Anaesthetic gases and vapours
N_2O, isoflurane, ethrane, halothane and sevorane

Radiello components to be used

Sampling kit code 125, containing 20 single packages each composed of:
1 permeative body (see code 120-3)
1 supporting plate (see code 121)
1 vertical adapter (see code 122)
1 adsorbing cartridge (see code 132)

the listed components are contained in a closed aluminum envelope, which is wrapped by a thermowelded paper-polyethylene bag.

The whole is sterilized by γ-rays.

The single components are also available **non-sterilized** in 20 pieces per package.

Principle

Code 132 cartridge is made of stainless steel net loaded with a mixture of molecular sieve and activated charcoal 35-50 mesh.

Nitrous oxide and halogenated anaesthetic gases permeate the silicone membrane and are sampled by the molecular sieve and by activated charcoal respectively.

The sampled compounds are displaced by a water-methanol mixture and are quantified by capillary gas chromatography and a headspace sampler.

N_2O, isoflurane, ethrane and halothane are detected by the Electron Capture Detector (ECD) with very good sensitivity; sevorane can not be quantified by ECD detection and has to be analyzed by mass spectrometry.

Sampling rates

Sampling rate values Q at 298 K (25 °C) and 1013 hPa are listed in the table on the right.

	Q_{298} ($ml \cdot min^{-1}$)
N_2O	1.01
forane (isoflurane)	2.25
ethrane	3.39
halothane	4.93
sevorane	0.92

Effect of temperature, humidity and wind speed

Sampling rate varies from the values at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation:

$$Q_K = Q_{298} \left(\frac{K}{298}\right)^{1.5}$$

where Q_K is the sampling rate at temperature **K** and Q_{298} is the sampling rate value at reference temperature of 298 K. This yields a ± 5% variation of Q for a 10 °C variation (upwards or downwards) from 25 °C.

Sampling rate is invariant with humidity in the range 10 - 90% for exposure time not exceeding 8 hours and with wind speed between 0.1 and 10 $m \cdot s^{-1}$.

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radiello is patented by
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Calculations

Concentration in air is obtained by the following equation:

$$C = \frac{m}{Q_K \cdot t} 1{,}000$$

where:
C = concentration in $mg \cdot m^{-3}$
m = mass of analyte found on the cartridge in µg
Q_K = sampling rate in $ml \cdot min^{-1}$
t = exposure time in minutes

Exposure

Sampling rate is constant for exposure time up to 8 hours at relative humidity up to 80% with N_2O concentration up to 500 ppm and overall halogenated anaesthetic compounds concentration up to 100 ppm.

Exposure time longer than 8 hours in presence of relative humidity higher than 80% leads to the loss of the nitrous oxide already sampled by the effect of competing water vapour adsorption on the molecular sieve sites.

Limit of detection and uncertainty

The cartridges are conditioned to ensure a chromatographic blank level lower than three times the instrumental noise at the minimum attenuation.

If a well conditioned ECD is employed, 4 hours of exposure ensure the following analytical sensitivities: 0.5 ppm of N_2O, 0.002 ppm of forane, 0.01 ppm of ethrane and 0.002 ppm of halothane. **Sevorane is not detected by ECD.** The Flame Ionisation Detector (FID) can be employed instead with acceptable sensitivity, but if nitrous oxide and the other halogenated compounds have to be quantified at the same time, a mass spectrometry detector must be used. Acquiring by the SIM (Single Ion Monitoring) technique detection limits close to the ECD performances can be achieved for N_2O, forane, ethrane and halothane. For sevorane, 1 hour exposure allows to detect 0.1 ppm.

The uncertainty at 2σ is: 5.5% for N_2O, 4.7 - 5.6% for forane, ethrane and halothane with ECD detection, 6.2% for N_2O and 5.5 - 6.2% for forane, ethrane, halothane and sevorane with MS detection.

