S-TYPE equipped for operation with conventional cigarettes. Due to the unique platform concept with docking stations an entire product change including cleaning can be performed in < 10 min (with a few prepared exchange parts).
Operation for e-cigarettes

Quick-lock holder system with e-cigarette support crown
The holders can be quickly exchanged for cleaning and the support crown holds heavier e-cigarettes safely.

Optional holder for e-cigarettes
Secure and tight connection of any puff-actuated device to Smoking Machine.

Programmable button actuator
The button actuator has a trigger function which is controlled by the VC 10® S-TYPE software.

Heated smoke path
The smoke path can be heated and temperature controlled to avoid eventual condensation.
Operation for conventional cigarettes

**Magazine**

The magazine stores up to 300 cigarettes and has a machine-controlled feeding and aligning system.

**Automatic leak detector**

There is the option to activate the leak detector prior to each experiment. The detector confirms the tightness of the system including cigarette holders and pump. The results are logged in the study files.

**Loading unit**

Damage-free loading of the cigarettes into the cigarette holders takes place fully automatically. The cigarette holders are equipped with labyrinth seals as required by ISO 3308:2012.
Ignition and smoking

**Lighter**

The electric lighter ensures the automatic ignition and a safe procedure without cigarette damage.

**Syringe drive**

The syringe pump is controlled with high precision by a strong linear motor. Due to the special design, the syringe can be dismantled for cleaning and refitted again in a very short time. The machine can be scaled up to 3 syringe drives to increase the puff frequency.

**Stepper motor for rotation of port holder**

The rotation of the port holder is controlled by a stepper motor with highest precision.

**Cambridge filter**

The Cambridge filter can be mounted easily into the system for analytical purposes.
Smoking and butt extraction

**Hood with sidestream smoke ducts**

The integrated fan evacuates the sidestream smoke. The air flow at the cigarette holders is adjusted by the fan speed.

**Butt length sensor**

The IR-sensor can be adjusted to a fraction of a millimeter and transmits reliable signals to the pump and butt extractor. If the critical butt length is reached, the pump stops immediately. Alternatively, it is also possible to work with a defined number of puffs.

**Butt ejector**

The cigarette butts are removed from the holder by ejection. The ashtray is kept permanently clean with a brush.

**Large butt reservoir**

The butts are forwarded into a large reservoir.
Example of 2-piston pump operation with 3 cigarettes

Example of 3-piston pump operation with 6 cigarettes
Unique 5-port exhaust system

5 individual machine-controlled exhaust lines direct the smoke to 5 dilution systems.

Software & Controls

**Electrical control box**

The control box houses the controls for the stepper motors, sensors and pneumatic valves. The whole process is controlled by Beckhoff software in conjunction with Microsoft Windows 10®. This setup offers extensive possibilities for integration with common Microsoft Office® applications and the exchange of data with Excel®-sheets.
Smoking parameters

Dimensions electrical control box: 790 x 300 x 600 mm (L x W x H); 31 x 12 x 24 inches
Dimensions smoking platform: 940 x 690 x 670/694* mm (L x W x H) / (height without hood); 37 x 28 x 27/28 inches
Power supply: 1 x 208-240 V, 50/60 Hz, 16 A
Compressed air: Operating pressure 6 bar (87 psi); system pressure 10 bar (145 psi)
Remote service module: Included / Internet access mandatory

Advanced, user-friendly software with recipe edit functions for favourite smoking / vaping regimes:

- Puff volume: up to 200 ml
- Puff frequency: 4 – 250 s
- Puff duration: 0.1 – 15 s
- Puff exhaust duration: 0.5 – 15 s
- number of cigarettes per run: 300
- number of puffs: 1 – 250
- smoking modes: single, cycle, serial
- profiles: bell, square, human

Smoking modes

- Single, cycle and serial mode
- Pre-loading mode
- Cycle mode with system purging after each cycle

VITROCELL® Vapestarter
For automatic button activation of e-cigarettes

This automated solution is designed to press the button in a precise manner and synchronized with the puff regime. The trigger function is controlled by the software of the smoking machine. The system consists of an e-cigarette holder and different Vapestarter units which are tailor-made to fit tank products having different diameters as well as square shapes.

Features

- Integration into software of VC 10 S-TYPE
- Vapestarters available for all sizes of tank products
- Inclination angle from 0-90°
- Quick-change mechanism for easy exchange of test products

Technical Data

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
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<td>Dimensions electrical control box:</td>
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<td>Dimensions smoking platform:</td>
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<tr>
<td>Power supply:</td>
<td>1 x 208-240 V, 50/60 Hz, 16 A</td>
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<td>Compressed air:</td>
<td>Operating pressure 6 bar (87 psi); system pressure 10 bar (145 psi)</td>
</tr>
<tr>
<td>Remote service module:</td>
<td>Included / Internet access mandatory</td>
</tr>
</tbody>
</table>

*platform opened
The VITROCELL® VC 10® CHEMCONTROL Smoking Robot is specifically developed for the chemical and biological analysis of single puffs. The effects of whole smoke as well as the gas phase of each individual puff can be analysed by a special smoking regime and sampling unit.

Special configuration for VC 10® CHEMCONTROL
Individual sampling points allow separate analysis of 8 puffs per cigarette. The puffs 1 to 8 are guided to a total of 8 individual sampling points, where e.g. impingers or other analysis tools may be placed. The base robot is as above.

4 Cigarettes are loaded and lightened automatically. The unique valve and purging system allows for the following regime:

- Each first puff of cigarettes # 1 - # 4 is directed to sampling point # 1. After that there is the choice to purge the system. For this purpose the valve towards the cigarette holders is closed and the valve towards the purging gas (e.g. Synthetic Air) is opened. The pump is performing 1..5 purging puffs. Thereafter the valve for the purging gas is closed and the valve towards the smoke ports opened.
- Each 2. puff of cigarettes # 1 - # 4 is directed to sampling point 2. Then purging takes place in the same way than above.
- Each 3. puff of cigarettes # 1 - # 4 is directed to sampling point 3. Then purging takes place in the same way than above.
- Same procedure for 4. until final puff 8 (or a fraction of final puff) which is directed to sampling point 8. Then purging takes place in the same way than above.

