The critical velocity of rebound determined for sub-micron silver particles

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Keywords: nanoparticle, bouncing, critical velocity, low pressure impactor

Particle rebound from a surface is a fundamental phenomenon in aerosol physics. Recently, it has been of interest in several fields of research, including atmospheric aerosols and aerosol synthesis. For instance, the amorphous solid state of biogenic SOA (secondary organic aerosol) particles was found by investigating the bounce behavior of the particles (Virtanen et al., 2012). The research on the particle–surface interaction in the field of engineered nanoparticles has been focused on the fragmentation and binding energy of agglomerates. However, one of the most important fundamental parameters in this respect, the critical velocity of rebound, has not previously been studied in a wide sub-micron size range.

A novel instrument, a variable nozzle area impactor is introduced to investigate the particle–surface interaction as a function of the particle impact velocity (Arffman et al., 2015). The impactor consists of a narrow slit with a small nozzle throat height, and the nozzle area can be varied by changing the slit length from 30 mm down to 3 mm. By decreasing the slit length, the impact velocity increases and a certain particle size chosen with a DMA can be scanned. The impactor stage and the filter stage placed downstream are connected to electrometers. After determining the critical slit length and the critical collection efficiency, the corresponding critical velocity can be calculated using computational fluid dynamics (CFD) simulations. In this study, the spherical silver particles were generated using furnace techniques and commercially available silver powder for different size ranges. The morphology of the particles was confirmed by electron microscopy and an effective density measurement. The effective density was also an important parameter in validating the model and simulations.

Finally, the critical velocity of rebound was determined for spherical silver aerosol particles in the size range of 20–1000 nm (Figure 1). The results show that the critical velocity of rebound decreases from 14 to 0.022 m/s as the particle size increases from 20 to 1000 nm. Furthermore, the critical velocity was found to be proportional to the power of –1.6 of the particle size, instead of the theoretical inverse proportionality. This result is in line with the previous studies for micron-sized particles (Wall et al., 1990). In the nanoparticle size range, the obtained critical velocity values are approximately 3 to 10 times greater than the recent literature values for silver particles (Rennecke & Weber, 2013). This discrepancy can most likely be explained by the different surface materials. All in all, our results give valuable information about the particle–surface interactions in the unexplored sub-micron size range.

Figure 1. The critical velocity of rebound as a function of the particle size for spherical silver particles and an aluminium substrate. The results are seen in relation to other previous studies for a variety of different particle and surface materials.

The authors acknowledge the TUT’s graduate school for financial support.


