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Editorial

Bioinspired Chemical Sensors and Micro-Nano Devices

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1. Introduction

Biological smell and taste systems can recognize the specific chemical signals presented by various odorants and taste substances with extremely high performance, which cannot be achieved by current artificial devices. With the rapid advancement in micro/nano-technologies and olfactory/taste signal transduction mechanisms, bioinspired smell and taste sensors have been increasingly recognized as promising candidates for the development of the next generation of chemical sensors. Significant progress has been achieved due to the utilization of novel micro/nano devices, biological/nano materials, and configurations, which has allowed for huge improvements in chemical sensing performance. For this reason, we are publishing this Special Issue, dedicated to the most recent developments and applications of bioinspired smell and taste sensors.

2. The Special Issue

This Special Issue is a collection of nine excellent original articles and one review, all dedicated to the development and application of bioinspired smell and taste sensors.

Nath et al. used a potentiometric E-tongue equipped with a sensor array that had seven chemically modified field-effect transistor sensors to compare the level of bitterness of milk-protein-derived peptides [1]. The measurement results show that the bitterness of peptides in tryptic-hydrolyzed liquid milk protein concentrate (LMPC-T) was increased with the increase in the concentration of trypsin. The potential application of the E-tongue using a standard model solution with quinine was shown to follow the bitterness of peptides.

Liu et al. reported a taste bud organoid-based biosensor for the study of taste sensation [2]. A microelectrode array (MEA) chip was used to simultaneously record multiple neuron-firing activities from taste bud organoids prepared from newborn mice. The results show that taste cells form spherical structures composed of multiple cells with obvious budding structures. The MEA chip could efficiently monitor the electrophysiological signals from taste bud organoids in response to various taste stimuli. This biosensor provides a new method for the study of taste sensations and taste bud functions.

Vahidpour et al. introduced an interdigitated electrode (IDE)-based enzyme biosensor for the detection of H_2O_2 vapor/aerosol at low concentrations towards the sterilization of equipment in the medical industry [3]. An enzymatic membrane of horseradish peroxidase that is selective towards H_2O_2 was utilized as a sensitive element. Changes in the IDEs' capacitance values under H_2O_2 vapor/aerosol atmosphere proved the detection in the concentration range up to 630 ppm with a fast response time (<60 s), no humidity cross-sensitivity and high repeatability. This method provides a new approach for evaluating sterilization assurance in the medical industry.

Yuan et al. explored an in vitro HL-1 cardiomyocyte-based olfactory biosensor by combining cardiomyocytes with microelectrode array (MEA) chips for screening the potential antagonists of the Olfr558 [4]. The results indicate that this biosensor could specifically respond to the ligands of Olfr558. In addition, β-damascenone greatly inhibited Olfr558, while citral showed no significant inhibitory effect. This biosensor has great potential to assist odor-related companies to develop novel antagonists of Olfr558.

Jiang et al. explored a light addressable potentiometric sensor (LAPS)-based microphysiometric system integrated with a Transwell insert and microfluidic chip for monitoring bacterial metabolism [5]. The measurement results show that the decrease in pH caused by glucose fermentation in *Lactobacillus rhamnosus* could be successfully achieved. This proves the feasibility of the system for the metabolic detection of non-adhering targets such as microorganisms, and even 3D cells and organoids.

Qin et al. reported a cell co-culture taste sensor using different proportions of Caco-2 cells and SH-SY5Y cells that endogenously expressed the human T2R38 receptor and T2R16 receptor, respectively [6]. Seven mixtures with [Caco-2]/([Caco-2] + [SH-SY5Y]) ratios of 0, 20, 40, 50, 60, 80, and 100% were designed and seeded on the 16 E-plates of the electric cell–substrate impedance sensor (ECIS) for bitterness detection. The measurement results show that continuous evolution profiles (CEP) show a negative correlation property after the activation of T2R16 ligands. However, when stimulated with compounds that could activate both T2R16 and T2R38, different response patterns are shown.

Ye et al. focus on clarifying the effect of concentrations and types of metal ions in the conditioning solution on the response mechanism of the sweetness sensor GL1, which can evaluate the sweetness of sugars and sugar alcohols, and is commercially available for the food, beverage, and pharmaceutical industries [7]. According to the different concentrations and types of metal ions in conditioning solutions, the complex formation and the hydrated radius were considered to influence the membrane potential measured in a reference solution and the sensor responses. This could help to elucidate the response mechanism and improve the selectivity and sensitivity of the sweetness sensor.

Gu et al. reported a layered Au/SnS2 nanosheet-based chemiresistive-type sensor using an in situ chemical reduction method followed by the hydrothermal treatment [8]. The results show that the response of this sensor to 4 ppm NO_2 at 120 °C was 65% higher than that of the pristine SnS_2 (2.39)-based sensor. Moreover, the response/recovery time was also significantly improved. The sensor presents a favorable long-term stability and a brilliant selectivity for several possible interferents. The "catalysis effect" and "spillover effect" of noble metals jointly improved the sensitivity of the sensor and effectively decreased the response/recovery time.

Liu et al. explored an odor-sensing system with chemosensitive resistors to identify the gases generated from overheated cables in order to prevent fire [9]. The results show that this system could distinguish among three cable samples at 270 °C with an accuracy of approximately 75%. Furthermore, the system could achieve a recall rate of 90% and a precision rate of 70% when the abnormal temperature was set above the cables' allowable conductor temperature of 130 °C. This system could effectively detect the abnormal heating of the cables before the occurrence of fire, which is helpful for fire prediction and detection systems in factories and substations.

Finally, Liu et al. assembled a comprehensive review of the applications of the light-addressable potential sensor (LAPS) as a multi-functional platform for chemical and biological sensing in recent decades [10]. The basic principle of LAPS and the general configuration of a LAPS measurement system are highlighted. The most recent applications of LAPS in chemical sensing, biosensing, and cell monitoring are outlined. The development trends of LAPS in terms of material and optical improvement are proposed and discussed, which provide research and application perspectives of LAPS for chemical sensing, biosensing, and imaging technology.

In conclusion, the original articles and review published in this Special Issue provide new insights into the development and applications of bioinspired smell and taste sensors. Some interesting examples and exciting advances are presented, which indicate the potential of integrating micro/nano-fabricated electronic devices with functional sensitive bio-materials for chemical sensing. This could help to attract increasing interest in the area, encouraging new research efforts from the scientific community.

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