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CHARACTERIZATION OF SOLVENT-EXTRACTABLE HYDROCARBONS FROM AIRBORNE PARTICULATES AND STREET DUST OF KUALA LUMPUR

By

NASR YOUSEF M.J. OMAR
DEPARTMENT OF CHEMISTRY
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA

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ABSTRACT

The solvent-extractable hydrocarbons were identified in PM_{10} airborne particles and roadside soil particles collected at eight locations in the city center and the suburb of Kuala Lumpur, Malaysia during the period from November 1998 to January 1999. Airborne particles were collected using high-volume PM_{10} sampler on glass fiber filters over 24 h average sampling period. After ultrasonic agitation with dichloromethane, the extracts were concentrated and fractionated on an alumina-silica column into three major fractions (aliphatics, aromatics and polar compounds). The aliphatics and aromatics fractions were then subjected to gas chromatography-mass spectrometric (GCMS) analysis. The major hydrocarbons identified in these fractions were n-alkanes in the range of C_{11} to C_{34}, polycyclic aromatic hydrocarbons (PAHs) ranging from phenanthrene (3 rings) to coronene (7 rings), and petroleum molecular markers including n-alkylcyclohexanes, pristane, phytane, hopanes, and steranes.

The atmospheric concentrations of n-alkanes in urban Kuala Lumpur vary from 56.34 ± 9.84 to 178.90 ± 41.05 ng/m^3, whereas the concentrations in roadside soil particles range from 6.10 ± 4.97 to 13.88 ± 10.07 μg/g. In atmospheric samples, the lower CPI values (CPI ~ 1) and the shift of C_{max} to lower molecular weight (e.g., C_{25}) indicated that vehicular emissions (petrogenic) are the major source of these compounds in airborne particles. However, in roadside soil particles, the biogenic input of n-alkanes was more apparent. This can be illustrated by the higher CPI values and the high molecular weight C_{max} (e.g., C_{31}).

Total PAHs concentrations in the atmospheric particles and roadside soil particles were found to be in the range of 1.84 ± 1.01 to 11.29 ± 4.99 ng/m^3 and 0.19 ± 0.10 to 0.26 ± 0.17 μg/g, respectively. Benzo[g,h,i]perylene and coronene, which are indicative of gasoline vehicle emissions were found to be the most abundant PAHs in

airborne particles at all locations. The most abundant PAHs in the roadside soil particles were phenanthrene, fluoranthene, and pyrene. These compounds are indicative of diesel vehicle emissions. Thus, vehicular emissions are the primary contributor to PAHs concentration in Kuala Lumpur.

For both airborne particles and roadside soil particles, the presence of petroleum molecular markers, coupled with the unresolved complex mixture (UCM) reflected the contamination by petroleum residues of vehicular emissions.

The results of this study indicate that the solvent-extractable hydrocarbons in Kuala Lumpur's atmospheric and roadside soil particles are of mixed petrogenic and biogenic sources.

ABSTRAK

Hidrokarbon-hidrokarbon yang boleh diekstrakkan telah dikenalpasti dalam zarahan terampai PM_{10} dan tanah tepi jalan. Sampel-sampel dikumpul di lapan lokasi di pusat bandar Kuala Lumpur dan persekitarannya untuk tempoh dari November 1998 sehingga Januari 1999. Zarahan terampai dikumpul di atas kertas turas gentian kaca untuk tempoh kira-kira 24 jam dengan menggunakan pensampel ipadu-tinggi PM_{10}. Selepas diekstrak dengan diklorometana melalui kaedah getaran ultrasonik, ekstrak dipekatkan, dan dilalukan melalui turus alumina-silika bagi mendapatkan tiga pecahan utama, iaitu, alifatik, aromatik dan sebatian-sebatian yang berkutub. Pecahan alifatik dan aromatik seterusnya dianalisis dengan kaedah kromatografi gas-spektrometri jisim (KGSJ). Hidrokarbon-hidrokarbon utama yang dikenalpasti di dalam pecahan-pecahan ini ialah, n-alkana, dari C_{11} ke C_{34}, hidrokarbon aromatik polisiklik (HAP), dari fenantrena (3 gelang) ke koronena (7 gelang), dan penanda molekul petrolium seperti n-alkilsikloheksana, pristana, fitana, hopana dan sterana.

