Machine learning enhanced 2D nanomaterials based electronic olfaction sensors and applications

Shirong Huang [1], Gianaurelio Cuniberti [1]
1Institute for Materials Science and Max Bergmann Center for Biomaterials, TU Dresden, 01062 Dresden, Germany
Email: shirong.huang@tu-dresden.de

Among our five human senses, sight, hearing, and touch have been highly digitized, while smell and taste remain in the nascent stages of digitization. Inspired by the biological example, gas sensors in combination with efficient machine learning algorithms aim to achieve similar performance and thus to digitize the sense of smell. Despite the significant progress of e-noses, their compactness still remains challenging due to the complex layout design of sensor arrays with a multitude of receptor types or sensor materials, and the high working temperature. In this talk, we present the development of machine learning-enabled graphene-based single-channel electronic olfaction (e-olfaction) sensors and propose a methodology to evaluate their olfactory performance. We selected four VOC-based odors, namely eucalyptol, 2-nonanone, eugenol, and 2-phenylethanol, which are widely used in human olfactory performance assessment. We achieved a low odor detection limit of 4.4 ppm (for 2Phe) and high odor discrimination (83.3%) and identification (97.5%) accuracies. Both molecular dynamics simulations (MDS) and density functional theory (DFT) were employed to elucidate the adsorption interaction between odorant molecules and sensing materials. Our work demonstrates that the developed e-olfaction exhibits excellent olfactory performance in sniffing out VOC-based odors. This work could facilitate miniaturization of e-noses, digitization of odors, and distinction of volatile organic compounds (VOCs) in various emerging applications, such as molecular discrimination, food quality identification, disease diagnosis, etc.

Keywords: machine learning, gas sensors, electronic nose, gas detection, gas recognition

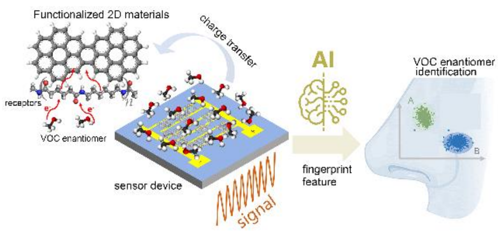

Fig. 1 Scheme concept of electronic olfaction sensors

References

[1]. Shirong Huang, et al. Applied Physics Reviews 10.2 (2023).
[2]. Alexandra Parichenko, Shirong Huang et al. TrAC Trends in Analytical Chemistry (2023)
[3]. Shirong Huang, et al. Advanced Intelligent Systems 4.4 (2022)
[4]. Shirong Huang, et al. Carbon 173 (2021)