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# Detection of Ammonia in Exhaled Human Breath

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***Abstract :*** *Now days, there is increasing demand for breath analysis in clinical society as it is used as a diagnostic tool. The exhaled human breath contains many gases. These gases are the indicators of the presence of different diseases. So, by measuring the concentration of these different gases, we can diagnose thevarious diseases. Some of the traditional methods for disease diagnosis such as blood test which is an invasive method and also take much more time to give the results. While, breath analysis is non-invasive method for disease diagnosis, also it is a real time method. This work focuses on detection of ammonia in exhaled human breath for the detection of presence of renal disease that is kidney dysfunction. This paper presents the use of semiconductor gas sensor which is sensitive to ammonia for the detection of ammonia from exhaled human breath.*

***Keywords –****Breath analysis, Disease diagnosis, Invasive method, Kidney dysfunction, Semiconductor gas sensor,*

## I. INTRODUCTION

The human exhaled breath consists of a number of different components, such as oxygen, carbon dioxide, nitric oxide and various volatile organic compounds (VOCs). These breath components are either exogenous or endogenous. Exogenous means the molecules which have been taken inside through the process of inhalation, from the source such as air or food thus, nor has any diagnostic value. And, the endogenous molecules are those, which are formed by the metabolic process. Metabolic process is a set of life sustaining chemical reactions within the cells of living organisms. Hence, the endogenous molecules have a diagnostic value [1]. Thus, the change in concentration of these molecules is an indication of the presence of disease or change in metabolism. For example, acetone is an indicator of the diabetes; nitric oxide is an indicator of the asthma and airway inflammation. In the same way, an elevation in the concentration of ammonia in an exhaled human breath is an indication of presence of renal disease.

The breath analysis plays vital role in the medical field, for the diagnosis of different diseases. A breath testing device is first developed in 1784 by Lavoisier, when he detected CO in exhaled breath of guinea pigs [2]. The breath analysis is usually performed by gas chromatography or electronic nose. In which, gas chromatography procedure is complicated and require much more time to give the result. Also, gas chromatography is expensive. On the other hand, electronic nose is not so expensive and in comparison to gas chromatography it gives faster results [2].

This work focuses on detection of ammonia in exhaled breath by using metal oxide semiconductor gas sensor for checking the presence of renal disease i.e. the kidney dysfunction. Basically, a person with renal disease has a disturbed urea balance. So, detecting the concentration of ammonia indirectly measures urea levels. The breath ammonia may also capable of providing patients requiring kidney dialysis and also gives information to physicians regarding the progress of dialysis in real time. So, it may help to improve the quality of renal care.

## II. RELATED WORK

In order to perform the breath analysis, different methods are implemented. The measurement of ammonia in exhaled breath is done using a nano-sensor. The semiconducting ceramic is used as a sensor material. A breath testing binary prototype device is developed. The device operates on the principle of resistive chemo sensing. Thus, the output resistance of the sensor is converted into a voltage signal by using a voltage divider. The output voltage is proportional to the concentration of ammonia in exhaled breath [2]. The e-nose (electronic nose) system is developed for the detection of liver cancer. The method is based on measurement of volatiles in the exhaled breath. This system uses eight different types of metal oxide semiconductor gas sensors sensitive to the broad range of volatiles in exhaled breath. The sensor circuit uses Ohm's law to calculate the resistance of each sensor and this resistance is converted into a voltage signal by using voltage divider method [3].