Kepekatan n-alkana di atmosfera Kuala Lumpur berada di antara 56.34 ± 9.84 dan 178.90 ± 41.05 ng/m^3, sementara kepekatan dalam zarahan tanah tepi jalan berada di antara 6.10 ± 4.97 dan 13.88 ± 10.07 μg/g. Nilai CPI yang rendah (~ 1) dan anjakan C_{maks} ke rantai karbon yang lebih pendek (contohnya, C_{25}) menunjukkan bahawa pemancaran daripada kenderaan (petrogenik) merupakan sumber utama hidrokarbon dalam zarahan terampai. Walau bagaimanapun, input n-alkana daripada sumber biogenik lebih ketara dalam zarahan tanah tepi jalan. Hal ini ditunjukkan oleh nilai CPI yang lebih tinggi dan C_{maks} pada rantai karbon yang lebih panjang (contohnya, C_{31}).

Jumlah kepekatan HAP di dalam zarahan terampai dan zarahan tanah tepi jalan didapati masing-masing berada dalam julat di antara 1.84 ± 1.01 dan 11.29 ± 4.99 ng/m^3, dan 0.19 ± 0.10 dan 0.26 ± 0.17 μg/g. Benzo[ghi]perilena dan koronena, yang

merupakan penunjuk bagi pemancaran kenderaan berpetrol, merupakan HAP paling dominan dalam zarahan terampai di semua lokasi. HAP paling banyak di dalam zarah tanah tepi jalan ialah fenantrena, fluorantena dan pirena. Sebatian-sebatian ini berasal daripada pemancaran kenderaan diesel. Adalah jelas bahawa pemancaran kenderaan merupakan penyumbang kepekatan HAP primer di Kuala Lumpur.

Bagi kedua-dua zarahan terampai dan zarahan tanah tepi jalan, kehadiran petanda molekul petrolium beserta campuran kompleks tak teresolusi (CKTR) mencerminkan kontaminasi oleh baki petrolium daripada pemancaran kenderaan.

Kepatusan daripada kajian ini menunjukkan bahawa pemancaran kenderaan merupakan satu-satunya sumber penting bagi hidrkarbon terekstrak dalam zarahan atmosfera dan zarahan tanah tepi jalan.

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ABBREVIATIONS

ANTH	Anthracene
ANTN	Anthanthrene
BaA	Benz[a]anthracene
BaP	Benzo[a]pyrene
BbF	Benzo[b]fluoranthene
BeP	Benzo[e]pyrene
BgP	Benzo[g,h,i]perylene
BkF	Benzo[b]fluoranthene
BR	Bukit Rengit
CH	Cheras
CHR	Chrysene
C_{max}	Carbon number maximum
COR	Coronene
CPI	Carbon preference index
dBahA	Dibenz[a,h]Anthracene
DW	Dang Wangi
FLO	Fresh lubricating oil
FLT	Fluoranthene
g	Gram
GC	Gas chromatography
GC-FID	Gas chromatography-flame ionization detector
GCMS	Gas chromatography-mass spectrometry
GCMSMS	Gas chromatography-mass spectrometry-mass spectrometry
h	Hour
hi-vol	High-volume
HPLC	High performance liquid chromatography
I.D.	Internal Diameter
IP	Indeno[1,2,3-cd]pyrene
JA	Jalan Ampang
JT	Jalan Travers
KE	Kepong

LC	Liquid chromatography
m	meter
min	minute
MPHEN	4,5-Methylenephenanthrene
n	Number of observations
n.a.	Not available
n.d.	Not detected
PAHs	Polycyclic aromatic hydrocarbons
PB	Pantai Baharu
PER	Perylene
PHEN	Phenanthrene
PM_{10}	Particulate matter ≤ 10 μm
$PM_{2.5}$	Particulate matter ≤ 2.5 μm
ppm	Parts per million
PU	Pudu
PYR	Pyrene
RfC	Reference Concentration
RfD	Reference Dose
RIC	Reconstructed ion chromatogram
SE	Sentul
sec	Second
SIM	Selected ion monitoring
SPE	Solid phase extraction
TIC	Total ion chromatogram
TLC	Thin layer chromatography
$TPM_{10}P$	Total PM_{10} Particles
TSEOM	Total solvent extractable organic matter
TSP	Total suspended particles
UCM	Unresolved complex mixture
ULOC	Used car lubricating oil
ULOM	Used motorbike lubricating oil
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
XAD-2	Styrene and divinylbenzene copolymer
σ	Standard deviation