# A calibration procedure adapted to measure in real-time droplet size distribution of e-cigarette aerosols

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The need to apply strict and accurate measurement protocols to evaluate aerosol physical properties is key for the evaluation of inhalable aerosols exposure. Among others, the most relevant set of parameters to be considered is the aerosol size distribution. Depending on the size distribution, the fraction of the inhaled dose is transported further to the tracheobronchial section and a fraction may be delivered to the alveolar region (Bernstein, 2004; Kane, 2009). It is generally agreed that an aerosol is considered respirable when its related Mass Median Aerodynamic Diameter (MMAD) is found below 2.5 micrometer, as more than 80% of the aerosol in mass reaches the alveolar region. This is a crucial parameter used to estimate the aerosol dose delivered in lungs for inhalation exposure evaluation.

From a regulatory standpoint, the use of the impactor technique is recommended as it classifies gravimetrically aerosol droplets in distinct size classes and mimic to some extent the deposition behavior in lungs. Due to the labor intensive nature of the multi-stage cascade impactor, other technics such as optical methodologies are usually preferred for high-throughput measurement of aerosol size distributions.

For this purpose, a commercial TSI Laser Aerosol Spectrometer (LAS) operating at a wavelength of 633 nm was tested and assessed. In order to investigate the influence of using particles/droplets with different index of refraction on the instrument response, DEHS and PSL were used to construct calibration curves. In Figure 1, the LAS signal response was plotted as a function of selected sizes where it can be seen that the instrument responses were found significantly different.

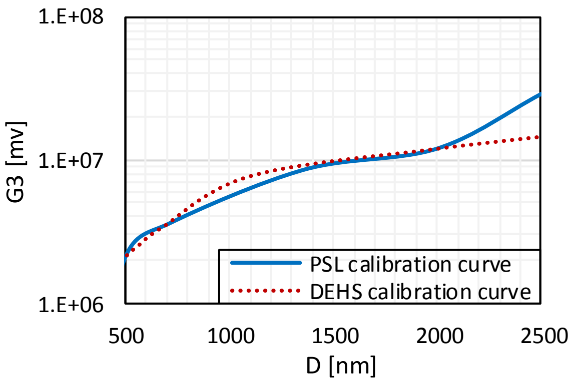


Figure 1: Calibration curves for two aerosol materials.

When different calibration curves were used for selected DEHS droplet sizes, typical size responses obtained with the LAS are shown in Table 1. For instance when considering droplet size of 600 nm, using PSL and DEHS calibration curves, size responses were 499 and 595 nm, respectively. In this example, a good match was found when using the DEHS calibration curve (±1%), whereas an underestimation of approximately 17 % was obtained when using PSL calibration curve. This underestimation is attributed presumably because the test aerosol has a different index of refraction in comparison to PSL particles.

Table 1. LAS size response for DEHS droplets using two different calibration curves.

| Generated DEHS droplet size (nm) | LAS size response when PSL calibration is used (nm) | LAS size response when DEHS calibration used is (nm) |
|---|---|---|
| 600 | 499 | 595 |
| 1050 | 822 | 924 |
| 2000 | 1705 | 1930 |

From this work, it was found that the LAS can be used accurately when the index of refraction of a test aerosol is close to that of PSL calibrated particles. Otherwise, an alternative calibration should be implemented or a bias correction factor could be applied. From our measurements, index of refraction of several e-liquids were found to be close to that of DEHS. Thus, the LAS size response provides an underestimated size response by 15-20 % of the true value for e-cigarette aerosols, when the PSL calibration curve is used. From preliminary measurements performed on 4 commercial e-cigarette brands, the Count Median Diameter (CMD) values were found to be from 130 to 191 nm (no bias correction applied) in agreement with literature values (Fuoco, 2014). It should be stressed that only test aerosols with known index of refraction should be measured. In fact, aerosols with a totally different chemical nature like iron or soot particles have a complex index of refraction and the instrument would probably fail in providing accurate and linear size responses when PSL or DEHS calibration curves are used.

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