CHEMCONTROL Feature
Whole smoke and gas phase analysis of single puffs for Smoking Robots VC 10® / VC® 10 S-TYPE
**Human Puff Profiles**

*For Smoking Machine VC 1 / VC 1 S-TYPE and Smoking Robots VC 10® / VC 10® S-TYPE*

Direct Reading from Puff Analyzer Data Files

Human puff profile capability
This optional feature for the VC 1 and VC 1 S-TYPE smoking machine, VC 10® and VC 10® S-TYPE smoking robots offers the possibility to feed data of human puff profiles registered by Smoking Puff Analyzers to the machine controls.

Puff time – precision of replication *

Inter puff time – precision of replication *

Puff volume – precision of replication *

Flow versus time – precision of replication *

*) Data from smoker compared with 2 channels of VC 10® smoking robot (VC 1 is using same technology).
VITROCELL® Vapestarter

Innovative solution for smoking machines: automatic button activation of e-cigarettes

Button activated e-cigarettes put the user of smoking machines into a problem: should one press the button every 30 or 60 seconds manually? The automated solution to press the button in a precise manner is the VITROCELL® Vapestarter. The device can be connected to any VITROCELL® smoking machine. The trigger function is controlled by the software of the smoke generator.

The Vapestarter device is also available with a timer function so that it can be used for other types of smoke generators.

The system consists of Vapestart Controller, e-cigarette holder and different Vapestarter units. The Vapestarter units are tailor-made to fit tank products having different diameters as well as square shapes.

Features

- Integration into software of VC 1, VC 1 S-TYPE, VC 1/7, VC 10® and VC 10® S-TYPE Smoking Machines
- Vapestarters available for all sizes of tank products
- Inclination angle from 0-90°
- Quick-change mechanism for easy exchange of test products
- Also available as standalone version
- Operation by compressed air

The Vapestarter unit is available for different dimensions of tank products.
<table>
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**VITROCELL**® **Dilution Systems**

*For dynamic dilution of the test aerosol*

**VITROCELL**® has developed specific dynamic dilution systems using unique double-jet systems which allow for a homogeneous mixing of the test aerosol with air. This principle facilitates highly flexible dose/response relationships. The dilution systems are made of stainless steel with unique VITROGLIDE surface treatment.

**Universal dilution system for VITROCELL**® 6 and 12 module family

This universal dilution system has entry and exit nozzles for the aerosol stream plus 2 jets for air. 3 or 4 fittings lead to the VITROCELL® module inlets. The inlets aspirate the required dose from the constant flow of diluted test substance through the dilution system.

**Single dilution system for VITROCELL**® HD distribution systems

The dilution system has entry and exit nozzles for the aerosol stream plus 2 jets for air. The exit fitting is connected to the entry nozzle of the VITROCELL® HD Distribution System and the aerosol is then further distributed to the module.

**6-fold dilution system for VITROCELL**® 24

The dilution system has entry and exit nozzles for 6 different aerosol streams. Each of which has 2 jets for air. Their exit fittings are connected to the 6 entry fittings of the VITROCELL® 24 module and the aerosol is then further distributed in the module.

**Features**

- Dilution of the test substances for greater variation of doses
- Unique double-jet system for superior mixing results
- Material: stainless steel with unique VITROGLIDE surface treatment to minimize deposition

Connection of the special dilution system to the VITROCELL® 12 module
VITROCELL® Distribution Systems for Gases

For distribution of the test gas
to the inlets of the VITROCELL® modules

The VITROCELL® distribution systems deliver clean air or the airborne test substances to the module inlets.

○ Clean Air Distribution System
  The clean air system has an entry and exit for the clean air stream. 1 tube leads to the SPIDER which distributes the air to the module inlets. The inlets aspirate the required air from the constant flow of test substance through the distribution system.

  The distribution system is made of boron silicate glass with PTFE fittings.

○ Universal distribution system
  for gases
  This universal distribution system has entry and exit nozzles for the aerosol stream. 3 exit nozzles lead to the VITROCELL® module inlets. The inlets aspirate the required dose from the constant flow of test substance through the distribution system. The distribution system is made of high-quality boron silicate glass with PTFE fittings.

Features

○ Distribution from the source of the test substances and clean air to the module inlets
VITROCELL® Isokinetic Distribution System
For Gases, Complex Mixtures and Particles
to the inlets of the VITROCELL® modules

VITROCELL® isokinetic distribution systems are universal systems to deliver airborne test substances to the module inlets.

The aerosol is guided from the central duct to the modules via isokinetic sampling probes enabling high reproducibility and uniformity of results. The inlets aspirate directly from the constant flow of test substance.

The isokinetic distribution system is made of stainless steel.

Optional dilution system with air jets for dynamic dilution to obtain dose / response results.

Features
- Distribution from the source of the test substances to the module inlets
- High reproducibility
- Optional dilution system
- Available for VITROCELL® 6 and VITROCELL® 12 series
- 3- and 4-fold distribution
VITROCELL® HD Distribution System

For enhanced delivery of airborne particles to the VITROCELL® modules

This highly developed distribution system guides airborne substances and particles from one sampling point directly to the inlets of the exposure modules. The special delivery path makes optimized distribution possible.

It is available for VITROCELL® 6 and VITROCELL® 12 modules with a choice of 3- or 4-fold distribution. The optional heating capability is of particular interest to avoid condensation or to maintain certain chemical properties of the test substance.

Features

- Optimized distribution to module positions
- Available materials: POM and Stainless Steel/VITROGLIDE surfacetreatment
- Optional heating capability
- Available for VITROCELL® 6 and VITROCELL® 12 series
- 3- and 4-fold distribution
Application examples

VITROCELL® 12/6 CF with HD3 distribution system, sampling probe, flow controller and rack

VITROCELL® 12 CF module with 2 HD Distribution Systems
Made of stainless steel with unique VITROGLIDE surface treatment.
VITROCELL® Sidestream Chamber
For testing and dilution of atmospheric substances

This highly developed system guides airborne substances and particles from a singular aerosol inlet point to the inlets of the exposure modules. The special delivery path using 2 heated chambers ensures optimized aerosol transportation and dilution.

