

# **A PROPOSAL FOR A NEW PASSIVE DEVICE USEFUL FOR LONG-TERM SURVEILLANCE IN SMOKING AND NON-SMOKING AREAS**

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## **ABSTRACT**

An Analyst2 type passive (diffusive) device has been tested in both a preliminary laboratory trial and an indoor field test, in order to verify its effectiveness in the determination of airborne nicotine, a classic tobacco smoke tracer, over monthly sampling periods. Preliminary laboratory tests, performed in an artificially polluted atmosphere, allowed us to determine the diffusion uptake rate of the proposed sampling device (about  $15 \text{ ml min}^{-1}$ ), by the comparison with active sampling tubes, filled with the same adsorbing agents (Tenax GC) and connected to an aspirating low-flow personal-type pump. Storage and recovery tests confirm the reliability of the proposed method and device for the employed adsorbing agent. The use of an highly polar extraction solvent (acetonitrile) guarantees a selective extraction, allowing us to minimize the interference of others co-adsorbed species. It permits the nicotine determination without using specific detectors. In fact, in the proposed Gaschromatographic conditions, nicotine is quite the sole and, in any case, the main and most insulated among the eluted peaks.

## **INTRODUCTION**

Tobacco smoking is identified as a cause of cancer in many sites, including lungs, mouth, oesophagus, stomach, pancreas and urinary bladder [1,2] and is responsible for the 20% of the annual deaths [3]. Passive smoking is actually focused as a relevant risk factor too and many restrictions were recently introduced about smoking permissions in public areas. This fact implies a punctual surveillance by the health authorities which need a suitable and objective watching device for this purpose.

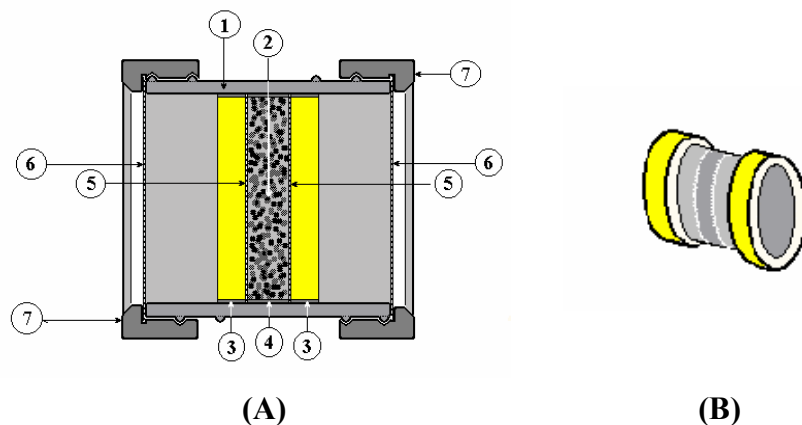
The most important tracer, used to quantify the exposure to the environmental tobacco smoke (ETS) is nicotine [4,5], a compound mainly associated with the airborne gas phase.

The aim of this work was that to check a new passive device useful for the long-term determination of the ETS associated nicotine vapours in indoor ambients. The goal of the proposed device and method is to dispose of a cheap and silent sentry, working day and night, able to indicate if regulations are usually violate in a determined site.

## **EXPERIMENTAL**

Many methods has been developed and proposed for the determination of airborne nicotine [6,7,8,9,10,11]. Most of them relate to a short period collection of air samples (with the use of sampling pumps) and a next, less or more complex, analytical determination. In this work we drawn inspiration from both an old, but well performed, work of Tang and co-workers [12] and from our experience in the diffusive sampling of semi-volatile compounds with long-term working devices [13]. The scope was that to obtain a reliable tool to collect, with a

suitable velocity, the airborne nicotine over a long period (weeks or months) and to avoid analytical artefacts coming from secondary reactions and/or interfering species.



**Fig.1- (A)** Scheme of the Analyst 2 sampler: 1: glass cylinder (i.d. = 20 mm, double diffusive path length = 10 mm); 2: adsorbent bed; 3: retaining S.S. rings; 4: viewing S.S. ring; 5 and 6: S.S. nets; 7: aluminium screwed rings, retaining the air barriers (consisting of (6) nets); **(B)** General view of Analyst 2 device.

