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Aliphatic and Aromatic Hydrocarbons in Indoor Air

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Air pollution caused by automobile exhausts has been studied and documented in the past (Hampton et al. 1982 and 1983; Ligockl and Pankow 1989; Takada et al. 1990). Typically the exhausts from vehicle contain various kinds of air pollutants including carbon monoxide, nitrogen oxides, sulfur oxides, hydrocarbons and particulate matters. In a study of hydrocarbon gases emission from vehicles on the road, Hampton et al. (1982) detected well over 400 gas-phase hydrocarbons $\geq$ C5. Twenty two gas-phase hydrocarbon compounds were determined and the distribution between the gas and particulate phases was related to their vapor pressures in a further study (Hampton et al. 1983).

Polycyclic aromatic hydrocarbons have been recognized as environmental pollutants. Some of them are mutagens or carcinogens to man. In addition to the source from various combustion processes, Takada et al.(1990) found a direct link between polycyclic aromatic hydrocarbons in street dusts and vehicle exhausts.

Recently a tremendous growth in the use of vehicles in urban districts of Taiwan has been found to relate to air quality in the indoor environment (Hung and Liao 1991). This paper reports further the findings of a study on aliphatic and aromatic hydrocarbon compounds in the indoor environment. Sources of compounds are the automobile exhausts from outdoors and pollutions from indoors.

MATERIALS AND METHODS

The solvent used for sample extraction was a GC grade cyclohexane from Merck Inc. The PAH Mixtures 610-M (#4-8743) and the n-paraffins quantitative calibration mix (#4-8882) purchased from Supelco Inc. were used as standard solutions. Glass fiber filter and Tenax-GC

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sorbent tube used in air sampling were bought from SKC Inc. These materials were used without further cleaning up. Field blanks were always used along with samples for analysis.

Air samples were taken using the personal pump made by SKC Inc. Sampling rate was set at 2 liters per minute and the duration was for 8 hours. Air sample inside and outside the house were obtained at the same time. Samples, filters and Tenax-GC sorbent tubes, were sent back to laboratory for further ultrasonic extraction with cyclohexane for 1 hour. Extracts were concentrated by purging with nitrogen gas before analysis.

The standard mixtures and samples were analyzed by a Hewlett-Packard 5988A GC/MS system. The HP 5890 GC was fitted with a 30 m x 0.25 mm i.d. DB-5 fused silica capillary column. Temperature of column was at first maintained at 75 °C for 3 minutes, then followed by an increase of 12 °C per minute to 174 °C, 4 °C per minute to 192 °C, 8 °C per minute to 252 °C and 3 °C per minute to 290 °C. This temperature was held for 5 minutes. The MS system was operated in the electron impact (EI) mode at 70 eV with scanning from 50 to 350 amu. The MS system was also operated in the selected ion monitoring (SIM) mode for quantitative analysis of samples for polycyclic aromatic hydrocarbons. All compounds were identified by using a HP 59970 MS ChemStation to carry out PBM searching in the NIST library database NBS49K.L.

RESULTS AND DISCUSSION

Very few aliphatic and aromatic hydrocarbons were detected in filter samples. However, most of these compounds were significantly present in the samples of Tenax-GC sorbent tube. Reconstructed ion chromatogram (RIC) from the analysis is shown in Figure 1 and 2, where a comparison is made for these outdoor and indoor samples with standards. The profile of these chromatograms is very similar for both samples.

Analysis of these chromatograms reveal two series of peaks; one series is for the aliphatic hydrocarbons with greater response and the other series is for the polycyclic aromatic hydrocarbons with smaller response. Result of these compounds detected in the air samples are given in Table 1 for aliphatic hydrocarbons. Aliphatic hydrocarbons in the air are tetradecane, pentadecane, hexadecane and heptadecane. The retention time, indoor and outdoor concentrations, and indoor/outdoor ratio are given for each compound. The ratio of indoor and outdoor air concentration is smaller than one for tetra-, penta- and hexa-decane and equals to one for heptadecane.