The breath analysis system is implemented to recognize the presence of lung cancer. The olfactory signals are acquired through an array of MOS (metal oxide semiconductor) gas sensor. These signals are classified by using a pattern classification technique. Three types of classifiers are used K-nearest neighbors (KNN), linear and quadratic discriminant function based classifier (LD and QD) and artificial neural network (ANN) [4, 12, 13, 14]. The fast response laser system is developed for breath analysis. The system is based on the principle of infrared absorptiontechnique. Three types of classifiers are used K-nearestneighbors (KNN), linear and quadratic discriminant functionbased classifier (LD and QD) and artificial neural network(ANN) [4,12]. The fast response laser system is developed forbreath analysis. Room temperature quantum cascade lasers are used, which simultaneously measures NO (nitric oxide), CO (carbon monoxide), CO2 (carbon dioxide) and nitrousoxide in exhaled breath. This system is fully non-cryogenic and measures multiple breath gases in real time [5]. Noninvasive measurement of acetone in the human breath is done for ketosis monitoring and control by mean of a MOS (metal oxide semiconductor) gas sensor. The MOS sensor is highly sensitive, resistive sensor in thick film configuration, fabricated by using layers of $In_2O_3$ (Indium oxide) and Pt-$In_2O_3$ Nanopowders. The sensor resistance data are collected. The sensor response S is measured by the ratio $\frac{R_{air}}{R_{gas}}$. Where, $R_{air}$ is electrical resistance of sensor in dry air and $R_{gas}$ is electrical resistance at different acetone concentration [6].

## III. GAS SENSOR MATERIALS

Two gas sensors are used in this system. The gas sensors used for detection of ammonia are highly sensitive to ammonia. One sensor is TGS826 metal oxide semiconductor gas sensor from FIGARO Engineering Inc. and second sensor is MQ135 semiconductor gas sensor from HANWEI ELECTRONICS. Both the sensors work on the principle that, when there is an interaction between ammonia gas and sensor, the ammonia gas gets ionized and is then adsorbed by the sensing element. The effect of adsorption creates a potential difference on the sensing element. This sensing element is housed under a steel exoskeleton and is subjected to current through the leads. This current is known as a heating current. Due to ionization of ammonia and adsorption by sensing element, there is a change in resistance of the sensing element, which changes the value of the current going out of it. So, from the gas sensor we get the output in the form of analog voltage [7].

### 1.1 TGS 826 Ammonia Gas Sensor

The TGS 826 metal oxide semiconductor gas sensor is as shown in Fig. 1

Fig. 1. TGS 826 ammonia gas sensor

This sensor is highly sensitive to ammonia gas. It gives quick response to the low concentration of ammonia and it uses simple electrical circuit. The sensor has a ceramic base which makes it resistant to severe environments. In sensing element of the sensor, metal oxide is sintered to form a thick film on the surface of an alumina ceramic tube which contains the internal heater, in order to maintain the sensing element at a specific temperature which is optimal for sensing. The sensing element of TGS 826 is a metal oxide semiconductor, which has low conductivity in clean air. In the presence of detectable gas, the sensor's conductivity increases depending on the ammonia gas concentration. This change in conductivity is converted to an output signal which corresponds to the gas concentration. The typical detection range of the sensor is 30- 300 ppm [8].

1.2 MQ 135 Ammonia Gas Sensor

The MQ 135 ammonia gas sensor is as shown in Fig. 2


Fig. 2. MQ 135 ammonia gas sensor

This sensor is highly sensitive to ammonia and it gives fast response. This sensor is stable and has long life. This sensor uses simple drive circuit. The sensor composed by micro$Al_2O_3$ Ceramic tube, tin dioxide ($SnO_2$) sensitive layer, measuring electrode and the heater is fixed into a crust made of plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive component. The MQ135 gas sensor has 6 pins, 4 of them are used to fetch the signal and 2 of them are used for providing heating current. The sensor has low conductivity in clean air and in the presence of combustible gas, sensor's conductivity rises. The typical detection range of MQ 135 semiconductor gas sensor is 10- 300ppm [9].

1.3 Sensor Base

Both the sensors are fixed on a separate sensor base. Fig. 3 showing how the sensor is fixed on a base and Fig. 4 showing the pictorial view of base, i.e., which different components are connected at the base.

