Mi BBIOV

The Bio-VOC™ Sampler

Award-Winning Device for Non-Invasive Measurement of the Body Burden of Volatile Chemical Pollutants

Background

Volatile organic chemicals (VOCs) are used extensively in industry and are present in the ambient environment in low concentrations. Primary routes of exposure for humans include skin absorption, ingestion and inhalation. Biological monitoring, ie measuring the body burden of VOCs, is a way of assessing total exposure by all routes. It also provides vital information on the potentially harmful build-up of chemicals in the body – particularly in fatty tissues - after prolonged low-level exposure.

Conventional biological monitoring methods measure the target compounds or their metabolites directly in blood or urine. Blood concentrations are judged to be the best guide to overall levels of chemicals in the body. However, methods to sample blood from individuals who may be at risk are invasive, unpopular with those being tested and require specially trained staff. This has made it expensive and practically difficult in the past to undertake large scale surveys of biological exposure, either at the workplace or of the general public, on a routine basis. As a result, occupational and environmental scientists have had to content themselves with standard tests of chemical concentrations in the atmosphere and ignore or calculate potential additional exposure via skin absorption and ingestion.

The Bio-VOC Sampler

The development of the Bio-VOC sampler for exhaled air has dramatically changed this situation. Based on pioneering work carried out at the UK Health and Safety Laboratory, the Bio-VOC sampler (figures 1 & 2) from Markes International Limited provides, for the first time, a non-invasive and low-cost solution to large scale biological monitoring.

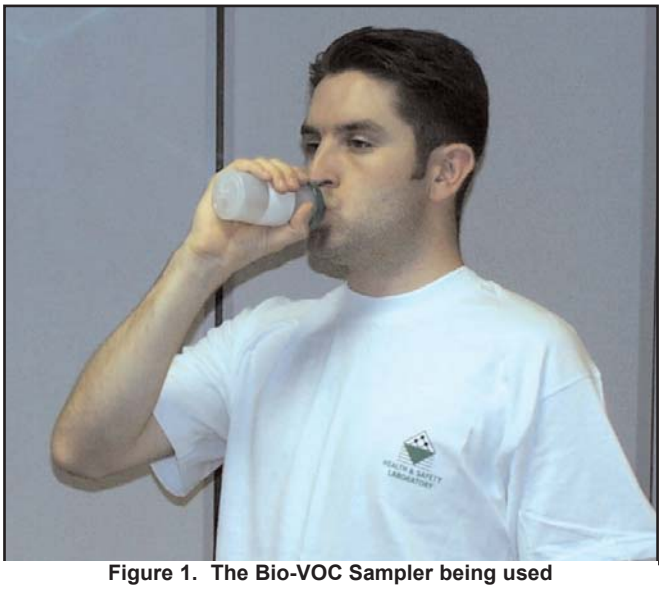

Figure 1. The Bio-VOC Sampler being used

The breakthrough came as scientists at the UK Health and Safety Laboratory (HSL) in Sheffield decided to harness the close relationship between chemical concentrations in the blood and the air deep down in the lungs – so-called 'end-tidal' air[1]. There is a rapid, almost instantaneous, exchange betweeen volatile organics in the blood and air across the thin membranes surrounding the alveolar portion of the lungs. In fact the concentration of organics in alveolar air responds so rapidly to changes in blood concentration that the organics in the end-tidal air can be considered to be in constant equilibrium with those in the blood. As the human body provides a very well controlled environment for this equilibrium, chemical concentrations in the blood can be accurately derived from those in the breath. Measurement of the VOC concentration in end-tidal air – the last portion of the exhaled breath – was therefore proposed as an alternative, non-invasive, method for biological monitoring.

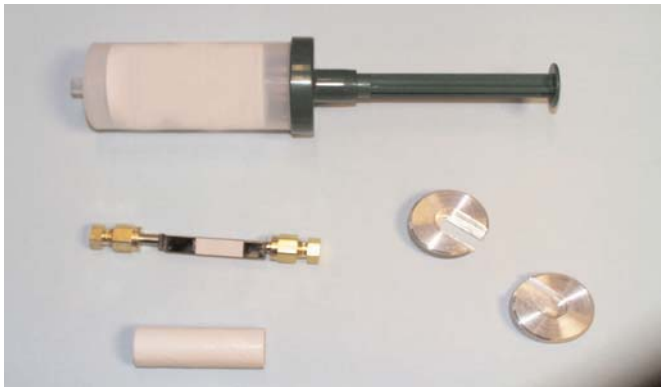

Figure 2. The Bio-VOC sampler with capped sorbent tube, CapLok tool and cardboard mouthpiece

The Bio-VOC Sampler was designed by staff at the HSL, and their collaborators TCM Associates. It collects a representative sample of end-tidal air, without contamination or dilution with breath from the bronchial tubes or mouth, and subsequently transfers it to a concentrating (sorbent) trap or direct read-out instrument. The Sampler is now commercially available from Markes International Ltd.

