Development of malodor monitoring system based on electronic nose technology

Theerapat Pobkrut[1], Satetha Siyang[2], Treenet Thepudom[2] and Teerakiat Kerdcharoen[1,*]

Abstract— **Odor can affect human health both directly and indirectly specifically malodor. In this work, the portable electronic nose is developed for environmental experiment and it can clearly classify characteristic of each odor source in the factory. Using a zero-grade air as a reference gas and reforming mechanisms of sample testing electronic nose can improve accuracy and efficacy including reduce time of experiment for environmental application. Therefore, this electronic nose can be used for finding the source of malodor that disturb the surrounding villager. The environmental electronic nose can apply to be the internet of things (IoT) device for remotely monitor the odor around the factory and in the village in the future.**

I. Introduction

Electronic nose, also known as E-nose, is wildly used in many fields with related to the smell such as food, beverage, healthcare, agriculture, cosmetic industry, and etc. E-nose consists of the array of gas sensors which can detect wildly volatile in the air or odorous samples. The interaction between gas sensors and target volatiles is comparable to the interaction of human olfactory cells and these reactions cause the change of electrical property, resistance, of the gas sensors. The processing unit of E-nose system detects the electrical property changes of each gas sensor and analyze these data to classify and recognize the kind or sort of that volatile [1]. These processes are the same in human mechanism to recognize the smell [2]. Generally, the principal component analysis (PCA) is used to analyze the odor data of E-nose to classify characteristic of each smell [3]. Among of various materials of gas sensors, metal oxide semiconductor (MOS) is the most reliable and popularity because of their high responsibility and reversible property. However, the most important problem of MOS gas sensor is their high-power consumption to heat the sensing material that has an operating temperature around 250 – 500 °C [4].

Using E-nose in environmental applications is an interesting topic because capability of discriminating and recognizing between variety kind of smells and odors. There are such applications in environment field that E-nose can use such as analyze odor data that cause from abnormal process control or odor control systems malfunction and also use for environmental air quality. Recently, Internet of Things or IoTs play an important role in the development of industrial technology to improve the efficacy of the machines [5]. The combination of Internet of Things, wireless sensor network and electronic nose will enable the factories to monitor the air quality around the factory and increase the quality of life of people nearby.

II. Current results

Zero-grade air is used to be a reference gas in the environmental application of electronic nose technology. Because it can reduce noise from surrounding air such as contaminant air, humidity, temperature, wind, etc. which can cause the noise in measurement. The result of improvement is shown in Fig 1. The environmental E-nose experiment is setup at 8 places in the factory including inside and outside factory to measure odor from each odorous source sample and compare the odor from factory and the odor in the villages. Sample air is measured for 45 seconds and 150 seconds is set for reference air. The odorous sample is collected by the vacuum pump through 10 m rubber tube from odorous source to the E-nose. Flow rate of air through E-nose system is controlled by the mass flow controller which is 1 liter/minute. The data are sent to monitoring laptop via USB port to collect and save as a raw data to analyses further.

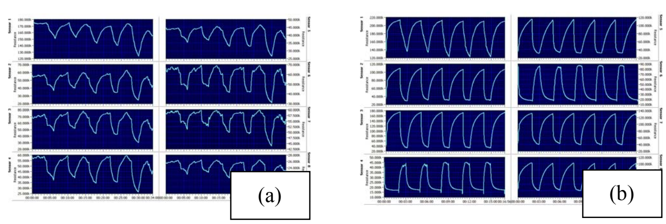

Figure 1. (a) Electronic nose signal without zero grade air be reference signal, (b) Electronic nose signal with zero grade air be reference signal.

TABLE I. List of semiconductor gas sensors

Sensor	Target gas	Sensor	Target gas
TGS 821	Hydrogen gas	TGS 2600	Air contaminants
TGS 822	Organic solvent vapors	TGS 2602	Air contaminants
TGS-825	Hydrogen sulfide	TGS 2610	LP gas

*Research supported by Center of Nanoscience and Nanotechnology.

Teerakiat Kerdcharoen Author is with the Department of Physics and Center of Nanoscience and Nanotechnology, Faculty of Science, Mahido University, Bangkok 10400, Thailand. (corresponding author to provide phone: +6683 2454499; fax: +662201 5843; e-mail: teerakiat@yahoo.com).

Theerapat Pobkrut Author, is with Department of Physics, Mahido University, Bangkok 10400, Thailand. (e-mail: T.pobkrut@gmail.com).

Satetha Siyang, and Treenet ThepudomAuthor are with Materials Science and Engineering Programme, Faculty of Science, Mahidol University, Bangkok 10400, Thailand (e-mail: S.satetha@gmail.com and T.thepudom@gmail.com)

Sensor	Target gas	Sensor	Target gas
TGS 826	Ammonia	TGS 2620	Solvent vapors

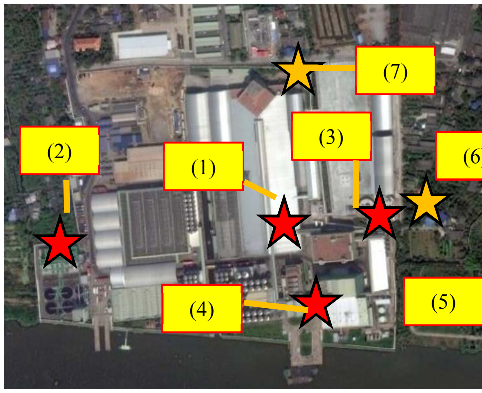

Figure 2. The location of mesurement places in and outside factory which are (1) Sump No.5, (2) Waste water treatment, (3) Stack of the boiler which is using LPG and fuel oil as a fuel, (4) Stack of Multi-wet scrubber of boiler room, (5) Spent grain silo, (6) The village nearby factory, and (7) The market in front of factory.

