Development of Electronic Nose for Evaluation of Fragrance and Human Body Odor in the Cosmetic Industry

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***Abstract*—In this study, we have developed a gas sensor array and electronic nose (e-nose) for evaluation of fragrance and human body odor. We proposed the use of these sensors together with artificial intelligence to track the body odor for personalized beauty. Results showed that these gas sensors and e-nose system can evaluate fragrance, artificial sweat and water. These observations have revealed that the e-nose can be a potential gadget for fragrance profiling as well as for the selection of the best suitable fragrance for individual person.**

Keywords*— *Body odor, Gas sensor array, Personalized fragrance, Cosmetic application.

I. INTRODUCTION

Nowadays, the detection of odors by using electronic nose (e-nose) has been applied to many industrial applications including environmental monitoring [1], quality control of food products [2], and detection of toxic gases or security [3]. Moreover, there have been increasing interests in the cosmetic applications, i.e., measurement of human body odor [4-5]. In general, people generate unique patterns of body odor and use the fragrance to protect body odor and become more confident. The fragrance contains several volatile compounds and it is quite complex as it has a broad range of aroma profile. The human nose of a general consumer may not distinguish the smell, so they cannot decide whether the smell is suitable for them or not.

Thus, we design an idea to use an e-nose for discrimination of perfume and body odor. People will be able to select the suitable fragrance for themselves and the body odor profiles can be known by using this e-nose. Furthermore, it can be applied in the near future not only for the cosmetic applications but also for the healthcare applications [6].

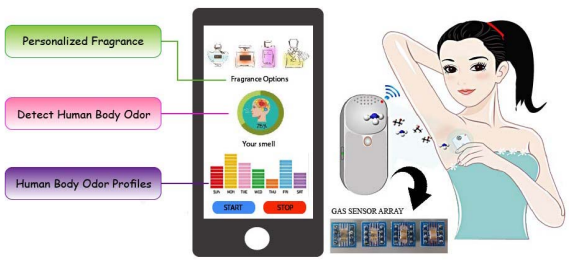

Fig 1. The concept of gas sensor array, electronic nose system and personalized beauty for cosmetic industry.

In the present study, we have proposed a novel concept to use a gas sensor array comprising four sensors being developed for this purpose to evaluate the fragrance, artificial sweat representing the human body odor, and water as shown in Fig. 1. This work is hoped to open the door in field of the cosmetic industry in the future.

II. MATERIALS AND EXPERIMENTAL

A. Materials

Polymer	Functionalized Carbon nanotube
Poly (4-Styrenesulfonic acid) Solution	SWNT-COOH
Cumene terminated polystyrene-co-maleic anhydride (Cumene-PSMA)	SWNT-COOH
Poly (styrenecomaleic acid) partial isobutyl/methyl mixed ester (PSE)	SWNT-OH
Polyvinylpyrrolidon (PVP)	SWNT-NH_2

The gas sensors were fabricated using four types of polymers, namely poly(4-Styrenesulfonic acid) solution, Cumene terminated polystyrene-co-maleic anhydride (Cumene-PSMA), poly (styrenecomaleic acid) partial isobutyl/methyl mixed ester (PSE), and poly vinylpyrrolidon (PVP), composited with functionalized single-walled carbon nanotube (90 wt%). The fabrication of these sensors folllowed the previous work[7] by spin coating on the electrodes.

B. Experimental

The e-nose used in this study was equipped with an array of 4 composites gas sensors as shown in Table1. The testing conditions are as mentioned, carrier gas: nitrogen, flow rate: 160ml/min., injection volume: 1µl. The samples were measured for 1min and repeated for 5 times. The results were chosen from the average raw data of measurements and were processed by the principal component analysis (PCA).

