Abstract

Characterizing transport and capture of finely divided dispersed phase on fibers and meshes: From filtration to fog harvesting

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The technologies of filtration and fog harvesting share a common challenge: designing meshes and filters that ensures high capture efficiency, minimal pressure drop, and are resistant to clogging. Dense meshes enhance deposition efficiency but increase pressure drop and clogging, while sparse meshes reduce pressure drop at the cost of filtration efficiency. Tackling these challenges involves understanding the interaction of dispersed liquid droplets passing through mesh fibers. This study has two key components on study of dispersed-phase transport and separation. The first one numerically characterizes dielectrophoretic (DEP) deposition of airborne, micron-sized water droplets on cylindrical fibers electrodes, using a 3-phase applied voltage. The effects of inertia, viscous drag and DEP forces, and Brownian motion on droplet trajectories are characterized, identifying the conditions for high filtration efficiency with minimal pressure loss. These findings offer guidelines for designing tunable, efficient DEP-based filtration systems suitable for healthcare, face masks, air filters, and industrial applications. The second part addresses strategies of cooling tower fog harvesting, using wettability-engineered metal meshes, sustainable method curbing water footprints of power plants. Conventional meshes used for fog harvesting often face clogging, poor drainage, and reduced collection efficiency. This study optimizes parameters like mesh pitch, shade coefficient (*SC*), and fiber wettability through numerical simulations and experiments. Simulations predict droplet morphology on fibers with different radii and wettability, validated by experiments. Findings define optimal parameters for clog-resistant, efficient fog harvesting meshes. For fibers with diameters exceeding the capillary length, wettability has minimal impact on efficiency, while overall efficiency decreases with larger fiber diameters due to reduced deposition efficiency. An optimal *SC* of 0.52 is identified for clog-resistant designs, providing a baseline for developing high-efficiency fog harvesting systems.