In the standard version, the test atmosphere enters the first chamber at a regulated flow rate of 50 – 150 m³/h. Optional VITROCELL® Particle Photometers can be used to monitor the particle concentrations. An isokinetic probe guides the sample flow to the second chamber. The atmosphere can then be diluted with up to 6.7 l/min of clean air resulting in a total maximum flow rate of 12.5 l/min.

The samples progress to the exposure module at 5 ml/min by means of isokinetic probes, the surplus is expelled. The entire system is heated in order to avoid condensation and to ensure that the chemical properties of specific test substances are maintained. It can be combined with VITROCELL® 6 and VITROCELL® 12 modules.

Features

- Reduction of high flows of test atmosphere by means of isokinetic sampling
- Integrated dilution system
- Heating capability
- Optimized distribution to module positions
- Combinable with VITROCELL® 6 and VITROCELL® 12 series
- Optional monitoring of test atmosphere using VITROCELL® Particle Photometers
Exhaust 1

2 Dilution System

3 Heated aerosol chambers

4 Exhaust 2

5 Aerosol sampling

6 Aerosol inlet

VITROCELL®
VITROCELL® Humidification Station
For humidification of clean/dilution air

High-end solution ensures a constant and stable supply of humidified air.

For sensitive cell systems and longer exposure times, humidification of the dilution and control air may be required – depending also on the air quality in the lab system.

This high-end solution offers the supply of humidified air at a constant level of humidity. With the genuine bypass system, the humidified air can be adjusted to the desired humidity level. The reliable operation using a permeation unit ensures a condensation-free operation.

Features
- Humidification of clean air up to 99.5 % RH
- Degree of humidification adjustable from base humidity to 99.5
- Max. air flow 40 l/min.
- Max. pressure 1.1 bar controlled by security valve
- Reliable humidification
- Online display of humidity and temperature
- Water bath with pumping function assures moisture delivery at constant conditions
- Dimensions humidification platform: 800 x 230 x 20 (W x D x H) mm
- Dimensions water bath: 181 x 332 x 370 (W x D x H) mm
VITROCELL® Washing Bottle

For humidification of clean/dilution air

VITROCELL® recommends using a set of 2 washing bottles.

The set is connected between the pressure regulator and exposure module. Just as the water temperature drops over time, humidity level change too. Therefore, this solution can only be recommended for short-term exposures.

VITROCELL® Inline Humidifiers

For humidification of the aerosol/test atmosphere before module inlet

The VITROCELL® Inline Humidifiers add moisture to the exposure modules immediately prior the inlets.

In using an inert permeation material, they are a viable solution whenever humidity cannot be added directly to the operating air of the aerosol generator, for example when dry powders must be aerosolized.
VITROCELL® Rack Systems
For tidy and safe installation of components

Designed specifically for user-friendly and easy handling: all components such as modules, dilution and distribution systems and flow calibration valves have their dedicated space on VITROCELL® Racks.

The rack systems are made of anodized aluminium and specifically designed holders. They are suitable for the VITROCELL® 6, 12 and AMES module family.

Rack for 2 modules

Features
- 1 complete rack for 2 modules
- Holders for HD Distribution System
- Suitable for low aerosol generator flow rates
- Ready mounted tubing system
- Possibility to integrate inline humidifiers
- Including holders for valves

Content of delivery
- Base plate with spirit-level
- Holders for valves, distribution and dilution systems, rotameter and flow controllers

Features
- 1 complete rack for 2 modules
- Holders for Isokinetic Distribution System
- Suitable for higher aerosol generator flow rates up to 16.7 l/min.
- Ready mounted tubing system
- Including holders for valves
Rack for up to 5 modules

- 1 complete rack for up to 5 modules
- Ready mounted, tubing system
- Including valves and all water quick connectors

Features

Content of delivery

- Base plate with spirit-level
- Holders for distributors and dilution systems
- Distributors for water circuit
- VITROCELL® vacuum flow calibration valves
- Holders for VITROCELL® modules
- Lifting mechanism for easy handling
Rack for up to 7 modules

Content of delivery

- Base plate with spirit-level
- Holders for distributors and dilution systems
- Distributors for water circuit
- VITROCELL® vacuum flow calibration valves
- Holders for VITROCELL® modules
- Lifting mechanism for easy handling

Features

- 1 complete rack for up to 7 modules
- Ready mounted, tubing system
- Including valves and all water quick connectors
Ames Rack
For optimal ease of handling

The rack features the unique track system for the base module. First, the module is loaded with the Petri dishes. The operator then slides the base module on the track to the connecting position. The aerosol exposure top is already mounted in a fixed position, with all tubing and connections to the dilution system in place.

By moving the manual lever, the base module is connected via the lifting device to the aerosol exposure top.

After completion of the exposure, the module is disconnected again by lowering the lifting device. The removal of the Petri dishes can be easily performed by sliding the module back to the loading position.

Then the module is ready again for the next exposure.

Content of delivery
- Base plate
- Holders for distributors and dilution system
- 1 valves for test gas or clean air
- 1 VITROCELL® AMES module holder on track system
- 3 VITROCELL® vacuum flow calibration valves
- Lifting device and locking unit

Feature
- Easy handling
VITROCELL® Cart Systems

For user-friendly and easy transport of all components of the *in vitro* exposure system

Designed specifically for user-friendly and easy handling. All components such as modules, dilution and distributions systems and flow calibration valves have their dedicated space on VITROCELL® Racks mounted on this cart. An integrated PC and monitor option is also available.

**Small Cart**

Dimensions: 1 200 x 800 x 840 mm

**Large Cart**

Dimensions: 1 500 x 800 x 840 mm
The filter housings are made for 25 mm diameter filter pads and have stainless steel fittings so that they can be connected to the distribution/dilution systems and the vacuum system. The particles are collected on the filter for further analysis by gravimetric or chemical methods.

VITROCELL® Filter Housings for 25 mm filter pads
The filter housings are made for 25 mm diameter filter pads and have stainless steel fittings so that they can be connected to the distribution/dilution systems and the vacuum system. The particles are collected on the filter for further analysis by gravimetric or chemical methods.

