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ABSTRACT

With the change in time, the hilarious development of the Internet-of-Things (IoT) technology came into existence, various industries, food processing units, cosmetics, smart mobiles etc and various other luxury items. More the demands, more is the waste discharge from industries, hence more is the chance of environmental pollution. Not only with this, more requirement of the prediction on quantity of raw materials is needed. More the productive units, more becomes the liability of need of safety equipment's for workers. In present scenario, it will not be wrong if it is said that the environment is full of toxic gases. Therefore, its detection becomes very critical and important for environmental monitoring, chemical process control, agriculture, and medical applications and even in National security.

The solution is only one for all such necessities, and that is the gas sensors, an electronic nose. Sensing technology has been broadly discovered as a most powerful tool utilized for gas detection. Due to its various utility and intrinsic limitations of different gas sensing technologies, researchers are continuously working on different platforms for improved gas sensor calibration.

Keywords: *toxic gases, gas sensors, electronic nose, Smart gas sensing technology*.

INTRODUCTION

In present scenario, it will not be wrong if it is said that the environment is full of toxic gases. Therefore, its detection becomes very critical and important for environmental monitoring, chemical process control, agriculture, and medical applications and even in National security. Hence, gas sensors and electronic noses (e-nose) are widely studied by researchers all over the world. Common gas sensor technologies employed to build e-noses include metal oxide (MOX), amperometric electrochemical (AEC), quartz crystal microbalance (QCM), conducting polymers (CP), and surface acoustic wave (SAW). Thus, limiting the design of an e-nose to a single sensor technology will restrict its performance and, quite often, prevent it from reaching the demanded specifications. This motivates the integration of different gas sensor technologies into a single e-nose, which would result in a sensor array with better dynamic capabilities and a more informative output than any single sensor technology by its own.

Our surrounding is composed of many toxic gases like ammonia (NH_3), oxides of nitrogen (like NO, NO_2), and oxides of carbon (like CO and CO_2) and formaldehyde (HCHO). The detection of these gas molecules, therefore, becomes necessary in many fields, principally in environmental monitoring due to their toxicity and related risk to the ecosystem. In summary, this article builds on research papers to increase the versatility of current e-noses and approaches the problem of gas-sensing technologies within an architecture based on interconnectable modules that host the specific electronics of each sensor.

Toxic Gases in Our Surrounding

Ammonia

Ammonia is present in the environment due to agricultural as well as industrial and biological discharges. It can be identified by its peculiar smell also by its irritating and corrosive properties. When exposed to low concentration, the skin, as well as eyes of one, can suffer severe irritation but if the same comes in contact with the higher concentration it may cause corrosive damage, including skin burns, permanent eye damage, or blindness [4].

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It has been reported toxic to freshwater organisms at conc. Ranging from 0.53 to 22.8 mg/l. Toxicity is directly proportional to pH and temperature. It is thought to be one of the main causes of losses in fish hatcheries [3].

Oxides of Nitrogen

Nitrogen oxides are formed naturally during the oxidation of nitrogen containing compound such as coal, diesel and silage. They are also formed during welding, electroplating, dynamite blasting and several nitration reactions [9]. They are harmful to both; plants and animals. High levels oxides of nitrogen can cause damage to human respiratory tract while its long term exposure can cause lung infections [13]. They also give rise to other phyto toxicological pollutants such as ozone [1].

Oxides of Carbon

Two oxides of carbon are till known having toxic properties and they are Carbon mono oxide (CO) and carbon dioxide (CO_2). They both are colorless, tasteless and are produced by incomplete burning of fossil fuels and also by the improper functioning of instruments in the industries [13].

CO is considered more toxic than CO_2. CO when inhaled passes through the lungs into the blood where it reacts with hemoglobin (Hb) of the RBCs to form a complex known as Carboxy hemoglobin (CO Hb). The latter is not in a position to transport the inhaled oxygen to various parts of the body. This will cause suffocation and will ultimately lead to death. This condition is referred to as Asphyxia [15].

The high concentration of CO will harmfully affect the plants causing leaf drop, reduction in leaf size and premature aging, etc.

Volatile organic compounds (VOCs)

Volatile organic compounds (VOCs) are organic compounds with high vapor pressures at normal room temperature. Harmful VOCs mainly do not have intense toxicity but have long-term health effects [4]. Which incorporates ENT (eye, nose, and throat) irritation; headaches; coordination disorders; and nausea [5,11]

Above all these gases are toxic in nature even if they are consumed directly or indirectly in minute or high concentration quantities or for less or high exposure period. To avoid the loss of health of workers and also the environmental pollution, their pre-detection is highly in need. Therefore, we all have to depend on such a device which can helps us in smell and thus pre-detection of their leakage, malfunctioning etc. This lead to the discovery of gas sensors which can also be said as e- nose (electronic nose).

Wide Applications of Gas Sensors (Need of Gas Sensor)

Other than these above toxic gases, with the upgraded lifestyle and development of high technologies for Internet-of-things, gas sensing has been introduced with smart life and smart industry:

(1) Food testing (e.g., predicting the freshness of food, especially milk products) and also detecting the fresh vegetables freezing time)

(2) Animal and plant husbandry (breeding) (e.g., determine the time of cow estrus and determining the time of fruit ripening)

(3) Air detecting (e.g., detecting ozone content and air quality monitoring)

(4) Disease diagnosing (e.g., detecting liver cancer based on breadth and detecting gastrointestinal diseases)

(5) Industrial field (e.g., oil and gas positioning) and pipeline leak detection)

(6) Hazard monitoring (e.g., explosion and toxic gas detection, fire warning), etc.

