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Personal Monitoring Sampler for Acetone Vapor Exposure

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Diffusive sampling has been a focus of keen interest because this method will enable personal monitoring of exposure of a worker to industrial chemicals, especially organic solvents, with no interference with his/her job (Berlin et al., 1987). Efforts have been successfully made in this laboratory to develope diffusive samplers applicable to monitoring of exposure to various solvents, and carbon cloth KF-1500 (Toyobo Co., Osaka, Japan) was proved to be suitable for monitoring of all solvents studied but for acetone, ethanol and methanol (Hirayama and Ikeda, 1979; Koizumi and Ikeda, 1982; Ikeda et al., 1984; Kasahara and Ikeda, 1987). In addition, one type of commercially available samplers was found to be good for methanol monitoring (Kawai et al., 1989). Thus, acetone remains so far to need proper samplers because it is quite a popular industrial solvent, whereas ethanol is seldomly found among industrial preparations (Inoue et al., 1983; Kumai et al., 1983) even though this alcohol is present in consumers products such as glue for plastic miniature models (Saito and Ikeda, 1988).

In the present study, a new sampler was developed that absorbs acetone vapor in a manner linear to the vapor concentration up to 1000 ppm and to the exposure duration of at least 8 hours.

MATERIALS AND METHODS

The diffusive sampler was made of two 2.5 ml Terumo® disposable plastic clinical syringes (Terumo & Co., Tokyo, Japan). The two syringes (one was without any change and the other was cut at 2 cm from the brim) were put together with epoxy-resin adhesives in a

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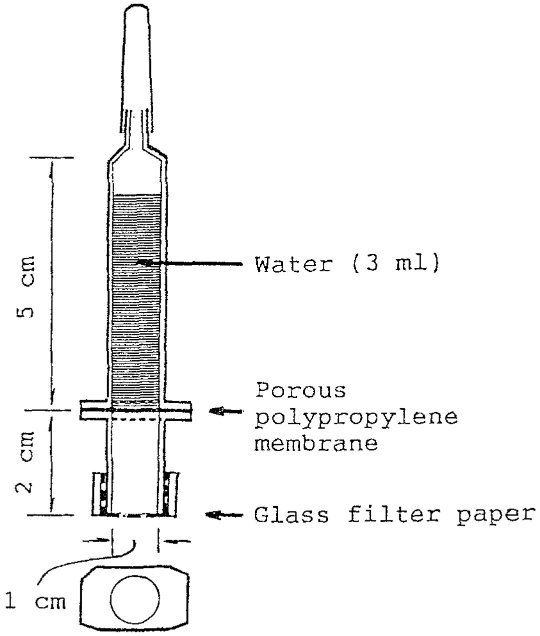

Figure 1. The structure of the diffusive sampler

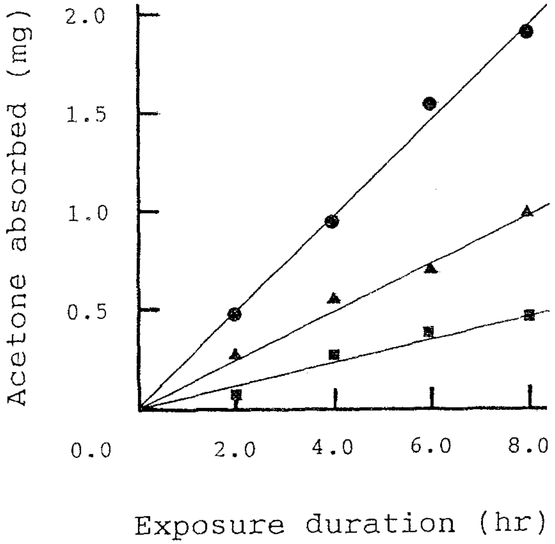

Figure 2. The amount of acetone absorbed as a function of acetone vapor concentration and exposure duration
Two samplers per concentration and per duration were exposed, and the average of the two measures was shown in the figure. Circles, triangles and squares indicate exposure at 200, 500 and 1,000 ppm, respectively.