**Figure 1** shows the shape of the tested diffusive sampler as well as its vertical section. Geometrical features are indicated in the figure caption. This model has the same shape of the SVOC-PAH Analyst 2 sampler but employs a Tenax GC adsorbing bed. In general, the use of a light adsorbent increases the solvent extraction efficiency. Moreover the use of a specific, very polar, solvent (acetonitrile) allowed a considerable reduction of interferences coming from the co-adsorbed non polar species, which are in the order of many hundreds of compounds.

In order to prevent eddy diffusion, two stainless steel nets were set as air barrier at 10 mm from adsorbent holders. 200 mg of Tenax GC are packed on the device.

The capability of collecting gaseous nicotine with this diffusive device was investigated by comparing it with active sampling, performed by using cylinder cartridges (L = 100 mm; i.d. = 4 mm) filled with 200 mg of Tenax GC. For this purpose, personal-type gas pumps were used, running at aspirating flows of about 20 ml min<sup>-1</sup>, corresponding to the expected order of magnitude of the uptake rate of the passive devices.

All analyses were performed with a GC model DANI 1000, equipped with a ZB-624 (provided by Phenomenex, U.S.A.) 75 m length x 0.53 mm i.d. capillary column (film thickness = 3.0 µm), accordingly with a single step temperature gradient from 200°C up to 250°C (+10°C min<sup>-1</sup>) for a 5' final isothermal. Solvent was acetonitrile for HPLC analysis (by Carlo Erba, Milan, Italy), whilst analytical grade benzyl alcohol (by MERCK, Germany) was employed as an internal standard.

In order to investigate the performance of the passive devices, two series of experiments have been performed. At first we determined the percent recovery of nicotine from the Tenax adsorbent through solvent extraction at a series of different quantities, varying from 0.1 up to 100 µg. Later we carried out sets of parallel samplings for long-term periods, using both

passive and active devices, in order to determine the sampling uptake rate of passive devices and their linearity over multiple periods.

In all cases, after collection or loading with nicotine standards, the adsorbent material was mechanically removed from the sampler and transferred to a screw-cap vial with a rubber/PTFE septum. 2 ml of acetonitrile were added together with benzyl alcohol, used as an internal standard. After two hours storage at ambient temperature the extract was analysed by GC, with the previously indicated column and program, using a flame ionisation detector (FID).

### ***Recovery tests***

Efficiency of recoveries obtained by acetonitrile extraction was tested by loading passive samplers with standard solutions whose nicotine concentrations ranged from 0.1 to 100  $\mu\text{g ml}^{-1}$  and a constant benzyl alcohol concentration of 10  $\mu\text{g ml}^{-1}$ . The used nicotine concentrations were 0.1; 0.2; 0.5; 1.0; 10.0 and 100  $\mu\text{g ml}^{-1}$  and the curve, obtained by plotting the area of nicotine peak to the area of internal standard ratio against the nicotine concentration (the average value of three determinations for each point), resulted on a straight line with a  $R^2$  correlation factor = 0.98.

### ***Evaluation of the diffusion uptake rate and of linearity***

Sampling flow of a diffusive sampler could be, in theory, calculated from the geometrical parameters of the device and the diffusion coefficient of the interesting species, simply by applying the first Fick's law. However, theoretical evaluations are rarely confirmed by the experience and an experimental determination is needed. For that purpose we carried out many sets of sampling in indoor real conditions and also in an artificially polluted atmosphere.

In all cases a set of 3 active samplers was always positioned at the same places and during the same period, with aspirating pumps working at an about 20  $\text{ml min}^{-1}$  flow. A laboratory test was performed by positioning six diffusive devices and three active sampling cartridges in a long (3 metres) tube with a 20 cm i.d.. At one end of the tube we lighted forty cigarettes, two by time, over an eight hours period and forced the smoke to go through the tube with the aid of a little external fan, which ensured an about 30-35  $\text{cm sec}^{-1}$  air flow passing through.

Another indoor test was performed in the private office of a smoking person for a six-week period, always by employing six passive and three active devices. In this trial six more passive devices were added at the beginning of the sampling period, retired after three weeks and substituted with other six spare devices, working for the remaining three weeks. The sum of the nicotine quantities sampled in the two three-week periods was then compared with the quantities recovered after the entire six-week period, in order to evaluate that the sampling flow does not change during the different sampling periods.

