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Highly time resolved measurement of indoor speciated organic aerosols in a typical Hong Kong residential apartment utilizing a Thermal desorption Aerosol Gas chromatography – Time of Flight – Mass Spectrometry

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1 Introduction

Nowadays people spend approximately 80%-90% of their time indoors. Previous epidemiological studies elucidated that indoor particle matters (PM) lead to adverse health consequence (Pope et al., 1995). In cities with dense population and compact urban development, these health impacts should be further accentuated.

Hong Kong, as one of the densely populated metropolises in the world, is known for its poor living conditions. Owing to high land prices and increased population, the buildings of Hong Kong are taller and bulkier with a higher plot ratio thereby economically eliminating the high construction costs. Tall and compress residential buildings usually have minimal open space in between, which causes lower permeability of air ventilation at the resident level (Zhao et al., 2004). The occupants in Hong Kong also have some unique activities, such as incense burning and Chinese style cooking, which significantly contribute to the indoor organic aerosol (OA) levels. Also, high street-level air pollution is a severe problem in Hong Kong, indicating the influence of outdoor pollutants on indoor air quality (Shi et al., 2016). In contrast to most developed cities, Hong Kong has a sub-tropical climate, where summer is long, hot and humid. To alleviate this impact, air-conditioning has become an indispensable part of peoples' daily life. This means that the chemical composition of indoor condensed-phase organic compounds, as well as the indoor-to-outdoor air exchange rate, would be affected during the long-running operation of air-conditioning (Yu et al., 2009).

In this study, a state-of-the-art instrument was set up to investigate the molecular compositions of PM in a typical residential apartment of Hong Kong. It is hypothesized that daily residential activities are significant sources of indoor aerosol, which may provide new insight into control strategies of airborne particles indoors.

2 Methods

On Nov. 18 to Dec. 11 2019, a sampling campaign was conducted in a typical residential apartment of Hong Kong to study the characteristics of organic compounds in indoor air. To simulate the situations in ordinary Hong Kong homes, activities, including cooking, incense burning, cigarette smoking, cleaning, and makeup were designed and carried out every day. A **T**hermal desorption **A**erosol **G**as chromatography – **T**ime **o**f **F**light – **M**ass **S**pectrometry (TAG-Tof-MS) was deployed to alternatively measure particle-phase speciated organics indoors with/without human activities and outdoors. Despite previous application outdoors, this was the first application in indoor aerosol study. The time resolution of samples is one hour, including 35 min sample collection and 15 min GC/MS analysis. Throughout the campaign, 56 compounds in 461 valid samples were quantified using internal standards to correct the variability in instrument response, and regular multipoint calibration of authentic/surrogate standards.

3 Results and Discussion

Figure 1 presents the fractions of OA markers in four sources of Hong Kong homes with significant emissions of these compounds.

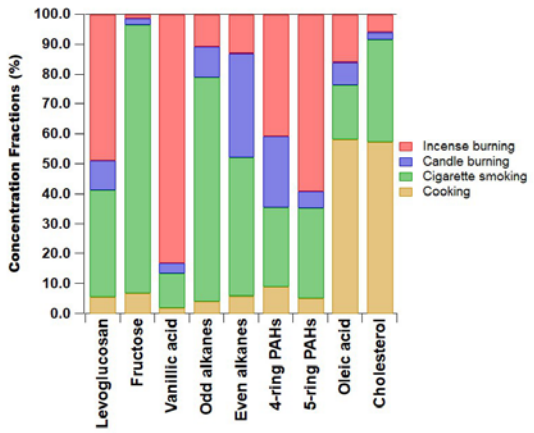

Figure 1: Average contributions of four significant aerosol emission sources indoors to individual or lumped species of condensed-phase organics. The fractions will vary when more sources are included.

Incense and candle burnings are traditional rituals, common in many families of Hong Kong. As shown in Figure 1, incense burning has a considerable impact on indoor organic aerosols. Compared to the indoor background levels, vanillic acid, a lignin breakdown product, was observed to increase by 66 times during incense burning, while only increased by 3 times for candle burning. Cigarette smoking also generated large amounts of indoor organics, including saccharides, alkanes, and some organic acids. The concentration of odd alkanes was significantly increased during smoking (51 folds), so was fructose (106 folds), both of which are usually emitted from biomass burning. Besides, a remarkable enhancement of vitamin E (183 folds) was detected when smoking, although it is not a typical product reported by previous cigarette smoking studies. In some cooking cases, we found that diffident food material usage affected indoor condensed-phase organic levels. For example, the abundance of cholesterol was substantially elevated during egg frying (112.63±75.17 ng/m^3). Moreover, the increment of polycyclic aromatic hydrocarbons (PAHs) indoors was mainly attributed to cigarette smoking and incense burning activities, implying their risk to human health. More attention should be given to related consequences.

In addition, outdoor emission sources also affected the indoor particle-phase organics. On 18 Nov. 2019 when a protest occurred near the sampling site, occasionally an abnormal increase in outdoor PAHs concentration (30-70 folds) was observed, and the following indoor sample was subsequently found to have unexpectedly high values. This result indicated that extremely high outdoor organics influenced the indoor air quality.

4 Conclusions

From the measurement data of TAG-Tof-MS, the tracers and characteristic emission profiles of various indoor activities were obtained. Emission factors of indoor activities and source contributions would be able to be explored in next stage. The potential health effects related to indoor organic aerosols emitted from daily residential activities should be further studied.

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