shape shown in Fig. 1. The two parts were separated by porous polypropylene membrane (Cellpore® NW-11 from Sekisui Chemical Co., Osaka, Japan), and the open end of the sampler was covered by glass fiber filter paper (Filter Paper GR100R from Toyo Roshi Kaisha, Ltd., Osaka, Japan) serving as a wind killer (i.e., to kill the wind but allow the movement of the vapor across the filter). Cellpore® permits penetration of vapors of low molecular weight but not water. A preliminary experiment showed that the rate of acetone vapor penetration was highest with Cellpore® NW-11 among the 4 types of Cellpore® tested (i.e., NW-07, -07H, -09, and -11). For examination of performance and also for use, 3 ml of redistilled water was taken into the syringe space through a nozzle (originally to attach an injection needle) utilizing a 5 ml injection syringe. The nozzle was sealed with a cap originally housed a injection needle. The sampler was exposed to acetone vapor keeping the cap up-ward and the glass filter down-ward so that the separating membrane was covered by water during the exposure. When exposure was terminated, the water inside the syringe was mixed by gentle vertical turning of the sampler, the cap was removed, and 1 ml water was transferred through the nozzle by means of a 1 ml tuberculin syringe into a 2 ml vial for gaschromatography. For analysis, 100 µl of 5 µl/ml ethanol in water was added as an internal standard.

A servomechanized vapor generating system (Koizumi et al., 1981) was employed for experimental exposures of the diffusive samplers to acetone vapors at constant as well as changing concentrations. The analysis for acetone absorbed in water was performed with an automated gaschromatography system consisted of a FID-gaschromatograph (Hitachi Model 163; equipped with an OV 101 capillary column), an automatic liquid sampler (Hitachi Autosampler Model 663-08) and an integrator for chromatography (Hitachi Chromato-Integrator Model 2000). The chromatographic conditions were as previously described (Saito and Ikeda, 1988) except that the oven was heated at 60 °C. The retention time of acetone and ethanol was about 2.30 and 2.20 min, respectively, under the conditions employed.

RESULTS AND DISCUSSION

The performance of the sampler was examined by exposing to acetone vapor at constant concentrations for fixed time periods. In practice, two samplers per acetone concentration and per time period were exposed at 200, 500 and 1,000 ppm for 2, 4, 6 and 8 hr. The results (Fig. 2) show that the amount of acetone absorbed was linearly related to exposure duration up to 8 hr, and also proportional to exposure concentrations up to 1,000 ppm.

To examine the rapidity of response to short-term peak exposure, 5 samplers were exposed to acetone at 1,000 ppm for 15 min, and the amount of acetone absorbed was compared with the amount calculated from the results shown in Fig. 2. The comparison showed that the amount absorbed was about 52% of the amount expected, suggesting that the response to short-term exposure is rather slow.

Because it is known that spontaneous disappearance of solvent from absorbent is one of the major problems in diffusive sampling (Koizumi and Ikeda, 1982; Kasahara and Ikeda, 1987), 10 samplers were charged with 3 ml each of dilute acetone solution (0.79 mg acetone/ml water) and kept in fresh air for up to 8 hr. Two samplers each were taken out at 2 hr intervals for analysis. The decay in the acetone concentration indicated that the half-time of the disappearance is about 60 hr. In other words, 4.5% and 8.2% will be lost in 4 and 8 hr, respectively.

In conclusion, the combination of water as absorbent, porous membrane as a port of absorption and glass fiber filter as a wind killer appear to be promising in the development of a diffusive sampler for acetone, a very popular industrial solvent. The sampler thus developed is good for monitoring of exposure to acetone up to 1,000 ppm for 8 hr. The application of the sampler may need further considerations in case fluctuation in acetone concentrations is wide in the workplace, because the response to rapid change in concentration is rather slow.

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