(7) Military (Security Purpose) Detecting of chemical, Biological weapons, and explosive material.

Although smart sensing has been playing a wide role in today's lifestyle and production, it should be emphasized that there are still many challenges in the development of smart gas sensing corresponding to the various stages of technology mentioned above

From the above, it is clear, that early detection of these toxic gases is very important to avoid the ill health effect of industrial workers and mishappenings (leakage) occurring in any industries as well as to protect the surrounding environment from the above-given damages. Therefore, there was an immense need to build such detectors which were possible only by gas sensing technologies also can be said as an electronic nose.

Electronic Nose (e-nose)

The term "electronic nose" is more often related to the detection of smells or the attempt to smell with a technical device that runs on smart gas sensing technology.

Smart gas sensing technology is a combination of a selective electrochemical gas sensor array and

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appropriate pattern recognition method for the detection, analyzation, and quantifying of mixed gases, through which high measurement accuracy can be achieved with smarter conclusions [7]. Generally, sensors in the array response to the gas generating a unique set of signals called gas fingerprint, and then, characterizing various odors or volatile compounds by pattern recognition [16].

Types and mechanisms of common electronic-nose gas sensors.

Sensor type	Sensitive material	Detection principle	Reference
Acoustic sensors: Quartz crystal microbalance (QMB); surface & bulk acoustic wave (SAW, BAW)	organic or inorganic film layers	mass change (frequency shift)	[17]
Calorimetric; catalytic bead (CB)	pellistor	temperature or heat change (from chemical reactions)	[17]
Catalytic field-effect sensors (MOSFET)	catalytic metals	electric field change	[18]
Conducting polymer sensors	modified conducting polymers	resistance change	[19]
Electrochemical sensors	solid or liquid electrolytes	current or voltage change	[20]
Infrared sensors	IR-sensitive detector	Infrared-radiation absorption	[21]
Metal oxides semi-conducting (MOS, Taguchi)	doped semi-conducting metal oxides (SnO_2, GaO)	Resistance change	[22]

Principle and working of e nose

The electronic nose is primarily composed of

1. an aroma delivery system, which transfers the volatile aromatic molecules from the source material to the sensor array system.
2. a chamber where sensors are housed: this has usually fixed temperature and humidity, which otherwise would affect the aroma molecules adsorption.
3. a transistor which converts the chemical signal into an electrical signal, amplifies and conditions it.
4. a digital converter that converts the signal from electrical (analog) to digital.
5. a computer microprocessor which reads the digital signal and displays the output after which the statistical analysis for sample classification or recognition is completed.

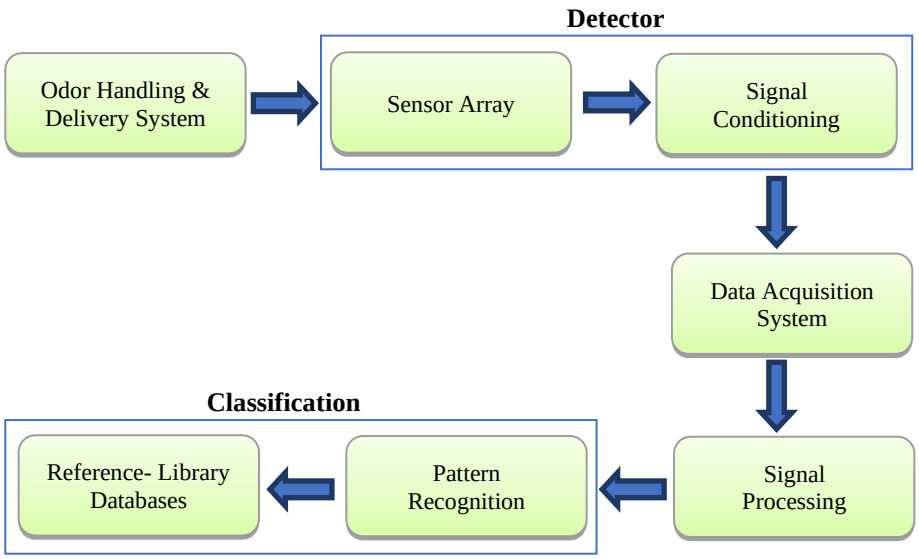

Figure 1: Schematic block diagram of e-nose sensor [23]

Gas molecules which are to be detected are offered in front of a gas sensor of an active material which converts a desired chemical reaction into a measurable electronic signal such as change in the resistance, frequency, current, or voltage [14]. The multiple responses of sensors to a peculiar smell or odour forms a response spectrum of the sensor array to the odor. To achieve qualitative or quantitative analysis of the odor, the sensor signal must be properly pretreated and processed by appropriate pattern recognition analysis [16]. The electronic nose is used to examine and assess the odor quality according to the principle that each of the gas sensors has a response to complex component gases but different from each other.

CONCLUSION

Smart Gas Sensing is a cross-disciplinary field that includes physical and chemical material sciences, electronic circuits, statistics, chemometrics, communication networks, and machine learning methods. Sensing technology has been widely investigated and utilized for gas detection. Due to the different applicability and inherent limitations of different gas sensing technologies, researchers have been working on different scenarios with enhanced gas sensor calibration.

Conflict of Interest

The authors declare no conflict of interest.

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