The procedure to calculate the uptake rate of diffusive samplers is rather simple. By determining the quantity  $Q_a$  of analyte sampled in the active sampler, where sampling volume  $V_a$  is known being sampled by pump, a simple expression is employed:

$$Q_a V_a = Q_p V_p$$

where  $Q_p$  is the analytically determined quantity of analyte sampled by the passive sampler. The virtually sampled volume  $V_p$  is therefore determined from the product of the  $V_a$ , actively sampled volume, to the ratio of the analytically determined sampled quantities. Dividing  $V_p$  by the employed exposure time of the passive sampler, the following expression is obtained:

$$\Phi_p = V_p t^{-1}$$

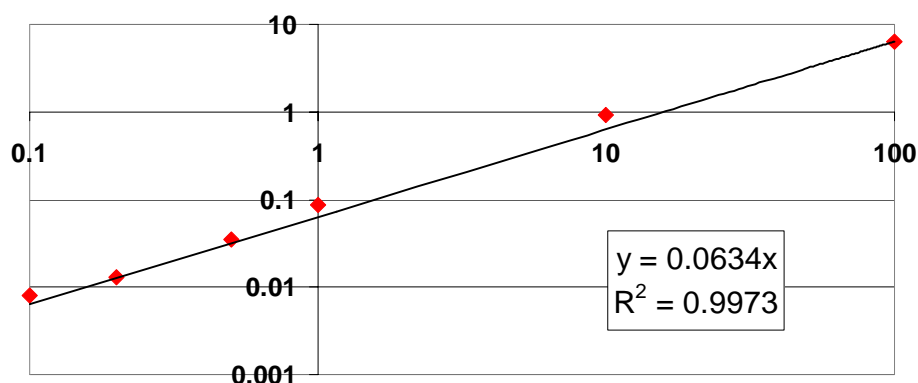
corresponding to the diffusion uptake rate.

### **Monitoring campaign**

A monthly monitoring campaign has been performed in three private apartments, two with non smoking inhabitants and one with smoking people. The apartments were positioned at different zones of downtown Rome and its surrounds. One apartment, with smoking inhabitants, was sited in Monterotondo, a little town 25 Km NE of Rome, the second was at an heavy traffic zone on the outskirts of Rome and the third was at a residential zone of Rome (both with non smoking inhabitants). Measurements were performed indoor and outdoor, by positioning three passive devices in the leaving room and other three samplers outdoor, in the terrace in front of the leaving room.

## **RESULTS AND DISCUSSION**

**Figure 2** shows the ratio of peaks of increasing nicotine amounts to the peak area of a constant internal standard amount against the nicotine concentration values. The straight line joining experimental points indicate that the recovery is independent from the collected amounts at the used concentration range.



**Fig.2-** Correlation between sampled and recovered nicotine in the proposed sampling device. Recovery is expressed as the ratio of nicotine peak to the internal standard peak (log-log scale).

**Table I** shows the results related to the determination of the nicotine uptake rate, performed *via* two experiments. The first carried out in an artificially polluted atmosphere, over an 8 hour period, and the second performed in a real atmosphere over a six-week period. Results, averaged over six passive devices and three active ones employed in each trial, coincide, within the standard deviation range.

**Table II** shows the comparison between the absolute amounts collected over two consecutive three-week periods and those obtained from the uninterrupted six-week samplings. The correspondence of the sum of the two short periods with the long one means that the uptake rate must be considered as invariant over the entire long-term sampling trial.

**Table III** shows results obtained in a monthly indoor/outdoor campaign performed in three private apartments of Rome and surrounds.

**Tab. I-** Uptake rate calculated of nicotine diffusive samplers in different concentration ranges. A,B and C are the active (pumped) *reference* samplers

Artificial atmosphere (8 hours sampling period)			Real atmosphere (6 weeks sampling period)		
Sampler n°	Sampling flow (ml.min <sup>-1</sup> )	nicotine concentrations (µg m <sup>-3</sup> )	Sampler n°	Sampling flow (ml.min <sup>-1</sup> )	nicotine concentrations (µg m <sup>-3</sup> )
1	14.2	1.8	1	16.4	0.55
2	16	2.1	2	14.3	0.48
3	13.4	1.7	3	13.4	0.45
4	16.8	2.2	4	13.8	0.46
5	15.4	2	5	15.2	0.51
6	14.8	1.9	6	16.1	0.54
Mean	15.1	2	Mean	14.9	0.5
S. D.	8.10%	8.10%	S. D.	8.50%	8.40%
A	19.5	2.2	A	19.5	0.55
B	19.8	2.1	B	19.8	0.51
C	19.2	2	C	19.2	0.44
Mean	19.5	2.1	Mean	19.5	0.5

**Tab. II-** Internal consistency test: correspondence of the sum of absolute quantities (µg) collected in short (3-week) consecutive periods and those obtained over the entire 6-week sampling period.

