DESIGNING AND OPTIMIZING COMPOSITE FILTERS FOR HIGH EFFICIENCY, LOW PRESSURE DROP, AND HIGH LOADING CAPACITY PM2.5 FILTRATION

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Pleated electret HVAC filters are often used in residences and commercial buildings to mitigate the particles that originate both indoors and outdoors. However, there are two concerns on the performance of electret media: 1. low efficiency for particles in diameter of 10-30 nm at initial filtration condition, which represent the MPPS (most penetrating particle size), and 2. significant efficiency reduction during the loading process due to the shielding of fiber charge. In this study, a composite filter media composed of a main layer of HVAC electret media on the top and a thin layer of nanofiber at the bottom was prepared and tested for its PM2.5 removal. In the initial efficiency tests, monodisperse nanoparticles ranging 8-500 nm were used to challenge the media. It was found that the nanofiber layer can enhance the efficiency for the MPPS (10-30 nm) of electret media significantly. Under 5 cm/s face velocity, the efficiency for 20 and 300 nm particles was as high as 98.8% and 99.5%, respectively, when the pressure was as low as 25 Pa (or 1 mm Aq). In the loading performance, polydisperse NaCl particles which mimicked the size distribution of typical atmospheric PM2.5 were used to challenge the media. It was found the reduction of total efficiency was less than 10% for particles with sizes 50-500 nm. This reduction due to the shielding of fiber charge was much less than the sole application of electret layer (>50%) without adding nanofibers because the nanofiber layer acted as the safety guard to catch the penetrated PM2.5. This decent performance over the loading process was expected since the composite media made the full use of both the mechanical forces and electrostatic effects. Surprisingly, the overall loading FOM (figure of merit) of the composite media was close to that of electret media, indicating that there was only a minor tradeoff of pressure drop increase when adding the nanofiber layer. In addition to the above mentioned merits, this composite media facilitated a deeper PM2.5 depositions, making the use of whole layers of fibers, when they were gradually giving up their fiber charges layer by layer. This efficient utilization of whole layers of feature is never obtained by any other filter media. In conclusion, this type of combination provided a unique structure to take advantage of electret media and a nanofiber layer for high efficiency PM2.5 removal in the application of pleated HVAC and indoor air purifier filters.