Fig. 3. Ammonia gas sensor fixed on base

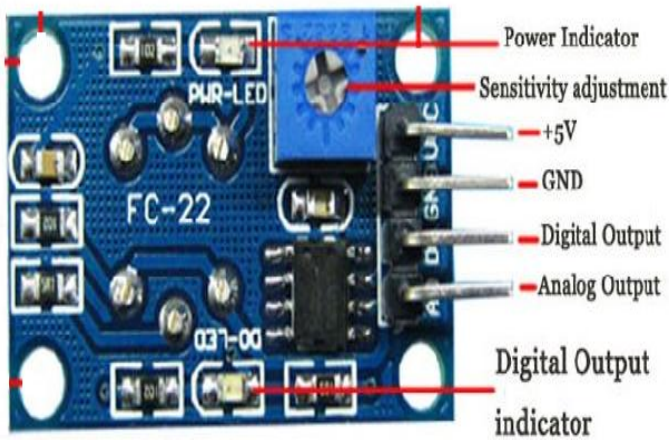


Fig. 4. Sensor base

Characteristics:

The sensor base has signal output LED indication. It gives 2-way signal output, analog and TTL-level output. For, the TTL output valid signal is low, which can be accessed by microcontroller I/O port. And, the analog output increases with the concentration of ammonia, higher the concentration voltage will be higher.

This sensor module has high sensitivity and selectivity with long life, reliable stability and fast response characteristic. For, sensitivity adjustment, pot is connected at the base. This sensormodule works on +5V DC supply [10].

## IV. EXPERIMENTAL RESULT

Once the sensor is fixed over a sensor base, +5V DC supply is given to the sensor module. After, preheating of both the sensors, these sensors are exposed to the different concentrations of liquid ammonia. These different concentrations of liquid ammonia are measured by weighing balance. The analog voltage readings are taken for these different concentrations. The analog voltage is recorded by connecting a digital multimeter to the analog output pin and ground pin of the sensor base.

Two sets of readings are taken. In Set-1, the sensor is exposed directly to the different concentrations of liquid ammonia and in Set-2 readings are taken, by mixing different concentrations of liquid ammonia in 1 liter of distilled water and exposing the gas sensor to this solution. These two sets of readings are taken for both the sensors, i.e. TGS 826 and MQ 135.

TABLE 1. Set-1 for TGS-826 Ammonia Gas Sensor

| Concentration of liquid ammonia | Analog Voltage |
|---|---|
| 1gm | 1.45V |
| 2gm | 1.93V |
| 3gm | 2.07V |
| 4gm | 2.09V |
| 5gm | 2.13V |

TABLE.2 Set-2 for TGS-826 Ammonia Gas Sensor

| Concentration of liquid ammonia | Analog Voltage |
|---|---|
| 1gm | 0.11V |
| 2gm | 0.14V |
| 3gm | 0.33V |
| 4gm | 0.46V |
| 5gm | 0.49V |

TABLE.3 Set-1 for MQ-135 Ammonia Gas Sensor

| Concentration of liquid ammonia | Analog Voltage |
|---|---|
| 1gm | 1.08V |
| 2gm | 1.26V |
| 3gm | 1.37V |
| 4gm | 1.53V |
| 5gm | 1.98V |

TABLE.4 Set-2 for MQ-135 Ammonia Gas Sensor

| Concentration of liquid ammonia | Analog Voltage |
|---|---|
| 1gm | 0.42V |
| 2gm | 0.50V |
| 3gm | 0.57V |
| 4gm | 0.59V |
| 5gm | 0.63V |

For this analog voltage measured at different concentrations of liquid ammonia, the responses are recorded on a digital signal oscilloscope. They are as shown below.

First the waveforms are recorded for 3 different concentrations of liquid ammonia without adding it to the distilled water for TGS 826 ammonia gas sensor as shown in Fig. 5, 6 and 7.


