Understanding and Measuring Sub-23 nm Particle Emissions from Direct Injection Engines

E. Papaioannou[1], D. Zarvalis[1], N. Vlachos[1], A.G. Konstandopoulos[1,2], G. Nicol[3], M. Sgroi[3], S. Zinola[4], B. M. Vaglieco[5], S. Di Iorio[5], C. Barrios[6], P. M. Moselund[7], H. Burtscher[8], M. Fierz [8]

[1]Aerosol &Particle Technology Laboratory, CERTH/CPERI, P.O. Box 60361, 57001, Thessaloniki, Greece

[2] Department of Chemical Engineering, Aristotle University, PO. Box 1517, 54006, Thessaloniki, Greece

[3] Centro Ricerche Fiat, 10043 Orbassano, Italy

[4] IFP Energies nouvelles, 69360 Solaize, France

[5] Istituto Motori – CNR, 80125 Naples, Italy

[6] SEADM S.L., 47151 Boecillo, Spain

[7] NKT Photonics A/S, 3460 Birkerød, Denmark

[8] Institute for Aerosol und Sensor Technology, Fachhochschule Nordwestschweiz, 5210 Windisch, Switzerland

A large fraction of the total number of particles emitted by direct injection engines are below the adopted 23 nm diameter threshold and although the EU aims to regulate these emissions and impose limits for new light-duty vehicles, this is not yet possible due to the absence of accurate and reliable quantification methods, especially under real driving conditions. The main reason for this is the lack of adequate knowledge regarding the nature of sub-23 nm particles from different engine/fuel combinations under different engine operating conditions. Four research organisations, three particle measurement instrumentation companies and one automotive OEM have joined forces in the framework of the EU-funded project SUREAL-23 to overcome such barriers by introducing novel technology for the measurement of sub-23 nm exhaust particle concentration, size and composition. In this work, we will present our latest efforts on (a) simplifying and making more robust the exhaust aerosol sample treatment, (b) elucidating the effect of different diesel and gasoline engine operating conditions (fuel additives, bio-content, gas fuel addition, after-treatment type and operation, etc.) on sub-23 nm particle emissions and (c) advancing particle measurement technology with the introduction of novel techniques. Use of a catalytic stripper device and operation of particle measurement systems at higher than the typical temperatures has been found to reduce the need for treatment/dilution of the exhaust sample, minimising particle losses and artefacts. The understanding of sub-23 nm emissions has been advanced by deploying a variety of fuel-flexible engines and particle generators to produce a wide range of sub-23 nm exhaust particles. With respect to instrumentation, an induced charged aerosol detector was modified for smaller size and higher temperature particle detection, a differential mobility analyser was adapted for high-resolution particle sizing below 23 nm and high temperature operation and, in an effort to obtain real-time composition information, a supercontinuum laser has been applied for the photoacoustic analysis of sub-23 nm exhaust aerosol.