Emission Characteristics of Terpenols in $PM_{2.5}$ Aerosol Emitted from Incense Burning

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When people are exposed to indoor environments where burning incense produces highly concentrated smoke that lingers, they are at an increased risk of inhaling allergens or absorbing them through skin contact. Because of the prevalence of Buddhism in both Taiwan and most of Asian countries, the allergens produced by incense smoke are likely to generate hydroxyl radicals through terpene ozonolysis (Waring and Siegel, 2013). Therefore, hydroxyl radicals reacting with organic compounds can spontaneously produce other potential toxins and residuals of second-hand or third-hand fragrances. These can cause an allergic reaction through direct contact with the skin or inhalation. Therefore, exposure to incense smoke is an ongoing concern.

This study examined four types of incense that are the most prevalent in Taiwan and Thailand: Shang Chen (SC), Lao Shang Tou (LST), Thai B, and Thai Y. Incense samples were placed in a test chamber (1.0m (L) ×0.5m (W) × 0.65m (H)), and the following conditions were simulated to collect $PM_{2.5}$ particles: (a) Samples were collected immediately upon burning; (b) Samples were placed in the dark; and (c) Samples were exposed to light (Kuo et al., 2015). A $PM_{2.5}$ sampler was employed to collect the $PEM_{2.5}$ aerosol particles produced by the incense smoke. The emission coefficient of the terpenols (including (+)-limonene, linalool, β-citronellol, geraniol, anisyl alcohol, and cinnamyl alcohol) was measured from the $PM_{2.5}$ particles in the smoke, and the photochemical reactions of carboxylic acid from the burning incense were compared under light condition.

Figure 1 shows the average concentration and percent composition of the terpenols in the $PM_{2.5}$ particles of the smoke from the incense sample that was collected immediately upon burning. The figure shows that, among the four incense samples, the mass percentage of undetermined organic carbon (OC) in the $PM_{2.5}$ particles ranged between 96.36 ± 0.19% and 96.88 ± 0.60%, indicating that the four samples differed only slightly. The mass percentage of clove phenols and terpenols in undetermined OC ranged between 2.74 ± 0.13% and 3.33 ± 0.38% and between 0.31 ± 0.09% and 0.40 ± 1.67%. These results indicate that according to the incense samples from Taiwan have a higher percentage of terpenols than those from Thailand; moreover, the LST incense had the highest percentage of terpenols among the four samples. Among the terpenols in the $PM_{2.5}$ particles, geraniol accounted for the highest percentage, with an average concentration ranging between 66.33 ± 0.11% and 83.48 ± 14.59%. This clearly shows that the incense smokes from Taiwan have a higher percentage of geraniol compared with those from Thailand. By percentage of geraniol, the samples were in the order of SC > LST > Thai B > Thai Y. In addition, the content of anisyl alcohol was lower than geraniol, with an average concentration ranging between 9.55 ± 0.77% and 18.53 ± 1.73%. The incense samples from Thailand have a higher percentage of anisyl alcohol content than those from Taiwan, with Thai Y accounted for the highest percentage. As for the (+)-limonene, linalool, β-citronellol, and cinnamyl alcohol content, the average concentration ranged between 2.01% and 24.12%. The incense smokes from Thailand have a higher percentage of these components compared with those from Taiwan.

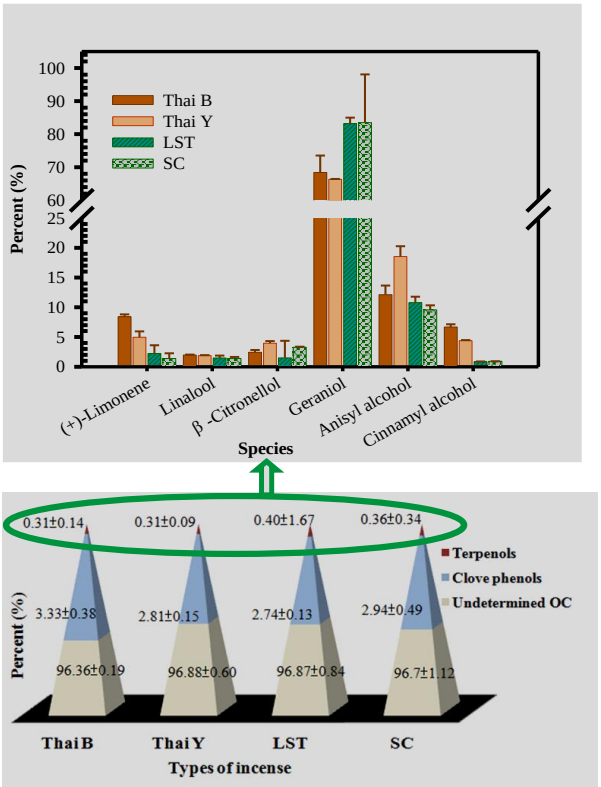

Figure 1. The composition percent of the terpenols burning incense in $PM_{2.5}$ emitted from incense burning.

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Kuo, S.C., Tsai, Y.I. and Sopajaree, K. (2015) *Build. Environ.* **87**, 23-33.

Waring, M.S. and Siegel, J.A. (2013) *Environ. Sci. Technol.* **47**, 6341-6348.