Sampling point	1 <sup>st</sup> 3-week period	2 <sup>nd</sup> 3-week period	3-week periods sum	6-week period
1	0.28	0.25	0.53	0.55
2	0.21	0.19	0.40	0.42
3	0.22	0.17	0.39	0.36
4	0.19	0.18	0.37	0.38
5	0.25	0.21	0.46	0.47
6	0.27	0.23	0.50	0.53
Average	0.24	0.20	0.44	0.45

**Tab. III-** Vapour concentrations (µg.m<sup>-3</sup>) of nicotine determined in a monthly monitoring campaign at three private apartments in Rome and Monterotondo.

Rome - via Nomentana (not smokers)		Rome - via M.Tiburtini (not smokers)		Rome - via Salaria (smokers)	
indoor	outdoor	indoor	outdoor	indoor	outdoor
0.05	0.04	0.04	0.04	0.35	0.03

## CONCLUSION

The proposed passive sampler resulted to be suitable for the long-term surveillance purposes. Its precision is largely inside the values commonly considered acceptable for this kind of devices, so it may be employed as a complementary tool in the indoor air quality evaluation.

## REFERENCES

1. US Department of Health and Human Services. The Health Consequences of smoking: Cancer. A report of the Surgeon General. US Department of Health and Human Services, Public Health Service, office of Assistant Secretary for Health, office on Smoking and Health. DHHS Publication No. (DHS) 89-8411, **1989**.
2. US Department of Health and Human Services. The Health Consequences of smoking: 25 Years of Progress. A Report of the Surgeon General. US Department of Health and Human Services, Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. DHHS Publication No. (CDC) 89-8411, **1989**.
3. Fiore MC, Novotny TE, Pierce JP, Hatziaandreu EJ, Patel KM, Davis RM. JAMA **1989**; 261:49-55.
4. P.R. Nelson, D.L. Heaven, B.B. Collie, K.C. Maiolo, M.W. Ogden, Environ. Sci. Technol. 26, 1915, **1992**.
5. D.L. Heaven, M.W. Ogden, P.R. Nelson, Environ. Sci. Technol 26, 1737, **1992**.
6. S.K. Hammond, B.P. Learderer, A. C. Roche, M.Schenker, Atmos. Environ. 21, 457, **1987**.
7. D.J. Eatough, C.L. Benner, J.M.Bayona, F.M. Caka, G. Richards, J.D. Lamb, E.A. Lewis, L.D. Hansen, Environ. Sci. Technol. 23, 679, **1989**.
8. C.L. Benner, J.M. Bayona, M.L. Lee, E.A. Lewis, L.D. Hansen, N.J. Eatough, Environ. Sci. Technol. 23, 688, **1989**.
9. C.V. Thompson, R.A. Jenkins, C.E. Higgings, Environ. Sci. Technol. 23, 429-435, **1989**.
10. F.M. Caka, D.J. Eatough, E.A. Lewis, H. Tang, K.S. Hammond, B.P. Learderer, P. Koutrakis, J.D. Fasano, J. McCarthy, M.W. Ogden, J. Lewtas, Environ. Sci. Technol. 24, 1196-1203, **1990**.
11. G. Bertoni, V. Di Palo, R. Tappa, M. Possanzini, Cromatografia, 43, 5/6, 296-300, **1996**.
12. H. Tang, G. Richards, K. Gunther, J. Crawford, M.. Lee, E.A. Lewis, D.J. Eatough, J. of High Resolution Chrom. and Chrom. Communication, 11, 775-782, **1988**.
13. G.Bertoni; A.Cecinato; R.Mabilia; R. Tappa, Chromatographia, 56, 361-365, **2002**.