Semi-volatile Organic Compounds (SOCs) and carbonaceous aerosol in rural atmosphere, UK during 2003 winter period

1. Introduction

A worldwide concern about the composition of the atmospheric carbonaceous particles in the atmosphere has arisen due to its responsibilities for environmental, health and climate effects. It is well known that organic particles can change the chemical and thermodynamic properties of particles in the atmosphere. Saxena et al. [1995] proposed that organics play an important role in particle heterogeneous reactions, which affects particle size and the visibility. Pope et al. [2000] suggested that human exposures to airborne particles, especially fine particles are high risk factors for cardiovascular disease and mortality. Adverse effects also are observed when breathing airborne particles in controlled acute human exposure studies, including cough, respiratory symptoms of asthma, and reduced lung function. Organic particles have potential impacts on human health because it contains possible mutagenic and carcinogenic compounds such as polycyclic aromatic hydrocarbons (PAHs). The limited understanding of concentration and composition of organic particles have hampered the implementation of source apportionment modeling in urban/rural atmosphere. Therefore, an intensive daily monitoring campaign provides an insight for future experimental design and planning for source apportionment studies using receptor models as well as epidemiological studies of human exposures to organic aerosols.

2. Aims of study

1. To chemically characterize the organic fraction of rural aerosol.
2. To improve understanding of the sources of SOCs and carbonaceous aerosol in rural area.
3. To provide an insight for future source apportionment models and health effect studies.

3. Sampling Site and Air Sampling

Atmospheric samples were collected at a country site in Whitbourne (52º12.46’N, 02º24.94’W, 8 km away from the Worcester City Centre). There are about 542,000 people living in a 174,000 hectare area of Worcestershire. The sampling location was inside a farmland. There are no major anthropogenic pollutants, like industrial emission and vehicular emission. Impinger samples were collected during the periods from November 2003 to December 2003 (winter period). Twenty-four hour sampling was carried out everyday at the sampling location. Twenty-four hour PM10, and vapour phase SOCS were collected simultaneously using high volume and a semi-volatile (OC, EC) was used in volume samplers (Grashey-andersen), operated at flow rates of 0.91.4 m3/min from November 2003 to December 2003 at Worcester. PM10 samples were trapped on 25.4 cm 2 Whatman microfilter foils (QFP). Vapour phase SOCS were collected simultaneously by a polyurethane foam plug (PUP) placed in line after the Filter paper. Prior to use, all the quartz filters and PUF from the same lot will be cleaned by 24 hour Soxhlet extraction with dichlooroethane (DCE) and then the filters were pre-heated before sampling at 900ºC for 3 hours.

4. Analytical Method

OC and EC analysis

The samples were analyzed for OC and EC using DRI Model 2001 (Thermal/Optical Carbon Analyzer) with the IMPROVE thermal/optical retraction (TOR) protocol [9]. The protocol binds a 0.526 cm3 parraldehyde of a sample quartz filter prior to temperatures of 120ºC (OC), 230ºC (OC2), 450ºC (OC3) and 550ºC (OC4) in a non-oxidising helium atmosphere, and 550ºC (EC1), 760ºC (EC2), and 800ºC (EC3) in an air atmosphere of 2% oxygen in a balance of helium.

SOCs analysis

Extraction: QFPs and PUFs were spiked with deuterated SOCs standard prior to Soxhlet extraction (internal standards, ISs) for 24h with DCM. DCM was then evaporated, then dried to dryness and the extract was made up to 1.0 ml with hexane.

Purification: Extracts were purified using the methodology developed by Stephanou et al. [1995] and Gogou et al. [1998] by elution through a silica gel solid phase extraction column and were fractionated into SOC groups by elution with solvents of various polarities (10-1). GC/MS Analytical Samples were analysed by GC/MS on a Finnion MD 800 instrument. Two microfrit of the sample extract was injected in the splitter mode. Injector temperature was 250ºC, interface temperature was 280ºC and the helium pressure was 25 psi. Injector pressure was 250ºC, interface temperature was 280ºC and the helium pressure was 25 psi. For PAHS analysis, the oven temperature was programmed at 60ºC for 1 minute then 10ºC/min up to 230ºC and the MS was operated in EI selective ion monitoring mode (SIM). For all other SOCS, the oven temperature was programmed at 60ºC for 1 minute then 10ºC/min up to 280ºC and the MS was operated in SIM.

5. Results and Discussion

1. Particulate-associated PAHs concentration in Worcester

The total PAHs concentration ranged from 0.6 to 152.9 ng/m3 and the average value is 3.99 ng/m3 with 83% of standard deviation (Table 1). The highest value of benzo[g]pyrene (BGP) was measured on 02-12-03 at 1.29 mg/m3 while the lowest was observed on 20-12-03 at 0.037 mg/m3. The average of BGP was 0.34 ng/m3 with 96% of standard deviation. This value is 1.3 times higher than the UK air quality standard (0.25 ng/m3) set by the UK government’s Expert Panel on Air Quality Standard (BQAS). The total PAHs is comparable to those measured in rural area in Grece, Hong Kong, Indonesia and Hungary (Table 1). Retene (Ret), a common biomarker of bonfire, conferrers wood combustion and resin seals ranging from 0.028 ng/m3 to 0.034 ng/m3 with the average of 0.024 ng/m3. This value is much lower than the average particulate trend observed by Didyk et al. [1999] in Santiago (7 mg/m3) indicated that heather activities and cinnamum wood burning are not the major sources of particulate PAHs in Worcester during the winter period.

Table 1: Semi-volatile Organic Compounds (SOCs) and carbonaceous aerosol in rural atmosphere, UK during 2003 winter period

<table>
<thead>
<tr>
<th>PAHs</th>
<th>Concentration (ng/m³)</th>
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<tbody>
<tr>
<td>BGP</td>
<td>0.34 ± 0.024</td>
</tr>
<tr>
<td>FS</td>
<td>0.001 ± 0.0006</td>
</tr>
<tr>
<td>Retene</td>
<td>0.03 ± 0.002</td>
</tr>
<tr>
<td>B[a]P</td>
<td>0.03 ± 0.002</td>
</tr>
<tr>
<td>B[a]A</td>
<td>0.05 ± 0.005</td>
</tr>
<tr>
<td>B[ghi]P</td>
<td>0.03 ± 0.002</td>
</tr>
<tr>
<td>EPA</td>
<td>0.02 ± 0.001</td>
</tr>
<tr>
<td>B[a]H</td>
<td>0.02 ± 0.001</td>
</tr>
<tr>
<td>B[a]F</td>
<td>0.01 ± 0.001</td>
</tr>
<tr>
<td>B[ghi]F</td>
<td>0.01 ± 0.001</td>
</tr>
<tr>
<td>Benzo[a]pyrene</td>
<td>0.02 ± 0.001</td>
</tr>
</tbody>
</table>

6. Conclusion

The strong positive correlations between EPIHS and vehicular emissions originated aromatic compounds indicated that the mobile sources could play an important role in the atmospheric environment in Worcester. However, the ratios of BGP/COR and BIP/BIP+COR observed in this study are the highest values comparing to any other results in urban areas implied that local biomass burning could responsible for acting as the main source of PAHS. The other sources could play an important role in the atmospheric environment in Worcester. However, the ratios of BGP/COR and BIP/BIP+COR observed in this study are the highest values comparing to any other results in urban areas implied that local biomass burning could responsible for acting as the main source of PAHS.

Future Work and Acknowledgements

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References