Fig.5.Output of TGS 826 gas sensor for 1gm of liquid ammonia

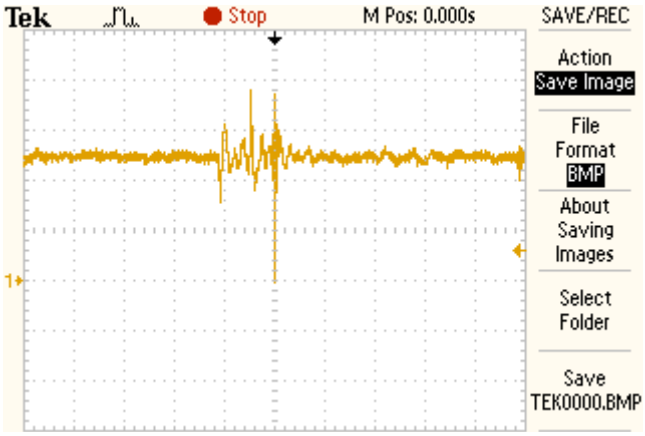


Fig.6. Output of TGS 826 gas sensor for 2gm of liquid ammonia

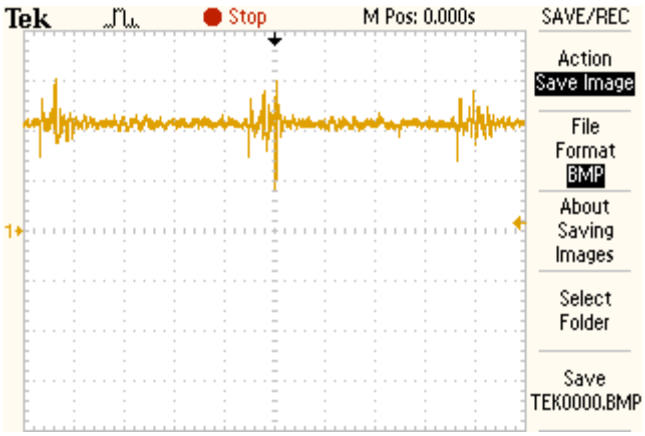


Fig.7.Output of TGS 826 gas sensor for 3gm of liquid ammonia

Then, the waveforms are recorded for 3 different concentrations of liquid ammonia mixing up with 1 liter of distilled water for TGS 826 ammonia gas sensor as shown in Fig. 9,10 and11.

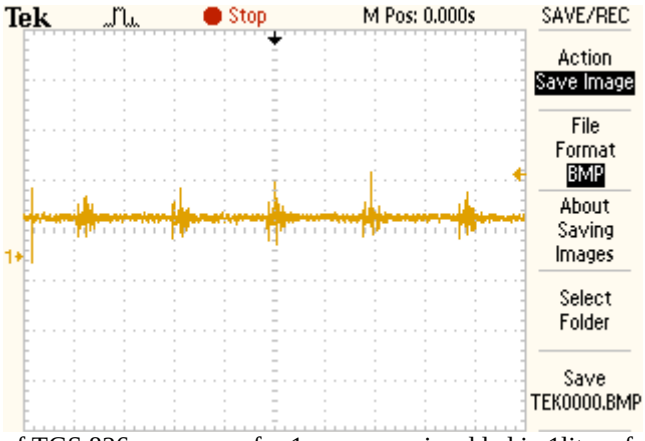


Fig. 9.Output of TGS 826 gas sensor for 1gm ammonia added in 1liter of distilled water


Fig.10.Output of TGS 826 gas sensor for 2gm ammonia added in 1 liter of distilled water

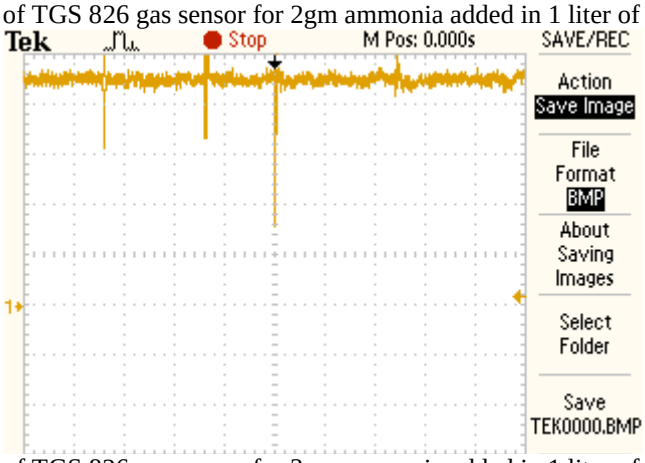


Fig.11.Output of TGS 826 gas sensor for 3gm ammonia added in 1 liter of distilled water

