Comparison of different techniques for aerosol surface area size distribution measurements: CEPI, ELPI and SMPS

M.I. Gini[1], L. Mendes[1,2] and K. Eleftheriadis[1]

[1]ERL/INRASTES, NCSR Demokritos Athens, 15310, Greece
[2] Department of Environment, University of the Aegean, 81100 Mytilene, Greece

Keywords: Cascade Epiphaniometer, ELPI, SMPS, Surface area, size distributions

Presenting author email: gini@ipta.demokritos.gr

During the last decades there was an increased concern worldwide regarding adverse health effects of human exposure to aerosol nanoparticles. European Commission has established limit values for exposure to coarse (PM_{10}) and fine ($PM_{2.5}$) particulate matter to protect human health. However, the use of mass concentration as a metric has recently been questioned, in particular because of the rapid growth of nanotechnology and nanomaterial science. The surface area of nanoparticles is a key parameter in determining their properties, since their increased surface-to-volume ratio enhances their reactivity. Additionally, several studies have identified surface area as an important determinant of low solubility nanoparticles toxicity. The most commonly used instruments for direct measurement of the surface area concentrations are based on the measurement of the mass transfer through the attachment rate of ions to the particle surface area (i.e. Electrical Low Pressure Impactor (ELPI), Diffusion Charger). However, questions arise about the influence of particle morphology on charging efficiency, and consequently, the instrument's response.

In this study, a comparison was performed between different techniques (direct and in-direct) for particle surface area characterization, aiming at investigating whether instruments response is affected by particles morphology. The direct techniques included measurement of aerosols surface area size distributions by means of an ELPI (DEKATI) and a CEPI (Cascade Epiphaniometer, (Gini et al. 2013)). The CEPI operating principle is based on the measurement of the mass transfer through the attachment of neutral atoms (^{211}Pb) to the particle's surface area, a process not greatly affected by electrostatic interactions (Rogak et al., 1991). The surface area was also indirectly determined based on number size distribution statistics (Scanning Mobility Particle Sizer, TSI), under assumptions regarding particle morphology.

The instruments were tested for different kinds of monodisperse and polydisperse aerosols. DEHS, $(NH_4)_2SO_4$ and NaCl aerosols were generated by an aerosol atomizer (TOPAS-GMBH). Carbon aggregates were generated by means of a spark discharge generator (Fasmatech Science and Technology SA). The instruments were also used in parallel to measure the surface area of ambient aerosol nanoparticles. The measurement campaign was conducted at the urban background monitoring station DEM-GAW, located at the grounds of NCSR 'Demokritos', Athens, Greece.

Figure 1 presents the results of the instruments comparison in the case of monodisperse spherical and non-spherical aerosol nanoparticles. CEPI signal (α-counts/sec) is well correlated with the calculated total surface area (SMPS). Particle shape seems not to significantly affect instruments response, which is in agreement with the outcomes of previously conducted studies (Gini et al. 2016, 2013). In the case of ELPI, it was observed that its signal, which is proportional to the active surface area, is also well correlated with SMPS and consequently with CEPI, independently of particle morphology. However, in the case of carbon aggregates, the ELPI signal was 32% higher than the expected, assuming spherical particles.

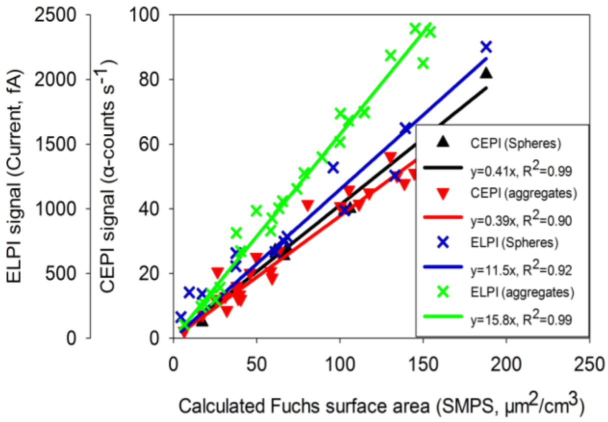

Figure 1. Comparison between CEPI and ELPI signal and SMPS-calculated total surface area (Fuchs surface area)

We would like to acknowledge Dr Tim Jones, Cardiff University/School of Earth and Ocean Sciences, for providing us with the ELPI.

This work was supported by (1) EnTec FP7 Capacities programme (REGPOT-2012-2013, FP7, ID: 316173) and (2) 11SYN_5_1861/DE_SPARK_NANO_GEN, implemented in the framework of the Action «Cooperation 2011», co-financed by the European Regional Development Fund (ERDF) & the Greek State

Gini M.I., Helmis C., Melas A.D., Papanastasiou D., Orfanopoulos G., Giannakopoulos K., Drossinos Y., Eleftheriadis K. (2016) *Aerosol Sci. & Tech.*, **50**, 133-147.

Gini M.I., Helmis C.G., Eleftheriadis K. (2013) *J. Aerosol Sci.*, **63**, 87-102.

Rogak S.N., Baltensperger U. and Flagan R.C. (1991) *Aerosol Sci. & Tech.*, **14**, 447-458.