

**POLYCYCLIC AROMATIC HYDROCARBONS IN ATMOSPHERIC
SIZE-SEGREGATED AEROSOLS AT TROMBAY, MUMBAI**

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Introduction

Amongst the organic compounds of anthropogenic origin, the polycyclic aromatic hydrocarbons (PAHs) make up a significant because of the way they endanger people's health and also because of the impact they have on the chemistry of troposphere (Masclet et al., 1986). PAHs are ubiquitous pollutants in urban atmospheres. It is well known that PAHs are formed by pyrolysis of organic material arising mainly from anthropogenic emissions in urban areas, essentially by the combustion of fossil fuels. The particle size distribution of all PAHs involves two mechanisms; rapid adsorption of PAH vapor, initially produced, on fine particles and continuous growth of the particles by means of redistribution of PAHs adsorbed on fine particles onto larger particles by condensation (Pistikopoulos et al., 1990). Characterization and quantification of PAHs in size segregated aerosol samples are important to reveal the relationships between the nature of the PAH and the variability of the physico-chemical phenomena in which they are involved during transportation from the source to the receptor sites. Several studies on concentration of PAHs in urban aerosols have been reported in the literature (Guo et al., 2003; Sahu et al., 2001). But, less attention has been paid to the size distribution of PAHs adsorbed on particulate matter. In the present paper, results of analysis of aerosol samples collected with cascade impactor at Trombay, Mumbai are discussed.

Sample Collection and Analysis:

Samples were collected over 72 hrs. average sampling period using an eight stage cascade impactor (Andersen Instruments Inc., USA). The impactor was connected to a continuous duty, carbon-vane pump and a constant airflow rate of 28.8 lpm was maintained with an in-line rotameter. The samples were collected on glass fiber filter paper (Whatman EPM 2000) cut to the size of impactor stages.

The filter paper samples were then extracted ultrasonically with 30 ml of dichloromethane (E. Merck, HPLC grade). The extract was filtered using sintered glass disc to eliminate other particulate impurities. The extract was then subjected to clean up procedure. The clean up procedure has been given elsewhere (Pandit et al 1996). The extract was then dried by a flow of dry nitrogen. The residue obtained was redissolved in 1 ml of acetonitrile for analysis by HPLC. The recovery efficiencies were determined by spiking filter paper samples with PAH standard mixture. The mean recovery varied from 80 to 97%. A strict regime of quality control and assurance was operated in every stage.

Results and Discussion

The distribution of two to six ring PAHs on size fractionated aerosol samples has been studied in Mumbai, India. The range and mean concentrations of particle bound

individual PAHs in size fractionated aerosol samples are presented in table 1. Total PAH concentrations (thirteen compounds) associated with the size-segregated aerosols collected on different impactor stages were in the range of 18.3 to 66.6 ng/m³. It has been observed that in case of naphthalene, acenaphthalene, fluorine, phenanthrene, anthracene fluoranthene and pyrene there is an increase in PAHs concentration with increasing in particle size. This may be attributed to the evaporation and recondensation of these semivolatile low molecular weights PAH on to bigger size aerosols as most of them exist mainly or partly in the gas phase (Allen et al., 1996). Benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene shows a decrease in concentration with increase in particle size. This could be due to the fact that these PAHs were attaching to the fine particulates (soot) from the combustion sources. In addition, smaller particles have a higher specific surface area and a higher attachment rate for organic pollutants and hence contain a greater amount of organic carbon, which allows more PAHs adsorption. The concentrations of perylene and benzo(ghi)perylene has not shown any dependence on particle size. The PAHs were mostly associated with fine particles (aerodynamic diameter < 4.7 µm), but the lower molecular weight PAH compounds (2-4 rings compounds) were predominating in the aerosol fraction >1.1 µm whereas the higher molecular weight PAH compounds were predominant in the aerosol fractions <1.1 µm. The predominating nature of lower molecular weight PAH compounds (2-4 rings compounds) in the aerosol fraction >1.1 µm could be due to the cyclic volatilization and adsorption of these semivolatile species on accumulation mode urban aerosols.