Storage

The sampling kit code 125 is sterilized by γ-rays. Use of the sampler makes it no longer sterile. With the exception of the adsorbing cartridge, the sampler is indefinitely re-usable. After the first sampling, if you can arrange for sterilization by yourselves you only need to re-order code 132 cartridges to perform other sampling campaigns. Adsorbing cartridges need not to be sterile.

IMPORTANT

DO NOT STERILIZE THE SAMPLER BY AUTOCLAVING. Autoclaving treatment **permanently** damages the silicone permeative membrane.

If kept in a dry place free from chemical contamination, the cartridges are stable for at least 12 months.

After the sampling, the cartridges are stable for 30 days if stored with the same precautions.

Analysis

Materials needed for the analysis

✓ 20 ml headspace glass vials with open-top aluminum crimp caps and rubber/PTFE septa
✓ water/methanol mixture 60/40 v/v
✓ usual laboratory glassware

Materials needed for the calibration curve

- ✓ pure N_2O in a gas cylinder
- ✓ halogenated anaesthetic compounds
- ✓ gastight syringe (volume 500 µl) and other syringes (volume 100 and 10 µl)
- ✓ 1 liter glass bottle with threaded neck, equipped with open-top screw cap and rubber/PTFE septum ***(the volume of the bottle must be precisely measured and the bottle must be rinsed with dry nitrogen before use***)
- ✓ magnetic stirrer with large magnetic stirring bar (about 30-40 mm long)
- ✓ usual laboratory glassware

Extraction

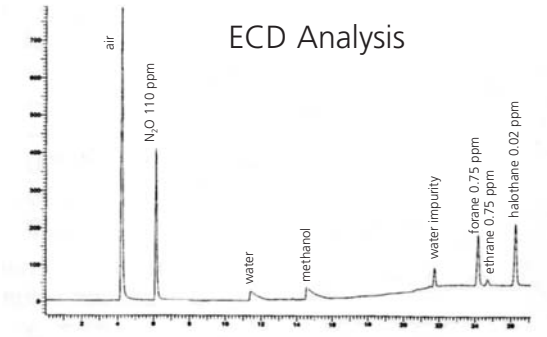
Introduce 10 ml of water/methanol mixture in a headspace vial by a volumetric pipette. Add the ***radiello*** cartridge and cap immediately. Stir and let equilibrate, place the vial in the headspace bath and let equilibrate for one hour at 45 °C.

Instrumental analysis

ECD detection (sevorane is not detected)

- ✓ vial pressurization gas: N_2 at 1.2 atm
- ✓ loop volume: 1 ml
- ✓ gas chromatographic column: polystyrene-divinylbenzene PLOT, 30m x 0.32mm, film 20µm (e.g. Supel-Q-PLOT, Supelco cat.no. 24242) (allows quantification of nitrous oxide and other anaesthetic gases in one chromatographic run)
- ✓ carrier gas: N_2 at 1.0 atm
- ✓ split ratio: 10/1
- ✓ make-up gas: Ar-CH_4 (CH_4 10% v/v) at 30 ml·min^{-1}
- ✓ GC oven: 40° C for 2 min, 10° C·min^{-1} up to 150° C, 6° C·min^{-1} up to 200° C, final isotherm for 5 minutes
- ✓ injector temperature: 150° C
- ✓ detector temperature: 300° C

In the described analytical conditions chromatogram similar to the one in the figure are obtained. In the example shown, exposure time was 4 hours at the concentration values indicated and with relative humidity of 70%.