III. RESULTS AND DISCUSSION

A. Evaluation of Fragrance, Artificial Sweat, and Water.

We tested the fragrance (Linalool), artificial sweat, and water with 4 gas sensor arrays in the e-nose system. The four

gas sensors can detect odors and yield different signals depending on the structure of polymer and functional groups of carbon nanotube. As a result, each sensor produced different signals and the reaction strengths to different types of odors as shown in Fig. 2. The PVP – NH_2 yields the best response with fragrance and its sensing response with artificial sweat and water is higher than that of the other sensors. The composite gas sensors which contain functionalized carboxylic group of carbon nanotube (4-Styrenesulfonic acid - COOH and Cumene-PSMA – COOH) showed the similar sensing response pattern for all samples.

In addition to preliminary experiment, we simulated the decaying smell of a fragrance under the passage of time. The smell of a fragrance drops with a volume of 1 µL was measured using the PVP – NH_2 sensor for 30, 60, 90, 120, 150, 180 min (Fig. 3) after be dropped into an open small vial. The result shows that e-nose can detect evaporation of the fragrance that simulates the fragrance left on the human skin or clothe. Thus, the e-nose can be a useful gadget for personalized fragrance determination.

B. Discriminant Classifications by Principal Component Analysis (PCA)

Fig.4 shows the pattern recognition based on principal component analysis (PCA) in which the fragrance, artificial sweat, and water data can be classified clearly. Moreover, we have shown the results from the e-nose measurement of the human body odor from 2 healthy female volunteers. The results evidently show that people have distinguished individual body odor.

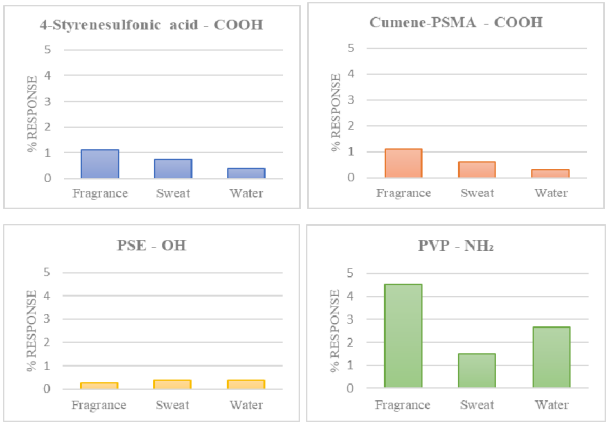

Fig 2. The sensing response of four nanocomposite gas sensors when exposed to fragrance, artificial sweat and water.

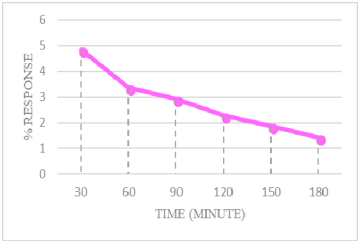

Fig 3. The sensing response of PVP-NH_2 polymer gas sensor when exposed to fragrance that simulate the decaying smell of fragrance.

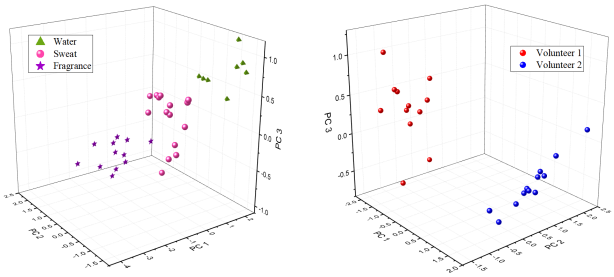

Fig 4. (a) PCA on the smell of fragrance, artificial sweat, and water. (b) PCA of the human body odors obtained from 2 female volunteers.

IV. CONCLUSION

In this work, we demonstrate the successful development of the composite gas sensors array to evaluate fragrance and human body odor by electronic nose which can be useful in the cosmetic industry. These four lab-developed sensors can respond and generate fingerprints of each sample due to different sensing materials. The PVP – NH_2 sensor shows the highest response to fragrance. The results also show that the composite gas sensors have specific pattern with each sample and it has capability to discriminate fragrance, artificial sweat and water. Eventually, we hope that this technology will be very useful for providing personalized fragrance for individual person and helping them to control their body odor levels.

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