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Evaluation of occupational styrene exposure by ambient air and urine analysis

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ENGSTRÖM, K., HÄRKÖNEN, H., PEKARI, K. and RANTANEN, J. Evaluation of occupational styrene exposure by ambient air and urine analysis. *Scand. j. work environ. & health* 4 (1978): suppl. 2, 121—123.

When occupational exposure to solvents is evaluated, the concentration of the parent compound in the ambient air, in the blood, and in the exhaled air or the analysis of the excretion of a metabolite in the urine can be determined. Each of these methods has its own advantages and limitations. When the most useful parameter is being selected, the physicochemical and the biochemical properties (volatility, tissue solubility, metabolic rate, etc.) of the solvent must be taken into account. Styrene is highly soluble in blood and tissues but undergoes significant biotransformation, producing mandelic and phenylglyoxylic acids, which are rapidly excreted into the urine (1). At high exposure levels, conversion of styrene glycol to hippuric acid may also occur (4). Mandelic acid is the main metabolite, corresponding to about 85 % of the retained dose, while the excretion of phenylglyoxylic acid is responsible for only 10 % (1). In the present study we measured the occupational styrene exposure of 47 laminating workers during the whole workday. Simultaneously, biological monitoring was carried out through the measurement of the concentration of mandelic acid in the urine. In addition, the hippuric acid concentration in urine samples from the whole day was determined for a group of nine workers with a high level of styrene exposure.

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MATERIAL AND METHODS

Subjects

The 47 subjects (9 females and 38 males, aged 17 to 55 years) came from 13 workshops manufacturing products of reinforced polyester plastic. In all cases the workers spread the polyester resin by hand.

Exposure

We measured styrene in the ambient air by collecting air from the breathing zone of the workers through charcoal sampling tubes with personal sampling pumps (MSA) for 0.5-h periods over the whole

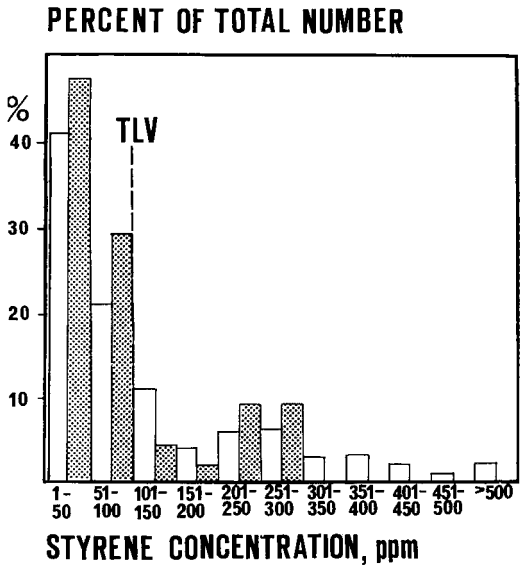

Fig. 1. Percentage distribution of airborne styrene concentrations, individual half-hour samples (empty columns) and calculated time-weighted averages (filled columns) in different workshops.

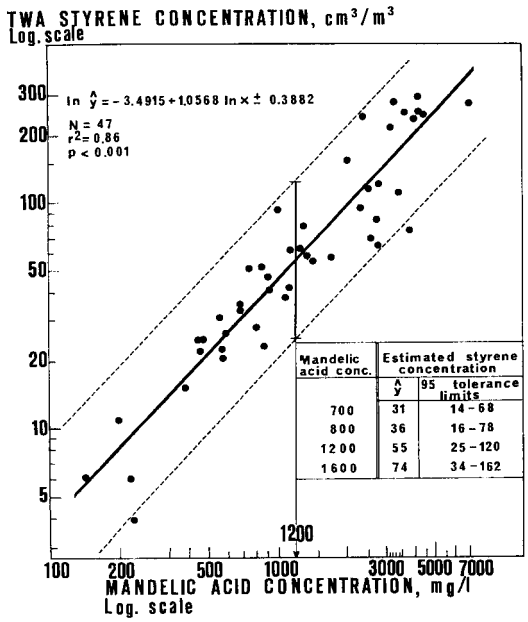

Fig. 2. Correlation between the 8-h time-weighted average (TWA) of styrene exposure and urinary mandelic acid concentration, adjusted to a constant specific gravity of 1.018.

workday. The adsorbed styrene was desorbed with dimethylformamide and analyzed by gas-liquid chromatography, and for each subject the 8-h time-weighted average (TWA) was calculated (5).

Urine sampling and analysis

All 47 subjects collected urine at the end of the workday for the determination of mandelic acid. For the hippuric acid determination nine workers with a level of styrene exposure between 155 and 291 ppm collected urine from the whole day. Urinary hippuric acid concentrations were determined for five controls as well. Mandelic and benzoic acid (obtained after the alkaline hydrolysis of hippuric acid) were extracted with diethylether, silylated, and analyzed with gas-liquid chromatography (2, 3). The results have been expressed as milligrams per liter and adjusted to a constant specific gravity of 1.018.

RESULTS AND DISCUSSION

The styrene concentration in ambient air during the workday varied remarkably (fig. 1). The highest peak concentration observed for a 0.5-h sample exceeded 700 ppm of styrene, and about 40 % exceeded the present Finnish threshold limit value of 100 ppm. The estimated individual TWAs ranged from 4 to 291 ppm, with a median value of 56 ppm of styrene.

The relationship between the TWA styrene exposure and urinary mandelic acid concentration (mg/l) correlated with an r value of 0.93 ($p < 0.001$, $N = 47$); an amount of 1,200 mg of mandelic acid per liter of urine corresponded to 55 ppm of styrene, the 95 % tolerance limits being 25—120 ppm (fig. 2). In addition to interindividual physiological factors, marked fluctuations in airborne concentrations seem to be a determinant factor in the influence of the variability of the results.

The concentration of hippuric acid in the urine rose slightly during the course of the workday. A similar elevation in hippuric acid concentration was found for

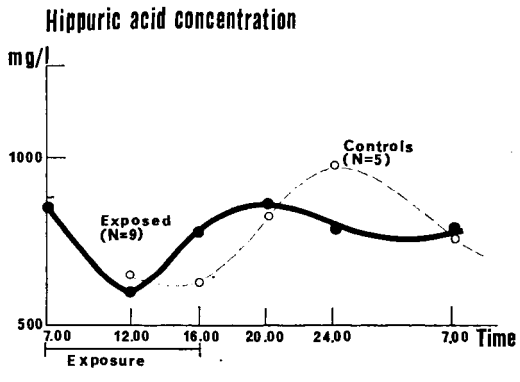

Fig. 3. Concentration of hippuric acid in urine of styrene-exposed persons (—●—) and controls (- -o- -) as a function of time.

nonexposed controls (N = 5) as well, and this finding suggests that this test is of minor importance in the biological monitoring of styrene exposure (fig. 3).

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QUESTIONS AND ANSWERS

Question to Ms. ENGSTRÖM

Prof. IKEDA: Did the workers use protective gloves?

Ms. ENGSTRÖM: Some workers did and some didn't. I believe that the protection by gloves is uncertain, because there is no material as far as I know which can effectively protect from the penetration of styrene.