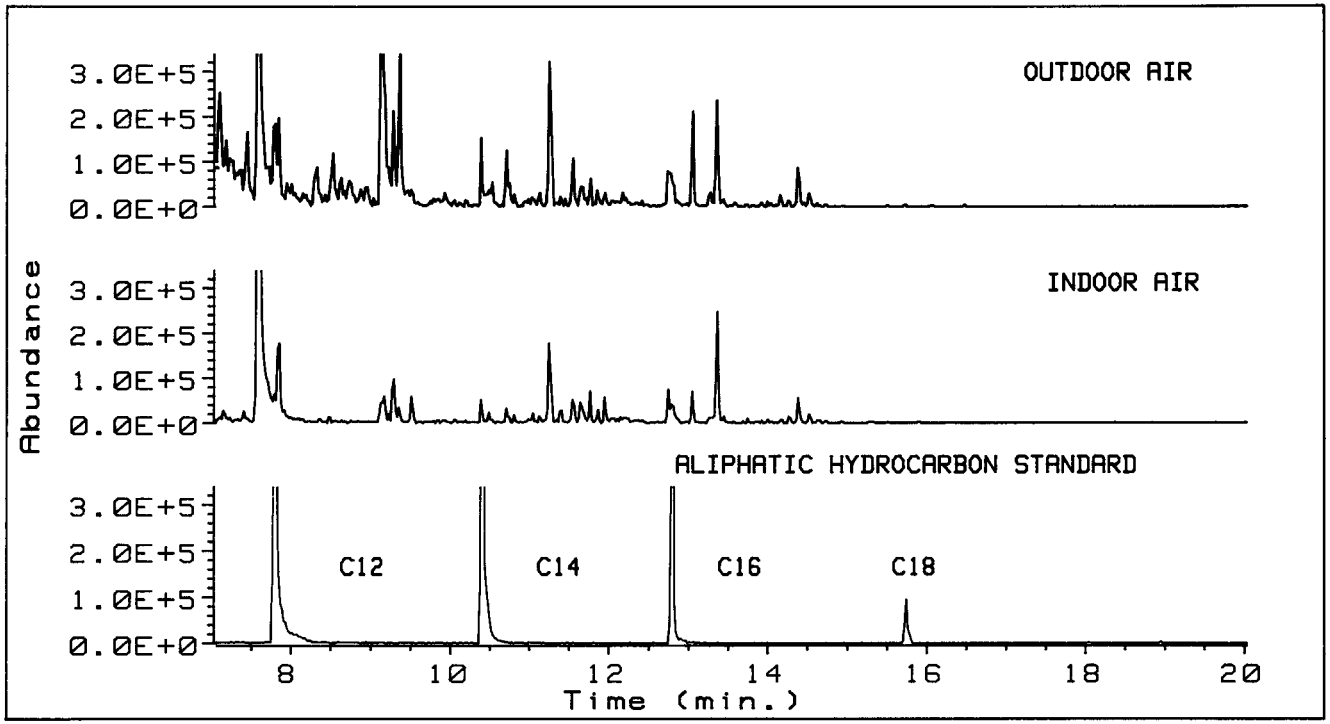

Figure 1. Reconstructed ion chromatograms of samples and aliphatic hydrocarbon standard.

