

P1 CLEAN AIR WITH NOVEL NANOFIBER TECHNOLOGIES

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Gaseous and particulate pollutants have been responsible for smog and chronic health problems. In filtering particulates or aerosols, high filtration efficiency is often accompanied by adverse high pressure drop, and vice versa. A suite of nanofiber filtration technologies has been developed by our group that offers high filtering efficiency while maintains low pressure drop. Low pressure drop means reduced energy consumption in filter operation and high breathability for personal face mask. 200-nm diameter nanofibers, distributed in thin multiple layers (referred hereafter as multilayer) separated by permeable support, can achieve high filtration efficiency yet low pressure drop as compared to installing the same amount of nanofibers all in a single filter layer. “Road tests” revealed extremely high concentration of harmful 100nm nanoaerosols emitted from traffic emissions and atmospheric photochemical reactions in Hong Kong. Our multilayer filter achieves at least 75% capture efficiency of these real nanoaerosols for people at rest and 60% for people engaging in heavy activities. The multilayer technology has been licensed to a start-up company creating jobs and producing nanofiber face masks supplying the global needs in protecting public health. To-date over 2 million nanofiber masks have been sold. Electrostatic charged nanofibers have been developed first time that further induce dipoles on neutrally charged aerosols with subsequent capture of these aerosols by the added electrostatic force; this significantly enhances filtration efficiency without additional pressure drop. It is extremely advantageous for capturing negatively charged airborne viruses, especially during flu virus outbreak. For long-term heavy aerosols loading, a microfiber filter layer added to the nanofiber layer can further enhance the performance of the composite filter with low pressure drop and excellent capture of nanoaerosols from initial filtration (due to downstream nanofiber layer) to subsequent surface/cake filtration (due to upstream microfiber layer). The composite filter finds important applications in airplane/train/vehicle cabins, hospital wards, offices, and auditoriums. We have also developed exclusively backpulse-backblow technology to clean loaded nanofiber filters for filter reuse.

Novel nanofiber-based photocatalysts have been developed by our group to break-down/convert harmful gases, such as NO_x and formaldehyde to harmless CO₂ and H₂O. The photocatalysts are made of TiO₂ and other semiconductors that work synergistically to harvest effectively visible light producing radicals to oxidize gaseous pollutant molecules and viruses/bacteria adsorbed onto the photocatalyst surface. The surface area is enhanced with 10-nm sized nano-crystallites coated on the nanofiber. To reduce electron-hole recombination which limits photocatalyst performance, rolled up graphene sheets eliminating edge effect, are embedded in the TiO₂ nanofibers of only 80nm diameter. This novel configuration enhances electron transfer that produces the needed radicals along the nanofiber for photocatalytic oxidation of gaseous pollutants, viruses and bacteria. For NO_x and formaldehyde conversion, our new TZBG nanofiber photocatalyst demonstrates superior performance, respectively, 7X and 3X better than the gold standard P25(25-nm TiO₂ nanoparticles). Most usefully, the nanofiber technologies on filtration of aerosols and purification of harmful gases can be combined in a multilayer filter-purifier to clean dirty air surrounding us. Our work has been published in 25 SCI papers in high impact journals and 4 issued United States patents.