Similarly, the responses are recorded for 3 different concentrations of liquid ammonia without adding it to the distilled water for MQ135 gas sensor as shown in Fig. 9, 10 and 11


Fig.9.Output of MQ 135 gas sensor for 1gm of liquid ammonia


Fig.10.Output of MQ 135 gas sensor for 2gm of liquid ammonia


Fig.11.Output of MQ 135 gas sensor for 3gm of liquid ammonia

Again, the responses are recorded for 3 different concentrations of ammonia by adding it into the distilled water for MQ135 gas sensor as shown in Fig.12, 13 and 14.

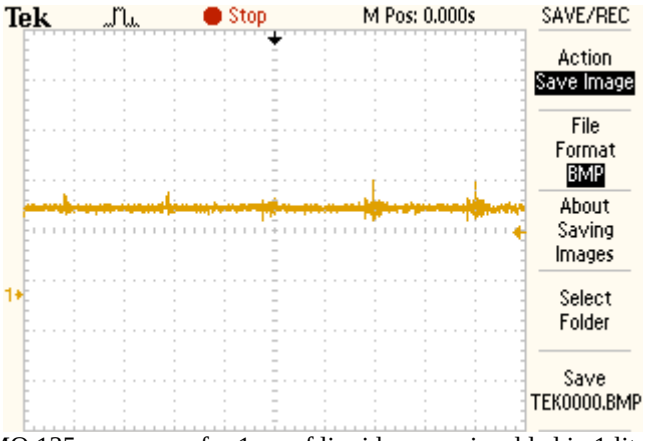


Fig.12.Output of MQ 135 gas sensor for 1gm of liquid ammonia added in 1 liter of distilled water

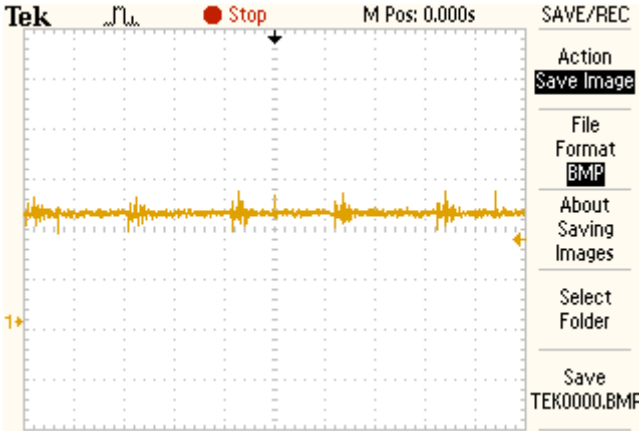


Fig.13.Output of MQ 135 gas sensor for 2gm of liquid ammonia added in 1 liter of distilled water

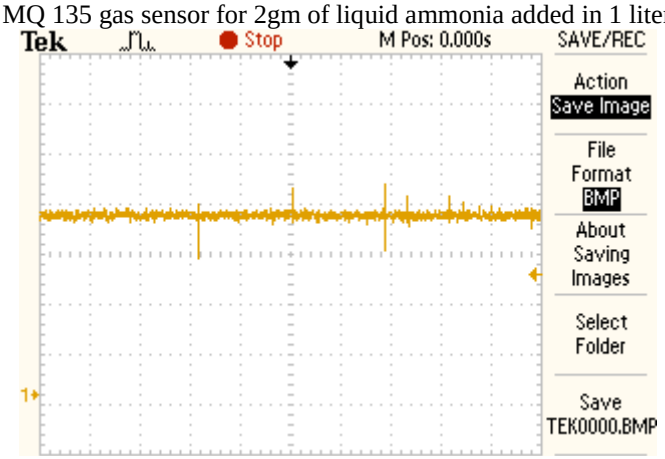


Fig.14.Output of MQ 135 gas sensor for 3gm of liquid ammonia added in 1 liter of distilled water

## V. CONCLUSION

The objective of this paper is to detect the concentration of ammonia gas by using metal oxide semiconductor gas sensor. From, all the analog voltage values and the responses which are recorded for both the sensors, i.e. TGS 826 and MQ 135 metal oxide semiconductor gas sensors, we can conclude that, if analog voltage is higher, the concentration of ammonia is higher. Thus, we can say that the higher concentration of ammonia, higher will be the analog voltage and vice versa. So, this module can be used for the detection of ammonia in exhaled human breath for detection of presence of renal disease.