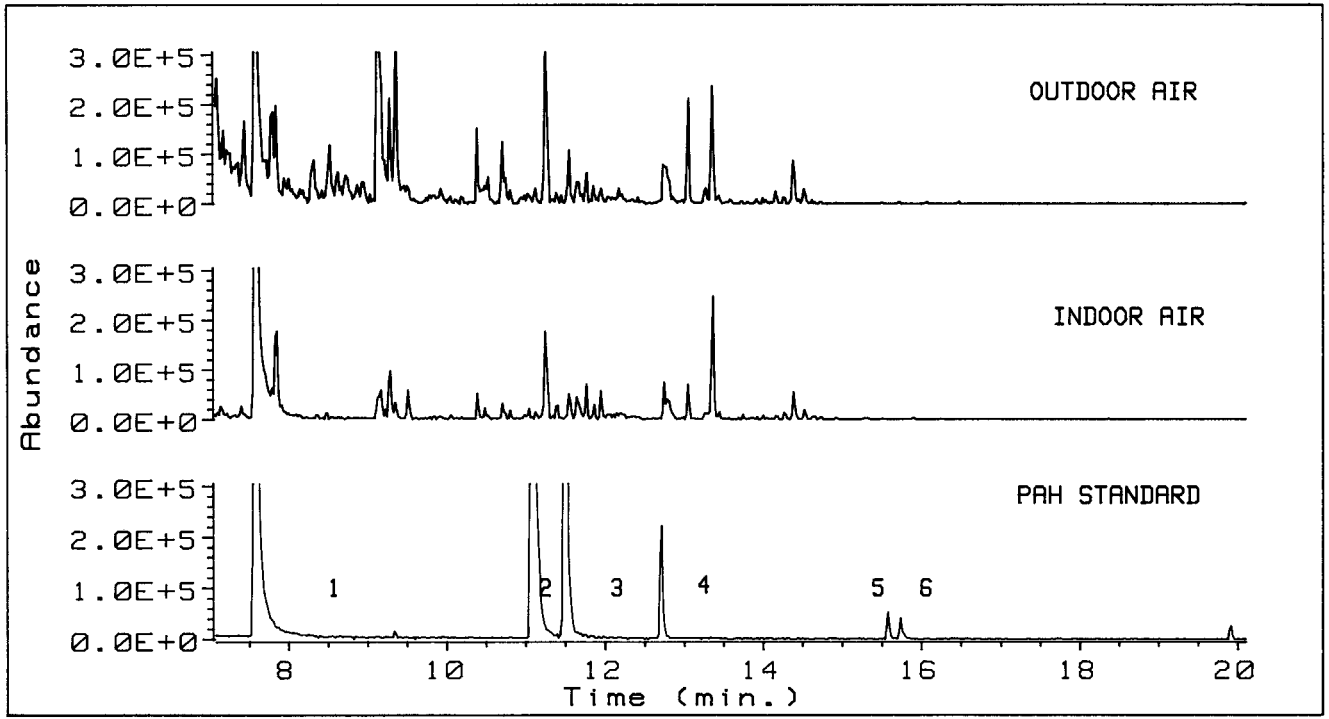

Figure 2. Reconstructed ion chromatograms of samples and PAH standard.

Table 1. Analytical results of aliphatic compounds

Compound	Retention Time (min.)	Concentration(ng/m3) in	out	Ratio in/out
tetradecane	10.645	469.0	1261.6	0.4
pentadecane	11.820	851.9	1352.6	0.6
hexadecane	13.092	2395.3	3732.8	0.6
heptadecane	14.545	391.4	398.9	1.0

Hampton et al. (1983) reported the hydrocarbons emitted from vehicles on the road. They found the partition to the particulate phase from vapor phase concentration of the n-alkanes C15, C16 and C17 to be slight in the C15 to C17 range. This is probably the reason why we found most of alkanes in the Tenax-GC sorbent tube and not in the filter sample. The ratio of concentration in indoor and outdoor air is smaller than one and this supports the conclusion that the outdoor source from vehicle emissions is the cause of the indoor air pollution.

Results of aromatic hydrocarbons found in the air are given in Table 2. These compounds are volatile polycyclic aromatic hydrocarbons. They are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene and anthracene. The retention time, concentration in indoor and outdoor air, and indoor/outdoor ratio are given in the table. The ratio is greater than one for all compounds.

Table 2. Analytical results of aromatic compounds

Compound	Retention Time (min.)	Concentration(ng/m3) in	out	Ratio in/out
1.naphthalene	7.831	32208.3	21908.3	1.5
2.acenaphthylene	11.321	197.9	45.8	4.3
3.acenaphthene	11.792	179.2	12.5	14.3
4.fluorene	13.024	297.9	14.6	20.4
5.phenanthrene	16.008	118.8	29.2	4.1
6.anthracene	16.174	20.8	2.1	10.0

Both indoor and outdoor air concentrations of these volatile polycyclic aromatic hydrocarbons are all comparable to other reported findings (Ligockl et al. 1989 and Offermann et al. 1990). A greater than one ratio of indoor and outdoor air concentration agrees with the conclusion that there are other major indoor pollution sources besides the ones from outdoors.

In conclusion, the presence of aliphatic hydrocarbons in indoor air can be attributed to automobile exhausts from outdoors and the presence of aromatic hydrocarbons in indoor air can mostly be attributed to pollutions from indoor sources.

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