Features
- Suitable for 25 mm diameter filter pads
- Stainless steel nozzles

VITROCELL® mm Filter Housings for 92 mm cambridge filter pads
The filter housings are made for 92 mm diameter filter pads and have stainless steel fittings so that they can be connected to the smoke path of the Smoking Machine. The total particulate matter is collected on the filter for further analysis by gravimetric or chemical methods. A user-friendly closing and opening mechanism allows for a safe and airtight operation.

Features
- Suitable for 92 mm diameter filter pads
- Stainless steel nozzles
- User-friendly closing and opening mechanism
VITROCELL® Photometers were specifically designed and developed to enable online measurements of particle concentrations at the inlets and/or outlets of the aerosol exposure top.

They are capable of measuring inline at very low flow-rates (e.g. 5 ml/min.) without any particle losses. The photometer measures a mere 62 mm in diameter. The photometers can be supplied with a control box and PC software for convenient read-outs.

Features

- Inline measurement with online read-out
- No losses of mass
- Extremely small
VITROCELL® Monitor Software for Photometers

Standard Edition

The VITROCELL® Monitor software enables data for max. 9 photometers to be presented online, including an area under curve calculation. The data is logged into a .csv file which can be opened in Excel®.

Options for 5 Parameters

The VITROCELL® Monitor software is capable to record 5 different parameters:

- Deposition on the VITROCELL® QCM
- Concentration of Aerosols measured by the VITROCELL® Photometer
- Carbon monoxide concentration
- Temperature
- Humidity

The software supports multiscreen use. By undocking charts from the main window they can be placed free in size and position or on a second screen.

GLP Edition

VITROCELL® Monitor software GLP Edition was developed for laboratories operating under GLP conditions. This software upgrade assures traceability to high standards.
The microbalance sensor can be fitted in all VITROCELL® installations. It is capable of measuring the deposited mass in the module at a resolution of 10 nanogram/cm² per second.

The sensors can be placed in all media compartments to validate mass deposition in the module. After validation, they may be removed so that the experiment can be carried out using the cell culture inserts. Alternatively, one microbalance sensor can remain in the module to monitor the dose during exposure. The remaining compartments of the module are used for cell culture inserts.

VITROCELL® Microbalance Sensor – optimal for dose-response measurement.

Features

- Deposition measurement in the module with online read-out
- Extremely sensitive for smallest masses
- Resolution of 10 nanogram/cm²
- Lower detection limit of 20 nanogram/cm² h
- Supplied as a turnkey system with PC and VITROCELL® Software
Aerosol Process Validation

Module Operation with Cell Cultures

Module Operation with Cell Cultures and Online Control
VITROCELL® Monitor Software for Microbalances

**Standard Edition**

The VITROCELL® Monitor software shows the deposition in ng/cm² online for max. 9 microbalances. The data is logged into a .csv file which can be opened with Excel®.

**Combined view with Photometers**

With the VITROCELL® Monitor software deposition data in ng/cm² of up to 9 microbalance sensors as well as for 9 photometers is available in a combined view.

**Microbalance Controller**

The VITROCELL® Microbalance Controller is available as laptop version (for 1 sensor) or PC version (for 3, 6 or 9 sensors).
GLP Edition

VITROCELL® Monitor software GLP Edition was developed for laboratories operating under GLP conditions. This software upgrade assures tracability to high standards.

Key Features:
- User Management via personal USB-Dongle
- Password protection
- Auto Lock or Manual Lock function in case the operator needs to leave the workplace

Special Administrator Features
- Admin is able to export the log file
- Admin can change the auto log off time
- Admin can unlock user dongle

Log File
Date, time, message type, user name, source, new content, old content and comment are displayed in the reporting file to ensure a consistent documentation of every exposure.
VITROCELL® CO Monitor

High-end solution for gas monitoring

CO measurement is an efficient way to monitor the gas phase in cigarette smoke and other aerosols. VITROCELL® offers a high-end solution for precise measurement of the CO concentration within different ranges and channels. Each unit is delivered turnkey, with inline reading and recording using the VITROCELL® Monitor software.

Features

- Sampling system with integrated gas pump
- Minimum sampling gas flow 0.3 l/min.
- NDIR Gas Analyzer SIEMENS ULTRAMAT 6
- Example for range configuration:
  - Range 1: 0 ... 5 000 ppm
  - Range 2: 0 ... 10 000 ppm
  - Range 3: 0 ... 15 000 ppm
  - Range 4: 0 ... 20 000 ppm
- Automatic and manual range switching
- Interface RS 485 / RS 232
- Bus cable and connector for Profibus
- VITROCELL® Monitor software incl. Laptop
- Dimensions Analyser Rack ca. 746 mm (H) x 600 mm (W) x 673 mm (D), ready mounted
- FAT included
This setup was developed in close cooperation with Gasmet. The system offers a puff-by-puff quantification of key constituents of aerosol from electronic cigarettes. It is combined with the proven VC 1, VC 1 S-TYPE, VC 10® and VC 10® S-TYPE smoking machines and offers a fast evaluation of the aerosol in intervals of 1 s. Therefore it is a powerful alternative to classical chemical analysis which takes time-consuming steps by trapping, extraction, measurement and evaluation.

Sampling and measurement system configuration:

1 | Aerosol generated by VITROCELL® smoking machine
   ○ HCl, ISO or CRM 81 regimes
   ○ E-cigarette aerosol mixed with N₂ carrier gas
   ○ Continuous purging after puff

2 | Controller for carrier gas (N₂)
   ○ N₂ flows from 50 ml/min up to 5.0 l/min
   ○ Integrated mass flow controller

3 | Hot Gas Mixer
   ○ Heated line after mixing of carrier gas and aerosol

4 | Gasmet FTIR analyser
   ○ Small volume sample cell, 200 cm path length
   ○ Calcmet PRO software & RS-422 for fast measurement (1 s measurement interval)

Flow chart of VITROCELL® FTIR
Gasmet™ FTIR – Analytics – Calcmet™ Software

Application library can be customized:
○ Add flavor components
○ Proprietary ingredients

Results 1
Sample cell: 200 cm
Heated Sample line: 4 m
N₂ Carrier flow: 2500 ml/min
Measurement interval: 1 s
No filter
8 s exhaust time, 30 s frequency,
square puff volume 55 ml

Results 2
Sample cell: 200 cm
Heated Sample line: 5 m
N₂ Carrier flow: 1900 ml/min
Measurement interval: 1 s
Hot particulate filter
8 s exhaust time, 30 s frequency,
square puff volume 55 ml

Results 3
Sample cell: 200 cm
Heated Sample line: 5 m
N₂ Carrier flow: 1900 ml/min
Measurement interval: 1 s
Hot particulate filter
8 s exhaust time, 30 s frequency,
square puff volume 55 ml

Summary
○ Reliable, easy to use online analysis tool
○ Wide range of components due to Calcmet library
○ Fast response
○ Ideal for quality control and dose monitoring
Photonion has developed a new on-line real-time measuring system for chemical gas analysis based on time-of-flight mass spectrometry (TOF-MS). This technology is now integrated in the VITROCELL modules in order to analyze the sampling at the spot where the cells are exposed.

