Real-time investigation of primary particle emissions and secondary particle formation from a gasoline direct injection vehicle

P. Karjalainen[1], H. Timonen[2], E. Saukko[1], H. Kuuluvainen[1], S. Saarikoski[2], P. Aakko-Saksa[3], T. Murtonen[3], M. Bloss[2], M. Dal Maso[1], E. Ahlberg[4,5], B. Svenningsson[5], W.H. Brune[6], R. Hillamo[2], J. Keskinen[1] and T. Rönkkö[1]

[1]Aerosol Physics Laboratory, Department of Physics, Tampere University of Technology, Tampere, Finland
[2]Atmospheric Composition Research, Finnish Meteorological Institute, Helsinki, Finland
[3]VTT Technical Research Centre of Finland Ltd., Espoo, Finland
[4]Centre for Environmental and Climate research, Lund University, Lund, Sweden
[5]Division of Nuclear Physics, Lund University, Lund, Sweden
[6]Department of Meteorology, Pennsylvania State University, University Park, PA, USA

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Presenting author email: topi.ronkko@tut.fi

Changes in vehicle emission reduction technologies significantly affect traffic-related emissions in urban areas. In many densely populated areas the amount of traffic is increasing, keeping the emission level high or even increasing. To understand the health effects of traffic related emissions, both primary (direct) particulate emission and secondary particle formation (from gaseous precursors in the exhaust emissions) need to be characterized. In this study we used a comprehensive set of measurements to characterize both primary and secondary particulate emissions of a gasoline vehicle. Our measurements cover the whole process chain in emission formation, from the tailpipe to the atmosphere, and takes into account also differences in driving patterns.

The test vehicle was a modern gasoline passenger car (model year 2011, 1.4 l turbo-charged GDI engine, emission level Euro 5 with a three-way catalytic converter). The driving cycle used in the study was the New European Driving Cycle (NEDC).

The sampling system consisted of a porous tube diluter (PTD) (dilution ratio (DR) 12), residence time chamber (2.5 s) and secondary dilution conducted by Dekati Diluter (DR 8). In terms of exhaust nucleation particle formation, the sampling system mimics the real exhaust dilution and nanoparticle formation processes in atmosphere. A potential aerosol mass (PAM) chamber (Kang et al., 2007, 2011, Lambe et al., 2011) is a small flow through chamber developed to simulate aerosol aging in the atmosphere. The PAM chamber was installed between the ageing chamber and secondary dilution. The particle instrumentation consisted of an ultrafine condensation particle counter (UCPC), a High-resolution low-pressure impactor (HRLPI) and aerosol mass spectrometer (SP-ToF-AMS).

We observed that in mass terms, the amount of secondary particles was 13 times higher than the amount of primary particles. The formation, composition, number, and mass of secondary particles was significantly affected by driving patterns and engine conditions (Fig. 1). The highest gaseous and particulate emissions were observed at the beginning of the test cycle when the performance of the engine and the catalyst was below optimal. The key parameter for secondary particle formation was the amount of gaseous hydrocarbons in primary emissions.

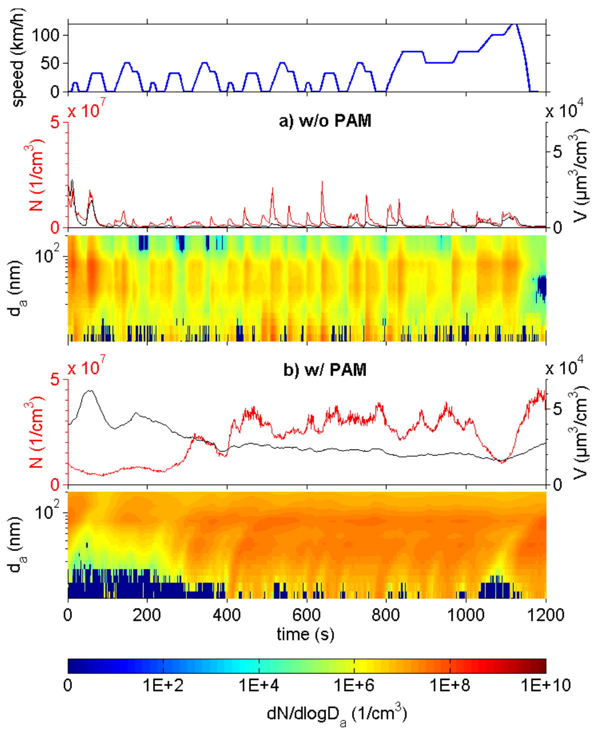

Figure 1. (a) Primary particle and (b) formed secondary particle concentrations (number, N, UCPC data) and size distributions measured by the HR-LPI during the NEDC test cycle

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