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**REFERENCES**

[1] Dongmin Guo, David Zhang, Fellow, IEEE, Naimin Li, Lei Zhang, Member, IEEE, and Jianhua Yang,"A Novel Breath Analysis System Based on Electronic Olfaction", "IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING"
[2] Perena Gouma, Krithika Kalyanasundaram, Xiao Yun, Student Member, IEEE, Milutin Stanacevic, Member, IEEE, and Lisheng Wang, "Nanosensor and Breath Analyzer for Ammonia Detection in Exhaled Human Breath", "IEEE SENSORS JOURNAL, VOL. 10, NO. 1, JANUARY 2010"
[3] Thara Seesaard, Chayanin Khunarak and Teerakiat Kerdcharoen Materials Science and Engineering Programme Faculty of science, Mahidol University Bangkok, Thailand, Taya Kitiyakara Division of Gastroenterology and Hepatology Faculty of Medicine Ramathibodi Hospital Mahidol University Bangkok, Thailand, "Development of an Electronic Nose for Detection and Discrimination of Exhaled Breath of Hepatocellular Carcinoma Patients","2012 IEEE International Conference on Systems, Man, and Cybernetics October 14-17, 2012, COEX, Seoul, Korea"
[4] Rossella Blatt, Andrea Bonarini, Elisa Calabro, Matteo Della Torre, Matteo Matteucci, Ugo Pastorino, "Lung Cancer Identification by an Electronic Nose based on an Array of MOS Sensors", "Proceedings Of International Joint Conference on Neural Networks, Orlando, Florida,USA, August 12-17, 2007"
[5] Joanne H. Shorter, David D. Nelson, J. Barry McManus, Mark S. Zahniser, and Donald K. Milton, "Multicomponent Breath Analysis With Infrared Absorption Using Room-Temperature Quantum Cascade Lasers","IEEE SENSORS JOURNAL, VOL. 10, NO. 1, JANUARY 2010"
[6] Giovanni Neri, Anna Bonavita, Giuseppe Micali, and Nicola Donato, "Design and Development of a Breath Acetone MOS Sensor for Ketogenic Diets Control", "IEEE SENSORS JOURNAL, VOL. 10, NO. 1,JANUARY 2010"
[7] "Insight- Learn the working of gas sensor", http://www.engineersgarage.com/insight/how-gas-sensor-works
[8] "Datasheet of TGS 826 ammonia gas sensor", http://www.figarosensor.com/products/docs/TGS
[9] "Datasheet of MQ 135 ammonia gas sensor", http://www.chinatotal.com/Product/meter/gas-sensor/MQ135.pdf
[10] http://www.aliexpress.com/item/1PCS-X-Ammonia-detection-sensor-MQ-137-NH3-gas-sensor-module-large-price-advantages-Wei-Sheng/1633266496.html
[12] Paithane, A. N., and D. S. Bormane. "Analysis of nonlinear and non-stationary signal to extract the features using Hilbert Huang transform." Computational Intelligence and Computing Research (ICCIC), 2014 IEEE International Conference on. IEEE, 2014.
[13] Paithane A. N., and D. S. Bormane. "Electrocardiogram signal analysis using empirical mode composition and Hilbert spectrum." Pervasive Computing (ICPC), 2015 International Conference on. IEEE, 2015.
[14] Paithane A. N., D. S. Bormane, and Sneha Dinde. "Human Emotion Recognition using Electrocardiogram Signals." International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 2 Issue: 2.