ABSTRACT

An improved virtual impactor type aerosol generator with minimum particle loss and capable of producing particles with narrow size distribution has been designed, fabricated and tested. The aerosol generator consists of two major components: generation chamber and improved virtual impactor. In the generation chamber, an atomizer generates polydisperse aerosols from a solution (5% to 100%) of di-octyl phthalate (DOP) in ethyl alcohol. Large particles are removed by gravitational settling in the generation chamber and an improved virtual impactor is used to remove small particles. Particle size distributions have been measured by an optical particle counter, LASAIR-2500 (Particle Measuring System Inc., USA). DOP particles generated have been found to have number mean aerodynamic diameter (NMAD) varying from 1.90 to 4.07 μm and geometric standard deviation (GSD) in the range of 1.41 to 1.49. The aerosol generator has been designed to have a compact size (152 cm in height and 15.2 cm in diameter) and minimum particle loss.

Droplet generation has been accomplished by a siphon type solid-cone spray Delavan nozzle (model P/N 30610-4). The operating parameters of the nozzle have been determined on the basis of generating polydisperse particles with wide range of size distribution and minimum liquid consumption. An atomizing air pressure of 17.1 kPa and liquid pressure of -22 cm of alcohol (relative to ambient pressure) have been selected to operate the nozzle in the aerosol generator. At these atomizing air and liquid pressures and at flow rates of 50, 40 and 30 lpm through the generation chamber, the DOP particles have been found to have NMAD and GSD of 1.40 μm and 1.79; 1.23 μm and 1.77; 1.15 μm and 1.80 respectively. The liquid consumption has been measured to be 10 ml/hr.

Liquid aerosols coming out from the generation chamber enter a plenum chamber placed at the top of generation chamber and the improved virtual impactor. The improved virtual impactor is attached to the bottom of the plenum chamber from where the liquid particles enter it.

In the improved virtual impactor, small particles are removed by inertial separation and the separation is enhanced by employing a clean air core in the center of the acceleration nozzle of the impactor. Three sets of acceleration nozzles and collection probes have been used to carry out various tests on the aerosol generator. All the three sets have been utilized to evaluate the performance of the aerosol generator to produce particles with narrow size distribution.

To generate aerosols with narrow size-distribution, virtual impactor set I has been operated at a clean air flow rate (Q_c) of 16 lpm, chamber flow rate (Q_{ch}) of 50 lpm and minor flow rate (Q_m) of 7 lpm; virtual impactor set II has been operated at Q_c=17 lpm,

Q_{ch}=40 lpm and Q_m=6 lpm while virtual impactor set III has been operated at Q_c=15 lpm, Q_{ch}=40 lpm and Q_m=5 lpm. Particles generated by set I have been found to have NMAD of 1.83 μm, GMAD of 1.67 μm and GSD of 1.45; NMAD of 2.87 μm, GMAD of 2.58 μm and GSD of 1.41 for set II; NMAD of 2.70 μm, GMAD of 2.42 μm and GSD of 1.42 for set III.

The set I and set II have been used to investigate the size control of DOP particles with narrow size distribution. In set I, by controlling the solution strength from 5% to 100%, particles having NMAD from 1.54 μm to 4.07 μm have been produced. While by varying the minor flow rate from 11 lpm (16.41% of total flow) to 3 lpm (4.47% of total flow) in set II, NMAD of DOP particles has been found to vary from 1.9 μm to 3.86 μm. Also, the size of narrowly distributed DOP particles in minor flow has been varied from 2.86 μm to 1.83 μm by varying the chamber flow rate from 20 lpm to 50 lpm in set I.

The modified set I has also been used to carry out the parametric studies of the improved virtual impactor. The parameters which have been changed are: chamber flow rate, solution concentration, minor flow rate, ratio of probe diameter to nozzle diameter and ratio of nozzle-to-probe distance to nozzle diameter. It has been found that increasing solution concentration and decreasing the chamber flow and minor flow rates, increase the mean diameter of particles rapidly in minor flow. However, the effect of rest of the parameters mentioned above has been found to increase the mean diameter of particles to a lesser extent as they are increased. An analytical study has been carried out to correlate the above parameters to the size of particles generated in the minor flow and the results have been compared with the experimental results. The agreement has been found to be good.