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The Electronic Nose

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Electronic Nose (eNose) is a device used to detect and recognize odours/vapours, i.e. a machine olfaction device with an array of chemical sensors.

"An electronic nose is an instrument which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern recognition system, capable of recognizing simple or complex odours"

The most common use at the present time for the eNose is within the food and drink industries. In addition to this field, eNose can be used in other areas such as petroleum qualitative and quantitative analysis, detection of explosives, classification and degradation studies of olive oils, development of a field odour detector for environmental applications, quality control applications in the automotive industry, discrimination between clean and contaminated cows' teats in a milking system, cosmetic raw materials analysis, plus many other important areas such as in the medical and space fields.

The principle of eNose is that it uses an array of sensors, whether in the form of different types of polymers or via the use of metal oxide semi conductors, the principle here is still the same.

When molecules from any element deposited on the surface of the sensor, the electrical conductivity changes, as and when the surface expands. This is the basic idea of how eNose works i.e. change of the sensor resistance when the sensor exposed to odours/vapours.

The pattern displayed on the monitor for each particular resistance is unique (i.e. the type of odour or vapour of a particular sample). In this way it is possible to distinguish a sample from another or the state/condition of the sample itself, as the headspace from each sample has a unique signature on the eNose sensors resistance.

Brief History

It is difficult to pin point the exact date of "when and how" the idea of designing a system, which can mimic the human nose, came about. However, the following dates with devices give a better understanding of how the design progressed for a machine olfaction devices (MOD) system. The MOD design led eventually for the conceptualisation of the eNose.

Please note that an eNose differ from other types of MOD by simply having multiples sensors, while other devices may have one sensor only or simply the mechanism itself differ substantially from the eNose basic working principles.

The name MOD, therefore, cover devices such as eNoses i.e. devices with multiple sensors, as well as devices with single sensors - or those devices which operate on a different design principles.

The four following dates are important in the history and development of the eNose:

1. The making of the first gas sensor, Hartman 1954
2. Constructing array of 6 termistors, Moncrief 1961
3. First Electronic Nose, Persaud and Dodd, 1982
4. Ikegami (Hitachi Research Laboratory, J) array for odour quality - 1985

Therefore, the first recorded scientific attempt to use sensor arrays to emulate and understand mammalian olfaction was carried out by Persaud and Dodd in 1982 [3], at the University of Manchester Institute of Science and Technology.

A device was built with an array of three metal-oxide gas sensors used to discriminate among twenty odorous substances. Using visual comparison for the ratios of the sensor responses, they obtained the pattern classification.

The name itself "Electronic Nose" used for the first time during 1988 and has come into common usage *"as a generic term for an array of chemical gas sensors incorporated into an artificial olfaction device"* [3][4] after the introduction of this title at a conference covering this field in Iceland 1991. From that point, the idea and the principles of the eNose has grown and developed into different fields across the globe.

Historically speaking, there are two different types of eNoses (Pearce 1997):

1. Static odour delivery.

2. Mass-flow systems.

As the two names suggest, the basic mechanism for the first type is that there is no odour flow but simply a flask contains the sensors array with a fan at the top to distribute the flow within the flask. This type was the design of the first eNose in 1982.

The second type which is very popular now is where the odour flows within the system. Most eNoses designs are made in this way.

To complete this brief historical outlook concerning the eNose, it is a good idea to look at the basic schematic comparison between human and electronic noses [6], summarized in the following two sections.

The Human Nose[6]

There are millions of self generated receptors (over 100 million) with selectivity classes can range from 10 to 100.

The human nose is very adaptive but unlike the eNose, saturation can happen and that is one of the reasons why it operate only for a short periods of time. Variety of odours can be identified, plus it can detect some specific molecules but it cannot detect some other types of simpler molecules.

As a biological system, infection can take place, which may affect the ability to smell.

And finally, smelling can be associated with various experience and memory.

The eNose [6]

Approximately 5 - 100 chemical sensors manually replaced. In comparison with the human nose, it is not possible to reduce automatically the number of signals to a particular one.

As the eNose continue to develop, it is possible in the future to become adaptive, it is also unlikely to become saturated and can work for a long periods of time.

If pattern recognition hardware provided within the device, then new real-time signal treatment can occur. Unlike the human nose, eNose needs to be trained for each application. It can detect simple molecules but it cannot detect some complex molecules at a low concentration.

The eNose can get poisoned (sensors' malfunction); at the same time it is possible for eNose with multi-sensors to be associated with other functions and recognitions.

How eNose work?

A number of operation parameters are usually required in order for the eNose being able to function "to a maximum effect". These operation parameters can be:

1. Setting up the temperature for the sample incubation
2. The size of the sample.
3. The rate of injection.
4. The quantity of injection.
5. The added solvent being used.
6. Flow rate.
7. Sensor type.
8. Sensor operational parameters.

The above are just examples; however, there can be other factors as well.

As mentioned briefly earlier on, the principle of eNose is mainly rests with the one or more (an array) of vapour-sensitive detectors (sensors). Usually the detector is made up from certain type of sensitive materials which its characteristic or behaviour change in response to absorbed or adsorbed molecules. As we measure the changes in each sensor, identification can be made for the unknown odour(s) by comparing it with the library data.

Conclusion

eNose devices have been developed over the past 20 years to perform a variety of identification tasks in various industries. However, merely a few years ago, the majority of work and publication related to this field were mostly restricted to the area of research. These days, various types of commercially available eNoses can be purchased anywhere in the world.

The reason for the relatively fast development and commercialization of these devices is because they attracted new interest in their application in the fields of food, environment, medical diagnosis, industries, security and other related areas.

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