Electrophoretic Focusing and Navigation for Intranasal Target Drug Delivery

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Abstract

Direct nose-to-brain drug delivery circumvents the blood-brain-barrier and has multiple advantages over conventional intravenous delivery. However, demonstration of its clinical feasibility is still in adolescence due to the lack of effective devices which can directly deliver medications to the olfactory epithelium. Previous studies [1,2] have shown that less than 0.5% of nasal-inhaled particles could reach the olfactory nerves which are secluded in the up most nasal cavity (Fig. 1). Therefore, it is of critical significance to search for drug-delivery strategies that can effectively deliver drugs to the olfactory region directly.

This study systematically evaluated the feasibility and effectiveness of targeted drug delivery with electrophoretic forces in a 2-D nose model. The influences of electric fields-, drug-release positions, particle sizes and initial velocities were examined and compared. Results of this pilot study hereof have implications for the development of effective intranasal drug delivery devices that target at olfactory epitheliums.

COMSOLl Multiphysics® AC/DC, CFD, and Particle Tracing Modules were used to simulate the effect of static electric field arrangements, particle initial velocity, particle size, and particle mass to the direct delivery.

Different geometric models as shown in fig 2 and 3 were made in COMSOL Multiphysics. With the AC/DC electromagnetic module, different electric potentials were added to different parts of the geometry as boundary conditions. The flow of the small charged drug particles was traced with the CFD and Particle Tracing Modules of COMSOL. The feasibility of precise particle guidance with various delivery protocols (Fig. 2, 3) were developed with COMSOL simulation. An ideal 2D nose model made in Solidworks was imported into COMSOL and the micro-particle electrophoretic motion in it was simulated and traced. Critical design parameters of the delivery parameters such as electrode layout, voltage frequency, and voltage magnitude variation were obtained that enabled us to develop a prototype of delivery platform (Fig. 3).

Reference

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Figures used in the abstract

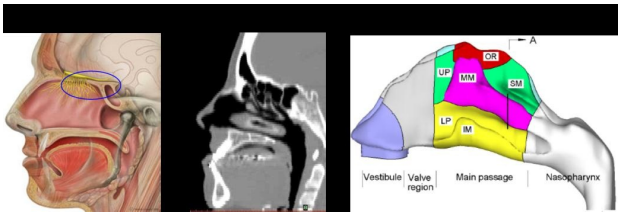

Figure 1: Nasal airway physiology: (a) anatomy; (b) MRI scan; and (c) surface model geometry.

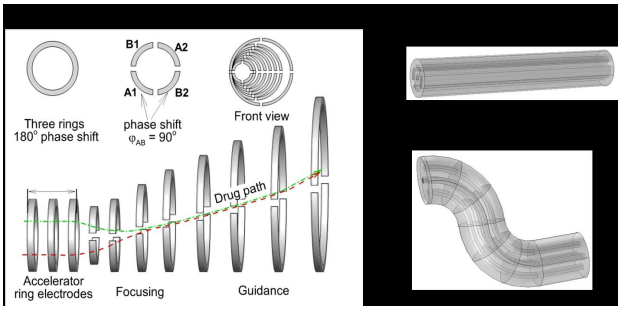

Figure 2

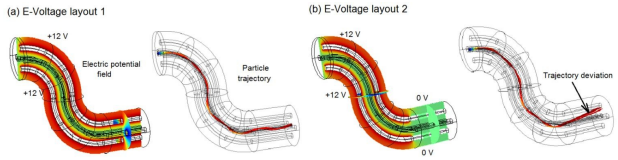

Figure 3: Electric filed and particle trajectories within the quadrupole with varying electrode voltage layouts.