Supplement. Qualification tests for man-made needle trap samplers.

NTS was packed with 60–80 mesh DVB adsorbents and used to determine sampling flow rates of BTEX. All experiments herein were carried out in triplicate. Table S1 reveals that, for all NTS, the RSD of sampling flow rates were less than 5%, indicating the high uniformity of packed DVB phases inside the needles.

The total amount of analyte that was extracted (n) in time interval (t) is estimated using Eq. (1) (Lord et al., 2010).

$$n = D_m \frac{A}{Z} \int C(t)dt \qquad (1)$$

where D_m is the diffusion coefficient of components that are sampled by the sorbent inside the needle; Z is the diffusion path distance (Fig. 2), and A is the area of the opening of the needle. The extracted mass of the analyte is expected to be proportional to the integral of sample concentration over time (C(t)) at a constant D_m with a constant needle opening area, and a uniform diffusion path distance. Table S1 reveals that the BTEX extraction rates (BTEX extraction mass (ng)/sampling time (min)) using NTS for 1 and 2 hrs for a given compound are close to each other. The

extracted mass of BTEX gradually increased during the 2-hr sampling. The extracted mass is reasonably assumed to have not reached the maximum adsorption capacities for NTS before that time. In two hours, the individual extraction mass of BTEX reached 275–459 ng at BTEX concentrations of 100 ppm (see footnotes in Table S1). Table 2 reveals that concentrations of all gaseous products of the freshener were much lower than 0.026 ppm (exactly 25.9 ppb). These experimental results demonstrate that NTS can be reasonably used for the passive TWA sampling the emitted products of fresheners with a one hour emission period, and that the VOC extraction mass does not reach the equilibrium adsorption mass of DVB adsorbent inside the NTS.

Table S1. Tests of sampling flow rates and extraction rates of VOCs using needle trap samplers.

Test item	Value
Sampling flow rate of NTS (mean values, mL/min)	
Hollow needle	778 (RSD = 2.0%)
NTS packed with 60–80 mesh DVB adsorbents	48.1 (RSD = 1.5%)
VOC extraction rates (mean values, ng BTEX/min)[a]	
1-hr adsorption sampling by NTS	
Benzene	2.30 (RSD = 1.6%)
Toluene	3.01 (RSD = 3.0%)
Ethylbenzene	3.15 (RSD = 4.9%)
o-Xylene	3.51 (RSD = 4.4%)
2-hr adsorption sampling by NTS	
Benzene	2.33 (RSD = 1.5%)
Toluene	3.14 (RSD = 4.0%)
Ethylbenzene	3.38 (RSD = 2.0%)
o-Xylene	3.72 (RSD = 3.3%)

Note:

a. The exactly extracted mass of BTEX by NTS:
1-hr adsorption: 137.5±2.6, 179.8±5.8, 188.1±9.1 and 208.8±10.2 ng; 2-hr adsorption: 280.0±5.0, 380.8±17.5, 404.1±8.6 and 443.9±14.9 ng.