A microfluidic model of the pulmonary acinus for studying particle dynamics and deposition

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Particle dynamics and deposition in alveolated lung airways are widely studied using numerical methods (Sznitman, 2013), and up scaled experimental models (Ma 2009). However, up scaled models do not capture diffusional effects, which are critical for submicron particles.

Here, we present a novel microfluidic device mimicking breathing acinar flow conditions directly at the physiological scale. The model (Fig. 1) features an anatomically-inspired acinar geometry with five dichotomously branching airway generations lined with periodically expanding and contracting alveoli. Deposition patterns of airborne polystyrene microspheres (spanning 0.1 µm to 2 µm in diameter) inside the airway tree network compare well with CFD simulations and reveal the roles of gravity and Brownian motion on particle deposition sites. Furthermore, measured trajectories of incense particles (0.1-1 µm) inside the breathing device show a critical role for Brownian diffusion in determining the fate of inhaled sub-micron particles by enabling particles to cross from the acinar ducts into alveolar cavities, especially during the short time lag between inhalation and exhalation phases.

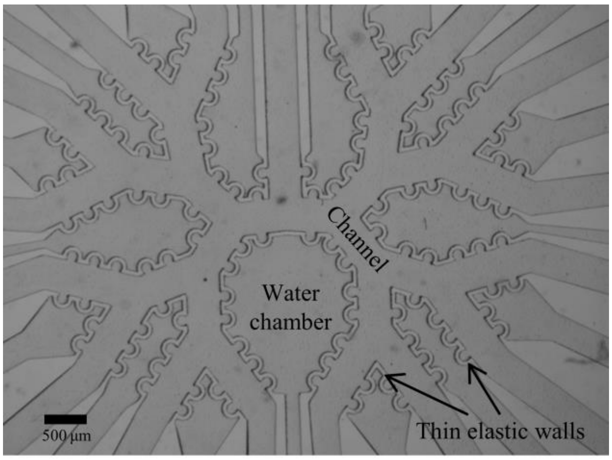

Figure 1. Microfluidic acinar model. Thin and elastic PDMS walls separate the alveolated airways from the surrounding water chambers. By changing the pressure of water within the chambers the walls are periodically deformed, mimicking a physiological breathing motion.

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