Application

Constructed of safe, non-emitting plastic the Bio-VOC Sampler may be operated with minimal training and without medically qualified staff in attendance. In field trials, the sampler has been well received both by industrial health and hygiene professionals and shopfloor workers.

An adult, exhaling deeply, typically breathes out over 4L of air. Only the last 100 ml of this, all from the alveolar portion of the lungs, is retained by the Bio-VOC Sampler. Once the breath

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has been collected, a screw-in plunger is used to steadily discharge the sample into a concentrating (sorbent) trap or direct read-out instrument. After collection in a sealed sorbent tube, the breath sample is stable for transportation and analysis – a distinct advantage over blood and urine samples. The Bio VOC Sampler may be re-used by the same individual over the course of a day, but is then discarded.

Solvent concentrations in breath level off soon after exposure (figure 3). The breath sample is best taken in a "clean area", i.e. a medical room or office, away from the source of solvent, about 10 minutes after the end of exposure. It is recommended that two duplicate samples should be taken, per worker per time point.

Range of Industrial Applications

With its simplicity and affordability the Bio-VOC is expected to revolutionise routine occupational hygiene testing. Large scale monitoring of the actual body burden of chemicals – the ultimate exposure test for workers in high risk industries such as paint, petrochemicals and dry cleaning - will be feasible for the first time. The device also provides a unique check on the efficacy of respiratory protective apparatus and protective clothing at work and will facilitate new environmental studies of the impact of long term exposure to chemicals on vulnerable members of society – children, the elderly, asthmatics, etc..

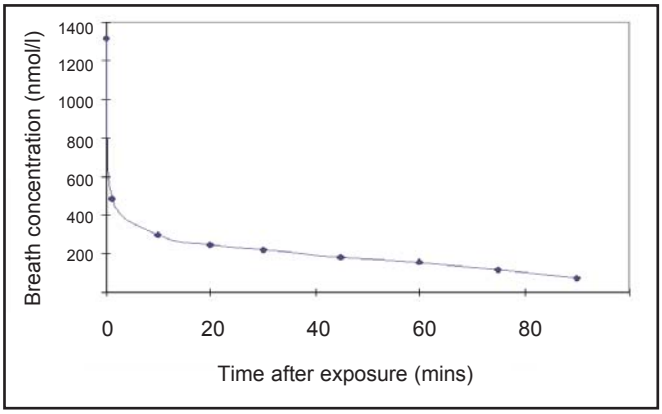

Figure 3 Elimination Curve of Butan-2-one in Breath

Application	Solvents involved
Shoe Industry	Acetone, MEK, Toluene, Ethylacetate, THF
Dry-cleaning	Tetrachloroethene
Degreasing	Trichloroethene
Use of White Spirit	Toluene, Xylene, Decane, Nonane
Printing	Acetone, Toluene, Decane, Nonane, Heptane, MEK Methylcyclohexane,
Miscellaneous	Dichloromethane, Styrene Methoxypropanol

Table 1. Typical industrial hygiene applications of the Bio-VOC Sampler

Wider Applications

The Bio-VOC Sampler has also been used for pioneering research into the clinical diagnostic potential of breath. Clinicians have long used the fruity smell of acetone on the breath as an early indication of diabetes and the pungent smell of ammonia as a sign of possible kidney failure. It is now widely hypothesised that the presence of specific chemicals or specific combinations of chemicals in the breath may provide a reliable diagnosis of certain otherwise difficult to diagnose and disabling diseases – among them psychiatric conditions, various cancers and metabolic failure in premature infants. Laboratory and clinical research in this area has been hampered until now by the lack of a reliable and simple method of sampling the alveolar portion of breath from patients and control groups. Indications are that the Bio-VOC Sampler will play a crucial role in this vital research and could ultimately prove to be the ideal tool for cost-effective screening of the general population – If the experts are right, breath tests could become a routine part of every medical examination, simplifying the diagnosis and improving the prognosis of many currently life-threatening conditions.

Availability

Bio-VOC Samplers are available from Markes International Ltd. as follows:

C-BIO01	Pack 1 Bio-VOC sampler (includes 1 disposable cardboard mouthpiece)
C-BIO10	Pack 10 Bio-VOC sampler (includes 10 disposable cardboard mouthpieces)
C-BIO50	Pack 50 Bio-VOC samplers (includes 50 disposable cardboard mouthpieces)
C-BIO100	Pack 100 Bio-VOC samplers (includes 100 disposable cardboard mouthpieces)
C-B100M	Pack 100 disposable cardboard mouthpieces
C-CPLOK	CapLok tool for untightening and tightening the brass storage caps

1. H.K. Wilson, Breath analysis. Physiological basis and sampling techniques. Scand. J. Work.Env. health, 12, 174-192, (1986.)

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Award Winner

Eurochem / ET Chairman's Choice

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