The first measure is setup in 6 places in the factory which are (1) Sump No.5, (2) Waste water treatment, (3.1) Stack of the boiler which is using LPG as a fuel, (3.2) Stack of Boiler which is using fuel oil as a fuel, (4) Stack of Multi-wet scrubber of boiler room, and (5) Spent grain silo. The result of measurement is shown in Fig.3.

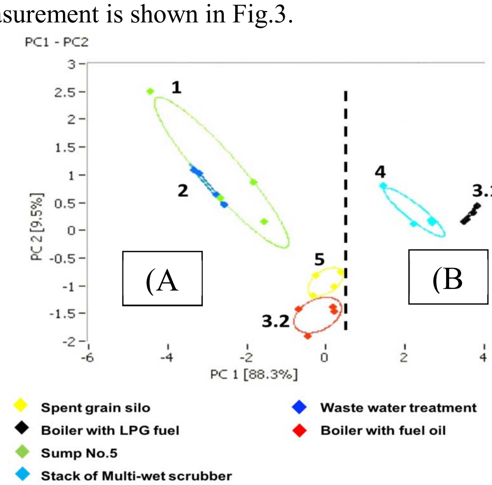

Figure 3. Two-dimensional plot of PCA of 6 odor sources in the factory

Fig. 3 demonstrates that the odor from the factory can separate into two groups which are (A) Strong odor group, and (B) Light odor group which is according to the human test. The PCA result of odor of Sump No.5 and waste water treatment are grouping because these two sources are in the same processes which the water from Sump No.5 flow through the waste water treatment later.

The second experiment is setup in the same 6 places in factory and the addition places outside factory which are (6) The village nearby factory, and (7) The market in front of factory. The result of measurement is shown in Fig. 4.

Fig. 4 demonstrates that the odor from the factory and the odor outside factory can clearly classify. Furthermore, the odor characteristic of (3.2) Boiler with fuel oil and (5) Spent gain silo are grouping because these two places are located nearby.

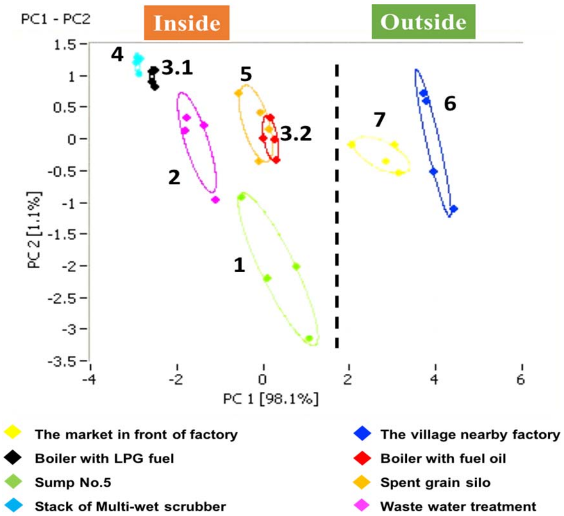

Figure 4. Two-dimensional plot of PCA of 6 odor sources in the factory and 2 places outside factory

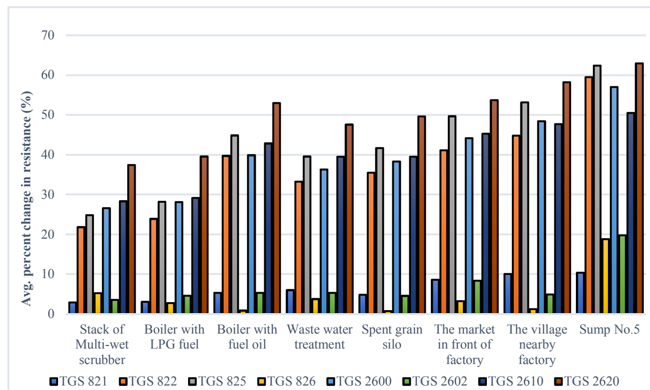

Figure 5. The average percent change in resistance of 8 semiconductor gas sensors which are used in the electronic nose

Fig.5 shows that the average percent change in resistance of the odor from (1) Sump No.5 is the highest among the other sources and the which are similar to human test that the odor from Sump No.5 is the strongest.

References

[1] K. Persaud, "Chapter 1 - Electronic Noses and Tongues in the Food Industry," in *Electronic Noses and Tongues in Food Science*, 2016, pp 1-12,

[2] S. Deshmukh, R. Bandyopadhyay, N. Bhattacharyya, R.A. Pandey and A. Jana, "Application of electronic nose for industrial odors and gaseous emissions measurement and monitoring – An overview," in *Talanta*, vol. 144, 2015, pp. 329-340.

[3] C. Wongchoosuk, A. Wisitsoraat, A. Tuantranont and T. Kerdcharoen, "Portable electronic nose based on carbon nanotube-SnO2 gas sensors and its application for detection of methanol contamination in whiskeys," in *Sensors and Actuators B*, vol. 147, 2010, pp. 392-399.

[4] G. F. Fine, L. M. Cavanagh, A. Afonja and R. Binions, "Metal Oxide Semi-Conductor Gas Sensors in Environmental Monitoring," in *Sensors*, vol. 10, 2010, pp. 5469-5502.

[5] J. M. Talavera, L. E. Tobón, J. A. Gómez, M. A. Culman, J. M. Aranda, D. T. Parra, L. A. Quiroz, A. Hoyos and L. E. Garreta, "Review of IoT applications in agro-industrial and environmental fields," in *Computers and Electronics in Agriculture*, vol. 142, 2017, pp. 283-297.