

# Aerosol particles from smoking, cooking, and various pyrotechnical devices: laboratory characterization and detection in a football stadium

P. Faber<sup>1</sup>, F. Drewnick<sup>1</sup> and S. Borrmann<sup>1,2</sup>

<sup>1</sup>Particle Chemistry Department, Max Planck Institute for Chemistry, D-55128 Mainz, Germany

<sup>2</sup>Institute for Atmospheric Physics, Johannes Gutenberg University, D-55128 Mainz, Germany

Keywords: HR-ToF-AMS, aerosol particles, emission source, football stadium

Presenting author email: peter.faber@mpic.de

Little is known about the chemical and physical characteristics of particles from less abundant anthropogenic aerosol sources (Zhang et al., 2011) such as those associated with football stadiums. Nevertheless, locally and temporally these sources can have a significant impact on the ambient aerosol and thus potentially on human health.

Several anthropogenic emission sources of aerosol particles that are typically found in football stadiums were therefore addressed in combined field and laboratory studies by using a set of modern online instruments for real-time measurements of particle, trace gas, and meteorological parameters (Drewnick et al., 2012). A high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) provided online data on the chemical composition of the non-refractory PM<sub>1</sub>.

The field campaign took place in a German football stadium (*Coface-Arena*, Mainz) during an official *Bundesliga* (German football league) match on 20<sup>th</sup> April 2012. The mass concentration of the organic aerosol fraction was elevated on average by a factor of almost 6 during the football match event ( $10.7 \pm 7.6 \mu\text{g m}^{-3}$ ) compared to background levels ( $1.9 \pm 0.5 \mu\text{g m}^{-3}$ ). Highly time-resolved online data on the organic aerosol explored a temporal structure that could be clearly related to the local activities reflecting different phases of the match. Additionally, the organic mass size distribution during the football match revealed considerable contributions of freshly emitted particles. Contrary to that, mass concentrations and size distributions of the inorganic non-refractory PM<sub>1</sub> components (NH<sub>4</sub>, NO<sub>3</sub>, SO<sub>4</sub>, Cl) were not significantly different from background measurements. Positive matrix factorization (PMF) established cigarette-smoking organic aerosol (CSOA) and cooking organic aerosol (COA) as the dominating fractions of the submicron organic particulate matter in the stadium during the match. Here we present the high-resolution mass spectra as well as the elemental ratios (OM:OC, O:C, H:C, N:C) of both factors. Furthermore, we compare the strength and the temporal evolution of these emissions concerning different phases of the football match event (Figure 1). All species that were elevated during the match reached their initial background levels within one hour after the match had finished.

Laboratory measurements of various specific aerosols were performed to support the analysis of the field data. These measurements include the characterization of emissions from deep-frying of French fries and from sausage cooking, from cigarette smoking, from different pyrotechnical devices (fireworks, hand

flares, color smoke bombs), and from laboratory-generated metal-containing aerosols. Although no aerosols from pyrotechnical devices could be detected in the field measurement, we estimated their potential influence on the local air quality by calculating emission factors based on laboratory data. In addition to information on the physical and chemical characteristics of the related aerosols, the laboratory measurements provided a large number of standard spectra that have not been available so far for HR-AMS ambient aerosol analyses.

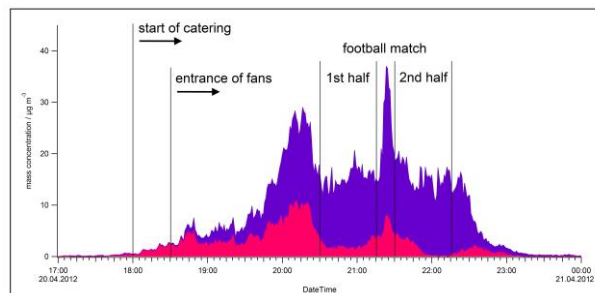


Figure 1. Temporal evolution of cooking organic aerosol (pink) and cigarette-smoking organic aerosol (purple) within a football stadium reflecting different phases of the match.

Although HR-AMS mass spectra of most investigated aerosols within this study were dominated by organics, the emissions from fireworks and hand flares explored distinct contributions of inorganic species and metal compounds. Here we present laboratory studies for a set of non-refractory metal chlorides that enable the quantitation of these compounds by the HR-ToF-AMS in ambient measurements for the first time.

Thomas Böttger and the Coface Arena team are gratefully acknowledged for technical support.

Drewnick, F., Böttger, T., von der Weiden-Reinmüller, S.-L., Zorn, S.R., Klimach, T., Schneider, J., Borrmann, S. (2012). *Atm. Meas. Tech.* **5**, 1443-1457.

Zhang, Q., Jimenez, J.L., Canagaratna, M.R., Ulbrich, I.M., Ng, N.L., Worsnop, D.R., Sun, Y. (2011). *Anal. Bioanal. Chem.* **401**, 3045-3067.