MS detection

The instrumental conditions are as described above, with the exception of the carrier gas (helium has to be used instead) and the make-up gas, which is not employed. Acquire by SIM (Single Ion Monitoring) focussing the detector on the following signals (the base peak is underlined):

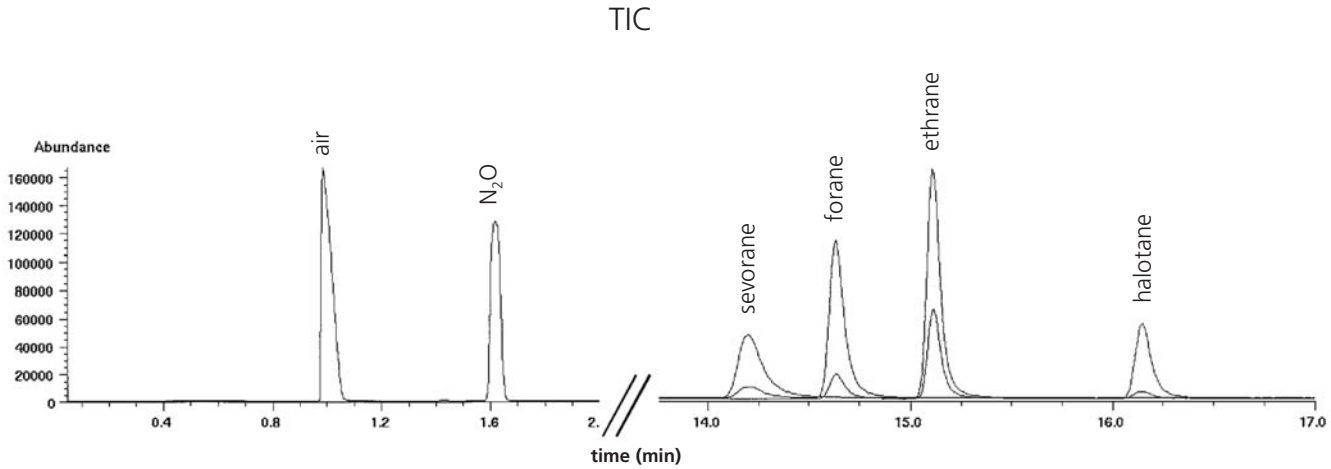
N_2O: 44; **forane** and **ethrane**: 51, 67, 117; **halothane**: 117, 198, 179; **sevorane**: 33, 131, 181

If high concentrations of CO_2 interfere (it gives a strong signal at m/z 44), N_2O can be quantified basing on the signal at m/z 30. On page L4 a typical GC-MS chromatogram (as total ion current) is displayed. It can be observed that, as an effect of the vacuum applied on the detector end of the column, retention times are shorter with respect to those obtained with ECD detection.

Calibration

Calibration curves for N_2O and halogenated anaesthetics can be prepared simultaneously.

Draw pure N_2O in a gas sampling bulb. Transfer 20 ml of pure N_2O in the 1 liter bottle through the septum by a gastight syringe. Switch on the magnetic stirrer and let the mixture equilibrate for 30 minutes.



Standard solutions of the halogenated compounds must be prepared in water/methanol 60/40 v/v in order to contain from 0.05 to 3.0 mg/l of each compound; five calibration levels are recommended.
For each level pipet 10 ml of calibration solution in an empty vial, add a blank code 132 cartridge and cap immediately.
Add also a precisely measured volume of diluted N_2O drawn from the bottle by a gastight syringe (usually added volume ranges from 50 to 1,000 µl), stir and let equilibrate at 45 °C for 1 hour.

The values above generally comprise the usual conditions of operating theatres. The analyst may choose different values if needed, but equivalent exposure values should not exceed 400,000 $mg \cdot m^{-3} \cdot min$ for nitrous oxide and 50,000 $mg \cdot m^{-3} \cdot min$ for each of the halogenated compounds.

Pay attention: the ECD response may not be linear. If this should be the case, use a **second order calibration curve**.

Useful data

name	chemical formula	molecular weight	1 $mg \cdot m^{-3}$ at 25°C = ppm
nitrous oxide	N_2O	44	0.556
forane	CHF_2-O-CHCl-CF_3	184.5	0.133
ethrane	CHF_2-O-CF_2-CHClF	184.5	0.133
halothane	CF_3-CHBrCl	197.4	0.124
sevorane	CH_2F-O-CH(CF_3)$_2$	200	0.123