

# Real time measurements of submicrometer aerosols in Seoul, Korea: Sources, characteristics, and processing of organic aerosols during winter time.

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Keywords: HR-ToF-AMS, Haze, sources, Seoul, Air quality.

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Highly time-resolved chemical characterization of non-refractory submicrometer particulate matter (NR-PM<sub>1</sub>) was conducted in Seoul, the capital and largest metropolis of Korea, using an Aerodyne high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). The measurements were performed during winter when persistent air quality problems associated with elevated particulate matter (PM) concentrations were observed. This is the first time that such detailed real-time measurement results have been reported from Seoul, Korea, providing insights into the various sources and processes of PM in the atmosphere.

The average NR-PM<sub>1</sub> concentration was 27.5  $\mu\text{g m}^{-3}$  and the average mass was dominated by organics (44%), followed by nitrate (24%) and sulfate (10%). Organics had average atomic oxygen-to-carbon (O/C), hydrogen-to-carbon (H/C), and nitrogen-to-carbon (N/C) ratios of 0.37, 1.79, and 0.022, respectively determined using the revised elemental analysis method reported in Canagaratna et al. (2015). Five distinct sources of organic aerosol (OA) were identified from positive matrix factorization (PMF) analysis of the AMS data (Zhang et al., 2011): vehicle emissions represented by a hydrocarbon-like OA factor (HOA; O/C = 0.06), cooking represented by a cooking OA factor (COA; O/C = 0.15), wood combustion represented by a biomass burning OA factor (BBOA; O/C = 0.34), and secondary aerosol formation in the atmosphere that is represented by a semi-volatile oxygenated OA factor (SVOOA; O/C = 0.56) and a low volatile oxygenated OA factor (LVOOA; O/C = 0.68). These factors, on average, contributed 16, 20, 23, 15 and 26% to the total OA mass, respectively, with primary organic aerosol (POA = HOA + COA + BBOA) accounting for a high fraction the OA mass (59%).

On average, both primary emissions and secondary aerosol formation are important factors affecting air quality in Seoul during winter, contributing approximately equal. However, differences in the fraction of PM source and properties were observed between high and low loading PM period (Fig.1). For example, during stagnant period with low wind speed (WS) ( $0.99 \pm 0.7$  m/s) and high RH (71%), high PM loadings ( $43.6 \pm 12.4$   $\mu\text{g m}^{-3}$ ) with enhanced fractions of nitrate (27%) and SVOOA (8%) were observed, indicating a strong influence from locally generated secondary aerosol. This enhancement may be due to the aqueous reaction or extra SOA formation contributed by

accumulated semi-volatile organics emitted from various primary sources. On the other hand, when low PM loadings ( $12.6 \pm 7.1$   $\mu\text{g m}^{-3}$ ), which were commonly associated with high WS ( $1.8 \pm 1.1$  m/s) and low RH (50 %), were observed due to dynamic meteorology, the fraction of regional sources, such as sulfate (12%) and LVOOA (21%) become higher whereas the fraction of locally emitted primary (COA, HOA) and locally formed secondary species (nitrate, SVOOA) become lower. Higher O:C ratio (0.41 vs 0.35 for low loading and high loading respectively) during this period further supports the influences from long range transport of oxidized organics during dynamic meteorology period.

Our results indicate that NR-PM<sub>1</sub> concentrations, compositions and sources in Korea are very complex and meteorological conditions and air mass origins have a strong influence on properties of PM.

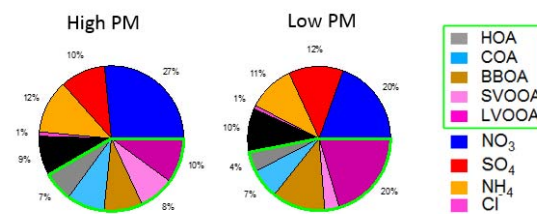


Fig1. Average compositional pie chart of PM<sub>1</sub>+BC species during high ( $43.6 \pm 12.4$   $\mu\text{g m}^{-3}$ ) and low ( $12.6 \pm 7.1$   $\mu\text{g m}^{-3}$ ) loading period.

This work was supported by the Korea Institute of Science and Technology (KIST)

Canagaratna, M.R., Jimenez, J.L., Kroll, J.H., Chen, Q., Kessler, S.H., Massoli, P., Hildebrandt Ruiz, L., Fortner, E., Williams, L.R., Wilson, K.R., Surratt, J.D., Donahue, N.M., Jayne, J.T., Worsnop, D.R., 2015. Elemental ratio measurements of organic compounds using aerosol mass spectrometry: characterization, improved calibration, and implications. *Atmospheric Chemistry and Physics* 15, 253-272.

Zhang, Q., Jimenez, J.L., Canagaratna, M.R., Ulbrich, I.M., Ng, N.L., Worsnop, D.R., Sun, Y., 2011. Understanding atmospheric organic aerosols via factor analysis of aerosol mass spectrometry: a review. *Analytical and bioanalytical chemistry* 401, 3045-3067.

