Biomimetic Capture of Odorant Molecules in a Microfluidic Device

E. Tulukcuoglu Guneri[a], T. Alava[a], Y. Fouillet[a], J. Casas[b]
CEA LETI MINATEC Campus, Univ. Grenoble F-38054 Grenoble, France
[b]*Institut de Recherche sur la Biologie de l'Insecte, IRBI CNRS UMR 7261 Faculté des Sciences, Université de Tours, F-37200 Tours, France*

Key words: biomimetic, odorant uptake, olfactory mucus

Olfactory system demonstrates a remarkable capability of detecting extremely low concentrations of molecules at the range of parts-per-trillion and discriminating thousands of odor molecules [1, 2]. Following steps are involved in perceiving the odors via the olfactory system: lateral transport of airborne odorants molecules in the olfactory region, partial uptake at the air-mucus interface, diffusion through the mucus layer and potential interaction with mucus and finally binding to olfactory receptors triggering neuronal stimuli thereby leading to processing information and discrimination of odors.

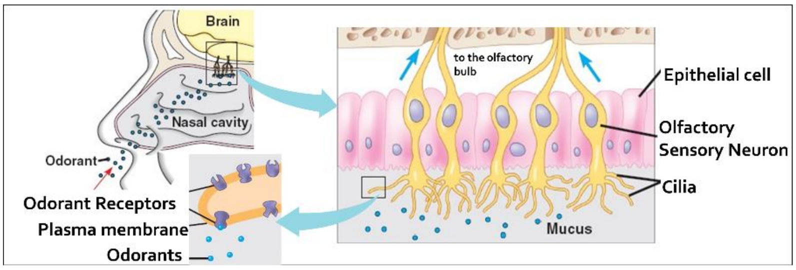

Figure 1: Scheme of a human olfactory system (image adapted from a figure in http://bio1151b.nicerweb.net/Locked/media/ch49/smell.html)

Olfactory system has been inspiring the development of systems for gas detection. For example, PDMS and agarose gel has been used to concentrate the gas molecules [3, 4] for subsequent detection analysis. A microfluidic system used water as a concentration layer mimicking the dimensions of the mucus layer in mammals [5]. Another biomimetic approach studied the role of the odorant binding proteins in odorant uptake using physiological conditions in human [6].

Despite its prevalence, the role physicochemical properties of olfactory mucus on olfaction is yet to be explored and olfactory mucus has not been a source of bio-inspiration. Here, we propose to develop a miniaturized the olfactory system recapitulating biomimetic olfactory mucus and nasal air flow using microfluidics. We are interested in studying spatial and temporal distribution of odorant uptake on the olfactory mucosa in which flow rate of the nasal air, solubility and diffusivity odorants in the mucus, thickness of the mucus, and potential interactions of odorant molecules with the components of the mucus are the key parameters effecting odorant uptake [7]. Hence, this study may uncover novel strategies for future sensor designs using bioinspired materials.

References

[1] Keller A. et al , Human olfactory psychophysics., Current Biology ,Vol 14, No 20, pp 875-878 (2004)
[2] Bushdid C. et al, Humans Can Discriminate More than 1 Trillion Olfactory Stimuli, Science, Vol. 343, pp 1370-1372 (2014)
[3] Olfaction-Inspired Sensing Using a Sensor System with Molecular Recognition and Optimal Classification Ability for Comprehensive Detection of Gases
[4] Fujii S., Pesticide vapor sensing using an aptamer, nanopore, and agarose gel on a chip, Lab Chip, Vol 17, pp 2421-2425 (2017)
[5] Piorek B, Free-surface microfluidics/surface-enhanced Raman spectroscopy for real-time trace vapor detection of explosives, Analytical Chemistry, Vol 84, pp 9700–9705 (2012)
[6] Yabuki M., Dynamics of Odorant Binding to Thin Aqueous Films of Rat-OBP3. Chemical Senses, Vol 36, pp.659-671 (2011)
[7] Hahn I. et al, A mass transport model of olfaction, J Theor. Biol. Vol 167, pp115-128 (1994)