Three different ionization techniques are applicable:

○ single photon ionization (SPI) with a special VUV excimer source or laser VUV source
○ resonance enhanced multiphoton ionization (REMPI) with a laser beam
○ electron impact ionization (EI).

SPI and REMPI are considered as soft ionization techniques allowing the acquisition of mass spectra with nearly no fragmentation. A heated transfer line allows direct gas analysis of e.g. engine exhaust, cigarette smoke or e-cigarette vapors.

Gaseous samples are addressed continuously by the Photo-TOF-MS mass spectrometry system at a flow rate of approx. 2ml/min. Depending on the ionization technique various relevant species can be ionized by SPI, REMPI or EI. After the ionization, the formed ions are accelerated into the reflectron time-of-flight mass analyzer where they are separated due to their different mass to charge ratios.

A typical TOF mass spectrum can be generated in some milliseconds. This fast on-line measurement system is a selective and sensitive analytical method to investigate complex gas mixtures such as from combustion processes.
VUV-photo ionization (SPI):
Universal soft ionization of organic compounds
VUV lamp with 98 eV - 10.78 eV (126 nm - 115 nm) or Nd:YAG laser with third harmonic generation VUV-cell with 10.5 eV (118 nm)
○ detection limits for most organics in ppb region

Laser-photo ionization (REMPI):
Superior selectivity and sensitivity for aromatics (optional)
Fixed frequency (266 or 248 nm) or tunable lasers (OPO) in wavelengths range 206 nm - 300 nm
○ detection limits for most aromatics in low ppb or ppt region

Electron ionization (EI)
Standard fragmenting ionization technique (optional)
70 eV for mass spectra with standard fragmentation (NIST) or tunable from 5 eV to 90 eV (special setup)
○ detection limits in ppm - ppb range

Multiplexing ionization mode (MIM)
Achieving SPI, REMPI and EI results simultaneously (optional)
The ionization methods (REMPI/EI/SPI) can be operated quasi-simultaneously via multiplexed acquisition methods.

Technical Data

TOF-mass analyzer
○ Direct reflection time of flight mass spectrometer (flight path 0.9 m)
○ Mass range: 10 – 2000 Th (m/z) (standard configuration)
○ Mass resolution: m/Δm = 2000
○ Mass accuracy: 100 ppm
○ Maximal primary data acquisition rate: 100 kHz

Rack configuration
○ 2x19"-module rack
○ Dimensions 1 200 x 800 x 1 300 mm (W x D x H)
○ Power supply 100-230 V, 50/60 Hz

Data acquisition and visualization software
○ Data is displayed in real time
○ Actual measured mass spectra and the variation of selected ions is displayed
○ Data can be exported (formats e.g.: txt, CSV)
○ Customer specific data anlysis software available.

Direct inlet TOFMS of diesel fuel headspace, recorded with (A) single photon ionization (SPI), (B) resonance enhanced multiphoton ionization (REMPI) and (C) electron impact ionization (EI).

3D graph showing different constituents of the gas phase from 10 puffs of a 3R4F cigarette.
VITROCELL® Skin
For the exposure of tissue to liquids and the analysis of volatile compounds

The VITROCELL® Skin module is a unique system for the exposure of tissue to liquids and volatile compounds. It has a 6-chamber capacity.

The base module and optional exposure tops are made of high-quality stainless steel. The unique tissue holders have been specifically designed to enable tight and reliable skin fixation. This module is a legitimate and superior alternative to Franz cells.

Base module including cover unit
The standard volume for the receptor fluid is 2.5 or 5.0 ml. The receptor fluid can be manually or automatically sampled by means of the VITROCELL® Skin Autosampler syringes. The module has a magnetic stirring capability for each individual compartment. The cover domes ensure a reduction in evaporation.

Base module including exposure top
The aerosol exposure top enables either a continuous or time-dependent exposure of the sample to gases, aerosols or complex mixtures.

The system is provided with a full set of holder counterparts. Thickness ranges:
- 500 μm
- 500 – 1000 μm
- 1000 – 1500 μm
- 1500 – 2000 μm

Features
- Durable and long lasting design
- Unique tissue holder
- Permanent or static media supply
- Integrated water bath heating circuit
- Suitable for diverse tissue thicknesses up to 2000 μm
- Option: exposure top for the analysis of volatile compounds
- Option: magnetic stirrers
Exposure to liquids

Analysis of volatile compounds
VITROCELL® Skin Max
For the exposure of tissue to compounds

The VITROCELL® Skin Max module is a unique system with 8 chambers for tissue exposure. The base module and covers are made of high-quality stainless steel. This module is a superior alternative to Franz cells. For automation of the sampling process please refer to the VITROCELL® Skin Autosampler.

Skin Max module illustration
The Skin module is used for samples with smaller surface of approx. 4.9 cm². The skin samples are fixed in the specifically designed skin holders for a tight separation between the exposure side and the receptor fluid. Alternatively, cell culture inserts may be used.

Features
- Durable and long lasting design
- Permanent or static fluid supply
- Integrated water bath heating circuit
- Suitable for various tissue thicknesses
- Tissue diameter: 50 mm
- Tissue exposure surface diameter: 25 mm
- Option: magnetic stirrers

Skin Max Module Cover
Fixation Bracket
The skin sample can be fixed using specific fixation brackets. The cover domes ensure a reduction in evaporation.