References

1. Allen, J.O., Dookeran, N.M., Smith, K.A., Sarofim, A.D., Taghizadeh, K. and Lafleur, A.L. (1996) Measurement of polycyclic aromatic hydrocarbons associated with size segregated atmospheric aerosols in Massachusetts, *Environ. Sci. Technol.*, 30, 1023-1031.
2. Guo, H., Lee, S.C., Ho, K.F., Wang, .M. and Zou, S.C. (2003) Particle-associated polycyclic aromatic hydrocarbons in urban air of Hong Kong. *Atmos. Environ.*, 37, 5307-5317.
3. Masclet, P., Nikolaou, K. and Mouvier, G. (1986) Relative decay index and sources of polycyclic aromatic hydrocarbons. *Atmos. Environ.*, 20, 439-446.
4. Pandit, G.G., Sharma, S., MohanRao, A.M. and Krishnamoorthy, T.M. (1996) Chromatographic methods for estimation of polycyclic aromatic hydrocarbons in atmospheric particulates. *Proceedings of the 10th National Symposium on Environment, Mumbai*, pp. 133-136.
5. Pistikopoulos, P., Wortham, H.M., Gomes, L., Masclet-Beyne, S., Nguyen, E.B., Masclet, P.A. and Mouvier, G. (1990), Mechanisms of formation of particulate polycyclic aromatic hydrocarbons in relation to the particle size distribution: effects on meso-scale transport, *Atmos. Environ.*, 24, 2573-2584.
6. Sahu, S.K., Pandit, G.G., Sharma, S. and Srivastava, P.K. (2001) Levels of polycyclic aromatic hydrocarbons in ambient air of Mumbai. *Proceedings of the 10th National Symposium on Environment, Mumbai*, pp. 279-281.

Table 1: Range and mean concentration of the individual PAH in the size segregated samples in ng/m³

PAHs	BF		0.4 –1.1 µm		1.1 – 3.3 µm		3.3 –9.0 µm	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
NAP	0.92 - 2.63	1.84	0.86 - 3.54	2.18	0.96 - 3.75	2.64	1.05 - 4.63	3.03
ACNAP	1.06 - 2.52	1.12	0.79 - 2.01	1.57	1.10 - 3.14	1.84	0.95 - 5.23	2.26
FLU	1.58 - 4.63	2.16	1.34 - 5.24	2.38	1.09 - 7.32	3.14	1.13 - 8.92	3.79
PHE	0.07 - 0.31	0.12	0.06 - 0.51	0.23	0.02 - 0.79	0.36	0.02 - 0.97	0.42
ANT	0.02 - 0.26	0.10	0.02 - 0.38	0.15	0.03 - 0.58	0.21	ND - 0.76	0.28
FLT	0.49 - 1.00	0.61	0.20 - 1.26	0.75	0.06 - 1.49	0.79	0.12 - 2.21	0.92
PYR	ND - 0.82	0.43	0.06 - 0.92	0.51	0.56 - 1.23	0.73	0.22 - 2.95	1.06
BaA	0.12 - 0.58	0.29	0.09 - 0.26	0.17	0.04 - 0.12	0.09	0.04 - 0.09	0.06
PER	0.91 - 1.71	1.15	0.07 - 0.62	0.38	0.05 - 0.93	0.47	ND - 0.71	0.34
BbF	0.82 - 1.65	1.16	0.05 - 1.02	0.84	0.12 - 0.87	0.53	ND - 0.32	0.19
BkF	0.10 - 1.15	0.48	0.10 - 0.98	0.35	0.15 - 0.43	0.29	ND - 0.26	0.14
BaP	0.44 - 1.02	0.76	0.03 - 0.91	0.57	0.03 - 0.57	0.28	ND - 0.10	0.07
BghiP	0.63 - 1.11	0.81	0.07 - 0.72	0.54	0.05 - 0.85	0.68	ND - 0.08	0.05

NAP: Napthalene, ACNAP: Acenapthalene, FLU: Flurene, PHE: Phenantherene, ANT: Anthracene, FLT: Fluoranthene, PYR: Pyrene, BaA: Benzo(a)Anthracene, PER: Perylene, BbF: Benzo(b)fluoranthene, BkF: Benzo(k)fluoranthene, BaP: Benzo(a) Pyrene, BghiP: Benzo(ghi)Perylene