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Time-Resolved Exposure to Volatile Organic Compounds Indoors

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Knowledge of human exposures to volatile organic compounds (VOCs) is critical for understanding their impact on human health. We measured time-resolved concentrations in combination with collecting occupancy data for a wide range of VOCs in two residences in northern California.

Measurements of spatiotemporal variability of a full VOC range were performed with a proton transfer reaction time of flight mass spectrometer (PTR-ToF-MS) which continuously measured the time-resolved mass spectrum (1.000-500.00 amu) in living spaces and outdoors. Three intensive measurement campaigns were conducted in two northern California residences (H1 summer 2016, H1 winter 2017, and H2 winter 2017/2018) for durations of 5-8 weeks. Complimentary lower time resolution measurements were made using sorbent tube collection and TD-GCxGC-VUV/EI-ToFMS analysis to further investigate compound speciation.

We report exposures to hundreds of volatile organic compounds present indoors, spanning orders of magnitude in abundance, toxicity and reactivity. We show that concentrations of most VOCs were considerably higher indoors than outdoors, with the sum of measured VOCs being of an order of magnitude higher, in each season and each residence. Occupant's activities were the largest source of short-term episodic exposures, while VOCs from wood degradation were prominent contributors to chronic exposures. We show a comprehensive account of known and newly observed air toxics, their sources, and quantify time-resolved and daily-integrated exposures.

The VOCs detected belong to many chemical families including aromatics, aldehydes, ketones, alcohols, organic acids, amides, amines, heterocyclics (e.g. furanoids), halogenated, and multifunctional. Incidental and cumulative exposures to specific, categorized and sums of VOCs are reported in the context of their magnitude, duration and toxicity. For certain groups of compounds, such as monoterpenes from orange peeling, exposures largely differed by season but for many compounds exposures were comparable in two seasons. Exposure and risk assessments are performed for full suites of VOCs, with particular focus on aromatics, furanoids, and other compound families of known or suspected toxicity. Overall, toxicity of compounds was inversely associated with their abundance, and we show the risk assessment which includes extended suite of air toxics.

Our data show that short-term episodic human exposures to VOCs can span orders of magnitude and are caused by occupant's activities, rather than the house structure. In contrast to other studies focused on new building materials, we point out that degradation of wood and other lignocellulosic content of the house is the considerable chronic source of exposure to a range of organic acids, aromatic and heterocyclic compounds. Not only formaldehyde but a series of organic aldehydes are present indoors despite the lack of new materials in these houses. Cooking activities in particular can expose occupants to a large number of semivolatile compounds which are deposited on the surfaces and are re-emitted as a function of temperature leading to secondary exposures.