Skin Max Module Compartment
The standard volume for receptor fluid is 4 ml. The receptor fluid can be manually or automatically sampled by means of the VITROCELL® Skin Autosampler.

The receptor fluid can be sampled by using practical quarter-turn valves.
Schematic view of VITROCELL® Skin Max

- Base Module
- 8 Magnetic Stirrers
- Tissue Holder
- Receptor Fluid
- Tissue
- Fluid Outlet
- Tissue Holder
- Fluid Inlet
- Fixation Bracket
- Cover
VITROCELL® Skin Aerosol Max

For the exposure of tissue to aerosols and gaseous compounds

The VITROCELL® Aerosol Max module is a unique system with 8 chambers for tissue to aerosols and gaseous compounds. The base module and covers are made of high-quality stainless steel. This module is a superior alternative to Franz cells.

The Aerosol Max module is used for samples with surface of approx. 4.9 cm².

8 single Aerosol Exposure Tops

The aerosol inlet stream flows through specifically shaped inlets. Aerosol inlets are connected to the VITROCELL® distribution or dilution systems. VITROCELL® calibration valves, which are connected to a vacuum pump, control flow rates over the issue effectively. The aerosol exposure tops feature an in/outlet for heating the water circuit, ensuring corresponding temperatures with the base module.

For automation of the sampling process please refer to the VITROCELL® Skin Autosampler.

Skin Max Module Compartment

The standard volume for receptor fluid is 4 ml. The receptor fluid can be manually or automatically sampled by means of the VITROCELL® Skin Autosampler.

Skin Aerosol Max with 8 individual Aerosol Exposure Tops and their respective holders on the rack.

Features

- Aerosol Exposure Tops
- Durable and long lasting design
- Permanent or static fluid supply
- Integrated water bath heating circuit
- Suitable for various tissue thicknesses
- Tissue diameter: 50 mm
- Tissue exposure surface diameter: 25 mm
- Option: magnetic stirrers
This system is specifically designed for dose-controlled and spatially uniform deposition of liquid aerosols on skin samples. The aerosol is applied for a short time of approx. 3-4 minutes.

The Cloud aerosol chamber is made of Polycarbonate. There are 2 options for the aerosol generation: Aeroneb® Lab with a particle size of 4.0 µm – 6.0 µm VMD or Aeroneb® Pro with a larger span of 2.5 to 6.0 µm VMD. Nebulizers for larger particle sizes are available upon request.

The VITROCELL® Cloud can be used for aerosols generated from liquids and suspensions. Possible fields of application include toxicity testing including nanoparticle suspensions. The unique tissue holders have been specifically designed to enable tight and reliable skin fixation. This module is a legitimate and superior alternative to Franz cells.

Please download the VITROCELL® Cloud demonstration video from our website.

VITROCELL® Cloud Skin
For the exposure of tissue to liquid aerosols

VITROCELL® Cloud Skin
For 12 skin tissue holders or 12 inserts (12-well size) with 9 places for exposure and 3 places for clean air control.
Phase 1
Emission Of Cloud

Phase 2
Homogeneous Mixing

Phase 3
Gravitational Settling

Features

- New exposure system for liquid aerosols
- High droplet output rate – cloud dynamics
- No external air-flow required (simple)
- No humidity control required
- Dose-controlled and spatially uniform aerosol deposition
- Small residual volume in nebulizer reservoir
- Easy handling
- Unique tissue holder

The system is provided with a full set of holder counterparts.
Thickness ranges:
- 500 \(\mu m\)
- 500 – 1000 \(\mu m\)
- 1000 – 1500 \(\mu m\)
- 1500 – 2000 \(\mu m\)
VITROCELL® Skin Autosampler
For automated, highly reproducible sampling of receptor fluid

The VITROCELL® Skin Autosampler enables precise receptor-fluid sampling at programmable intervals. Once you have set up your VITROCELL® Skin module with skin samples, it is fully automated to deliver bubble-free samples in cooled vials. Thus, offering you an indispensable tool for lab automation.

The VITROCELL® Skin Autosampler enables you to take precise samples from the receptor fluid in individually programmable intervals. This makes the autosampler a powerful device for toxicokinetic studies.

All functions are edited via an intuitively designed touch panel.

1 | Receptor fluid is stored in glass bottles and can be supplied gravimetrically or by syringe to the VITROCELL® Skin Exposure Module.

2 | The VITROCELL® Skin Exposure Module has an 8 chamber capacity and an integrated water bath heating circuit (e.g. 32-34 °C). Magnetic stirrers enable receptor-fluid agitation at variable rates.

3 | A linear arrangement of up to 8 stepper-motor controlled individual syringes ensures precise sampling and highly reproducible results.

4 | The samples are delivered to an arrangement of 10 vial magazines each containing 8 s. The magazines can be cooled (e.g. 5 °C).
Features

- Automated, time-based sampling from up to 8 individual exposure chambers
- Ideal tool for toxicokinetic studies
- High reproducibility of results
- Programmable sample volume 0.1 – 1.0 ml
- Freely programmable sampling intervals
- Suitable for VITROCELL® Skin and VITROCELL® Skin Max Modules
- Exposure module made of high-quality stainless steel with an integrated heating circuit
- Integrated magnetic stirrers
- 10 cooled vial magazines for up to 8 vials (1.5 ml)
- Bubble-free automated delivery of fresh receptor fluid with high reproducibility
- Possibility to integrate impedance measurements

Technical Data

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Auxiliary Equipment

- Magnetic stirrer set incl. control unit
- Cooling liquid device
- Heating liquid device
VITROCELL®
Skin Punching Tool

This heavy-duty tool is the solution for punching skin samples in an effortless and reliable way.

The procedure is as follows: place the skin sample on the ground plate, push the lever of the press downwards and punch into the skin. Then move the cutting tool in a circular manner to finalize a precise cut. Remove the sample.

