Diffusive sampling of airborne VOCs in indoor environment: theoretical versus experimental uptake rates

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Because people in the industrialized world spend about 90% of their time in an indoor environment, there is a current interest in the occurrence of potential harmful volatile organic compounds (VOCs) in indoor air. Given the low (µg/m³) concentration levels, a preconcentration step is indispensable during sampling/sample preparation in order to match with modern analytical instrumental detection limits. Most often, airborne VOCs are quantified by means of thermal-desorption gas chromatography hyphenated to mass spectrometry (TD-GC-MS), preceded by active sampling on sorbent tubes filled with activated carbon based or polymeric enrichment phases [1]. Nowadays, passive sampling gains interest in ambient VOCs monitoring, because of the reduced need of man-power and equipment (resulting into a lower cost per analysis) and the possibility to obtain time-weighted average concentrations over prolonged sampling times. The main challenge, however, in passive sampling analysis, is the need for accurate compound and sampler dependent uptake rates [2].

Here, we present a systematic laboratory research investigating the diffusive uptake of four target compounds (limonene, toluene, ethylacetate, hexane) on axial sorbent tubes filled with Tenax TA. In a controlled atmosphere (temperature: 21.3 ± 1.9°C; relative humidity set at different values between 5 and 80 %), these passive samplers were exposed for 1, 3 and 7 days to a constant target compound concentration ranged between 40 and 480 µg/m³. Simultaneous multiple active sampling and TD-GC-MS analysis was performed to determine VOCs concentrations. Results showed that experimentally determined uptake rates may be up to a factor of 2 lower than the theoretical sampling rates, calculated from the molecular diffusion coefficient and the geometrical parameters of the sampler, and commonly used if no experimental data are available [3]. Among all parameters, sampling dose proved to be the most critical, with a power law relationschip (uptake rate = A x dose^{b}; b<0) between the uptake rate and sampling dose. This behavior is the most pronounced for compounds with a higher air to Tenax partitioning coefficient. Moreover, uptake rates determined in real indoor air environments showed to be at least a factor of 1.3 to 2.4 lower than those determined in lab conditions at low sampling doses (<30 ppm.min). Explanations are proposed, taking into account theoretical considerations based on driving forces and back-diffusion processes.

Literature

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