443c Filtration of Submicron Particles by Agglomerates of Nanoparticles

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In the present work, agglomerates of nanoparticles are introduced as a filter media to remove submicron size particles (0.1 to 1 microns, solid and liquid) which are the most difficult to filter, and are commonly known as the most penetrating particle size (MPPS). Recent research conducted by our group revealed that a bed of nanoparticles in the dry state consists of porous agglomerates with a hierarchical fractal structure and a porosity of 0.99 or more. This structure results in a multi-modal pore size distribution within the loose agglomerates, and is very different from the uni-modal pore size distribution commonly found in commercial fiber-based HEPA filters that are widely used to filter MPPS. The large pores result in low hydrodynamic resistance, implying smaller pressure drop across the bed, and having pores as well as capture surfaces that are of a smaller size scale within the same filter bed, should result in a low penetration for MPPS as well as a high filter capacity. The nanoparticles used as a filter media are fumed silica, hydrophilic or hydrophobic, and carbon black. These powders consist of fluffy fractal agglomerates, less than 500 microns in size, which can be customized into thin filters to form a porous layer so that filtration occurs due to the cake filtration mechanism, providing very good collection efficiency. The powders can also be treated or processed, i.e., granulated or consolidated by vibration during sieving, to form granules ranging from 150 to 800 microns in size that can be customized into a granular bed. In this case, filtration occurs due to the deep bed filtration mechanism. It was found that the granulated bed provides a larger capacity than HEPA fiber based filters. Solid aerosol was generated by a powder disperser (Rodos by Sympatec Inc.), which was fed with SiC powder with an average particle size of about 0.6 microns. The aerosol concentration was measured using a time-of-flight particle analyzer, Aerosizer LD from TSI Inc.; measurements were taken upstream and downstream of the filter isokinetically at similar operating conditions. The customized filters were characterized during operation by their pressure drop and collection efficiency. The pressure drop across the filters was constantly monitored to determine its change with respect to time at certain aerosol loadings in order to evaluate filter's capacity by comparison against HEPA. The collection efficiency measured for particles larger than 0.3 um is 99.7%, about the same as HEPA fiber-based filters.