Features

○ Rapid changeover of punching tool due to the easy and secure adjustment of the working height
○ Ground plate with precision T-slot and precise alignment
○ The original position of the hand lever can be varied by 360°
○ Available for left-handed and right-handed use

○ The return stroke force of the ram can be adapted to different tool weights
○ Precision Alignment < 0,05 mm between upper and lower tool
○ Maintenance-free
○ No lubrication necessary
○ Tool diameter 25 mm (other sizes available)
○ Height: 46 cm
VITROCELL® Flow Control

Introduction

Constant and defined flow of the test atmosphere over the cells is an important factor for the experiment. The VITROCELL® modules are designed to operate at low flow rates, in most cases the flow rate is 5 ml/min. In some applications higher flow rates are used. The recommended and most economical way to adjust the flow rate is to use the unique and efficient VITROCELL® flow calibration valves. The desired flow rate level is adjusted to a mass flow meter read out.

Alternatively VITROCELL® offers electronic mass flow controllers. In this case one mass flow controller per cell culture insert compartment is permanently required.

VITROCELL® Flow Calibration Valves

VITROCELL® flow calibration valves regulate the flow of the aerosol through the modules in the ml range.

The valves are located between the vacuum pump and the aerosol exposure top. Mass flow meters enable accurate valve read-outs. The consistent and adjustable flow rate ranges from 0...20 ml/min.

Alternative flow rate ranges are available upon request. The valves enable fast control of the flow rates prior to the experiment. They are manufactured from Teflon/stainless steel and can be easily cleaned. If the aerosol contains particles, we recommend installing disposable microfiber filters in front of the valves.

Features

- Easy and quick flow adjustment
- Economical solution
- Can be easily cleaned
VITROCELL®
Flow Control Equipment

VITROCELL® Mass Flow Meter

Mass flow meters are required to adjust the vacuum flow by means of vacuum calibration valves and to accurately set dilution and aerosol generator airflows. They are available in ml/min to l/min. ranges.

**Most frequent ranges for vacuum flow:**
- 0-10 ml/min
- 0-20 ml/min
- 0-100 ml/min
- 0-200 ml/min

**Most frequent range for dilution air flow:**
- 0-10 l/min

VITROCELL® Mass Flow Controller

Mass flow controllers have been specifically designed to regulate dilution and aerosol generator airflow precisely. They are available various l/min. ranges.

**Most frequent ranges for dilution air flow:**
- 0-1 l/min
- 0-2 l/min
- 0-5 l/min
- 0-10 l/min

**Most frequent range for vacuum flow (HD System):**
- 0-5 l/min

VITROCELL® Flow Monitor Software

In previous installations flow controllers had to be set manually. With the integration of the controllers into the VITROCELL® Monitor Software setting of target flows and reporting of actual flows is made easy.

Existing installations can be supplied with cable sets, distribution hub and a plug-in for the Monitor Software.
VITROCELL® Clean Air Purification Station
For clean air control supply, dilution systems and aerosol generators

The VITROCELL® Clean Air Purification Station is recommended when the air quality of a central air supply system or of a lab compressor contains oil or particles which may influence the test results.

An indication of impurities in the system and thus the need for an improvement of the air quality is evident if the cell viability drops substantially in the clean air exposure modules.

Components of the station:

1 | Pressure regulator
2 | Pre-Filter with condensate trapping
   Filter unit 5 μm
   Manual Condensate Drain
3 | Membrane Dryer
4 | Activated Carbon Filter
   Reduction of oil mist content <0.003 mg/m³
5 | Fine Filter
   Retention rate 99.9999 % (0.01 μm)
VITROCELL®
Water Bath

Introduction

VITROCELL® cultivation and exposure modules can be operated without an incubator. The modules can be heated to maintain a media temperature of 37° C (99° F). For the VITROCELL® 6/6, 12/12, 24/24 and 24/48 systems, heating is controlled electrically. All other modules are heated by warm water.

Water Bath

VITROCELL® uses water baths to efficiently heat and pump water through the circuit of the exposure modules, ensuring accuracy in temperature control with a modern state-of-the-art design. These units provide best-in-class economical performance while remaining user-friendly by reducing unnecessary functions and focusing on reliability. Engineered from highest-quality components and materials, such as stainless steel for the baths, durable heating thermostats with a long operation life are guaranteed.

Features Standard Version

○ For up to 3 modules
○ 3-Key operation with LED-Display
○ LED temperature display
○ Temperature Range 25° C to 100° C
○ Prolonged operating life
○ Dimensions: 147 x 307 x 330 mm (W x D x H)
○ Delivered with cover plate and tubing connectors
○ Max. flow 20 l/min
○ Max. pump pressure 0.2 bar
○ Bath volume max. 6 Liters
○ Filling volume min. 4.9 Liters

Features High Performance Version

○ For more than 3 modules
○ 5.7” touchscreen and comfortable menu navigation
○ 5-point calibration
○ Temperature Range 25° C to 100° C
○ Prolonged operating life
○ Dimensions: 147 x 307 x 330 mm (W x D x H)
○ Delivered with cover plate and tubing connectors
○ Max. flow 27 l/min
○ Max. pump pressure 0.7 bar
○ Bath volume max. 6 Liters
○ Filling volume min. 4.9 Liters
VITROCELL® Vacuum Pump

Introduction

All VITROCELL® cultivation and exposure modules receive the test atmosphere by negative pressure at low flow rates. The negative pressure is taken from the in-house vacuum line or – if this is not available – by using a vacuum pump. The minimum performance of the vacuum source should be 2.0 m³/hour (35 cf/h). The vacuum pump is connected to the vacuum distribution lines delivered with each VITROCELL® installation.

Vacuum Pump

The vacuum diaphragm pumps supplied by VITROCELL® have been developed and manufactured to be chemically resistant. Thus, they are suitable for aggressive or corrosive gases and vapors alike.

The dry-running devices are specifically developed for laboratory applications and are maintenance-free. The pump exhaust line must be guided to a laboratory hood for proper extraction.

Damping Unit for Vacuum Pump

High-end solution which was specially developed by VITROCELL® for a vibration-free operation in the lab environment. It is highly recommended when the vacuum pump is located close to the exposure module, e.g. in the same extraction hood.

Features

○ Compatible with all vapors and condensations
○ Chemically-resistant
○ Suitable for highly aggressive or corrosive gases
○ Maintenance-free
To expand the analytical possibilities inside the Vitrocell® exposure modules, special analytical inserts have been developed together with the Karlsruhe Institute of Technology (KIT). They can be equipped with sample carriers for transmission electron microscopy (TEM-Grids) to analyse number and morphology of deposited particles. The grids are located on the same level as the cells during a regular exposure. Furthermore, the grids can be fixed on different radii on the insert surface. The TEM Grid Holders are available for the 6- and 12-well format.

VITROCELL® TEM Grid Holder
Easy and reproducible analysis of deposited particles

Components with highest precision

1. Holder base plate (left) with counterplate (right) in mounting position.

2. Holder base plate with inserted grids.

3. Holder base plate with counterplate and TEM grids in receiving position.

4. Complete TEM Grid Holder.
**VITROCELL® Precision Pump System**

For dosing of very small liquid quantities (5 – 180 µl)

**Introduction**

The VITROCELL® CF modules feature the option for culture media exchange: fresh media can be pumped in at – if desired – very low flow rates and forwarded out at the same speed. The media which has been pumped out of the compartment can be further analyzed. This procedure is also recommended for long exposure times.

**VITROCELL® Precision Pump System**

The VITROCELL® Precision Pump System was specifically developed and engineered for the time-based dosing of miniscule quantities (5-180 µl).

This stepper motor controlled diaphragm dosing pump system has been specifically designed to accurately dose small quantities of liquid over long periods of time. It has two distinctive features – its scalability and durability (pump and electronics).

The VITROCELL® CF modules feature a media exchange option.

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**Advantages**

- Simple and precise pump control (interval and volume)
- Flexibility of the control process
- Modular concept: various pump controllers can be interconnected
Features

○ Excellent repeatability
○ High stability in the long term
○ High chemical resistance
○ Fast priming and purging mode
○ Self priming
○ Run-dry ability
○ Prolonged operating life
○ Maintenance-free (>10’000 h)

Content of delivery

○ Pump Controller with 3 pumps
○ Power supply
○ Laptop with control software

Technical Data

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispense mode:</td>
<td>5 – 180 µl</td>
</tr>
<tr>
<td>Priming mode (max.):</td>
<td>20 ml/min</td>
</tr>
<tr>
<td>Max. suction height:</td>
<td>4 mWg</td>
</tr>
<tr>
<td>Max. back pressure:</td>
<td>6 bar</td>
</tr>
<tr>
<td>Accuracy:</td>
<td>±2 %</td>
</tr>
<tr>
<td>Repeatability:</td>
<td>±1 %</td>
</tr>
<tr>
<td>Allowed ambient temperature:</td>
<td>+5 – +40 °C</td>
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<tr>
<td>Allowed liquid temperature:</td>
<td>+5 – +80 °C</td>
</tr>
<tr>
<td>Max. viscosity liquid:</td>
<td>150 cST</td>
</tr>
<tr>
<td>Dimensions Power Supply and Pump Controller:</td>
<td>240 x 200 x 88 mm (W x D x H)</td>
</tr>
<tr>
<td>Voltage:</td>
<td>100-240 V, 50/60 Hz</td>
</tr>
</tbody>
</table>
The VITROCELL® EPITHELIX Nanopress enables particle and powder dosage in a precise and reproducible manner, thus making it an optimal tool for exposure to 3-D cell cultures.

The process was developed by EPITHELIX.

First, the test substance is mixed with Dextran powder. The mixing ratio can be varied according to the required dose/response relationship. Using the nanopress, tablets are produced so that they can be placed directly on the cell cultures. After incubation of approximately 15 min. the Dextran tablet dissolves and the cells are directly exposed to the test substance.

**Features**

- Exposure to a defined and small dose possible
- Easy to use
- Perfect screening tool
1 | Add Dextran powder to the press

2 | Fill the reservoir

3 | Remove surplus powder from the press surface with a cell scraper

4 | Push the lever

5 | Push the button to expel the tablet

6 | Remove the tablet

7 | Place the tablet on the apical surface

8 | Incubate for approx. 15 minutes

9 | The Dextran tablet is entirely dissolved
VITROCELL® Aerosolist
Automated sampling system for aerosol monitoring

Introduction

Should aerosols need to be sampled directly on-site e.g. at workplaces, it is vital to have controlled flow conditions for the different sampling points.

Additionally, timing and sampling intervals need to be clearly defined.

The VITROCELL® Aerosolist with integrated vacuum pump and flow controllers can be individually programmed according to the requirements of sample collection. This vacuum flow control-unit is the ideal tool to monitor desired and real vacuum flow rates for 4 to 99 channels.

Features

○ Defined vacuum flow control for each channel. Flow rates can be specified as required.

○ Individually defined sampling intervals: measuring and stand-by times, number of cycles, start-/end times.

○ Monitoring of vacuum differential pressure for each channel with trend analysis. Important to monitor filter saturation.

○ Integrated vacuum pump

○ Recording of atmospheric pressure, temperature and relative humidity surrounding sample

○ Data logging to PC with .csv file: System time and date, target and real MFC readings, vacuum pressure loss, surrounding conditions

○ Data can be exported to Excel®

○ Remote operation without PC and system integration in Network possible

○ Individual selection of the vacuum channel
About VITROCELL®

VITROCELL® exclusively concentrates on the developing, producing, installing, training and servicing of advanced in vitro exposure systems.

The VITROCELL® Systems’ team is driven by their vision for new in-vitro standards through state-of-the-art technology, highly qualified workmanship and absolute client dedication. VITROCELL® has successfully collaborated with clients from leading research institutes, contract research organizations, regulatory authorities or industrial laboratories across the world. Working with our team experts, all modules have been tailored to create durable and complete turnkey-systems for in vitro inhalation toxicology. Gases, environmental atmospheres, nano particles and complex mixtures are analyzed on lung cells at the air/liquid interface using these systems. VITROCELL® technologies are also applicable to solutions for skin research.

Over a decade of devotion to research in this specific field has given our team of design & precision manufacturing specialists the opportunity to mentor highly diversified and complex projects from conception to completion. We strive to become a constructive member of each research team, providing support when it is needed, advice when it is required and modules of the highest quality, which are even polished by hand before leaving here to be integrated into your workspace. Every piece of our German engineered equipment is manufactured to the highest of standards – yours.

For more information please scan the QR-Code: