INVESTIGATION OF GRAPHENE COMPOSITE BASED GAS SENSOR FOR E-NOSE APPLICATION

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A project report submitted in partial fulfilment of the
requirements for the award of a degree of
Master of Engineering (Electrical-Electronic and Telecommunication)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JANUARY 2012

Special for:

My dearest husband and daughter …
Mohd Hazami Bin Mohd Iqbal
&
Nur Iman Khalisah Binti Mohd Hazami

also to my father and mother
Hj. Zainal Bin Ishak
&
Hjh. Ainon Binti Salleh

and not forgotten to my friend

In thankful appreciation for support and encouragement to
my supervisor…

Dr. Fauzan Khairi Bin Che Harun

ACKNOWLEDGEMENT

ABSTRACT

Serious studies have been made on how to improve the performance of e-nose system. This is typically based on the chemo resistive sensor which mainly depends on the sensing material. These factor leads to the era of searching new sensing material which can give contribution to e-nose system. The previous studies had gone through a lot on the various type polymer composites that give significant attribute on air quality monitoring system. Then, the studies continued to carbon black-polymer composition for the need of optimizing the gas sensor performance. In searching a new composite as sensing material, graphene is said one of the potential conductive materials indeed can replace carbon black in future. Thus, this project introduces graphene-carbon black-polymer composite investigation with different weight of percentage based on 80:20 ratios that represents the polymers to conductive material ratio. The interest part is without carbon black existence in the composite could give a major distribution on new composite based gas sensor development. Apart from that, a spray coating technique is performed to deposit the material onto the electrode sensor. It being used because it need to be deposited individually and hence this method is suitable in this project. The resistance value must be monitored throughout the deposition process which provides the sensor within specified range. This direct to the how the sensor react to the sample in such a way the sensor arrays with high range of resistance will give high magnitude response to the sample and vice versa. This project purposely only covers on the three samples having same concentration which lies on different aromas; apple, lemon, and rose. It shows that, magnitude response diversity in this project is going to be proposed as a based gas sensor for e-nose application. Therefore, graphene composite is said has a potential as a sensing material in this area of work.

ABSTRAK

Kebanyakan kajian berkenaan sistem *e-nose* telah mendapat perhatian daripada banyak pihak di seluruh dunia. yang telah dilakukan ke atas. Sistem ini dapat ditingkatkan melalui pengesan yang berasaskan keperubahan kimia oleh sesuatu bahan yang dinamakan bahan pengesan. Kajian yang terdahulu telah pun menunjukkan prestasi beberapa jenis komposit polimer terhadap mengawasi kualiti udara. Kemudian, kajian diteruskan dengan melihat gabungan bahan bernama *carbon black* bersama beberapa jenis polimer sebagai bahan pengesan. Oleh itu, projek ini memperlihatkan kajian tentang bahan pengesan baru yang dikenali sebagai *Graphene*. Bahan ini dikatakan mempunyai potensi tinggi yang dapat ditambah ke dalam sebuah pengesan yang mempunyai banyak pengesan individu. Maka, projek ini dijalankan dengan menyediakan komposit baru yang berasaskan *graphene* ini berdasarkan nisbah 80:20 yang mempersembahkan nisbah polimer terhadap bahan konduktif. Bahagian yang paling menarik dalam projek ini ialah sumbangan terbesar komposit *graphene* apabila ketiadaan bahan *carbon black*.Di samping itu, teknik *spray coating* digunakan untuk menyembur bahan ke atas pengesan individu. Teknik ini amat berkesan daripada teknik-taknik lain yang sedia ada. Setiap nilai rintangan pada individu pengesan diawasi selama proses ini dijalankan supaya ianya berada dalam nilai yang ditetapkan. Ini akan member impak kepada tahap kecemerlangan pengesan tersebut. Sebenarnya, projek ini hanya memberi fokus pada tiga jenis sampel yang mempunyai tahap konsentrasi yang sama manakala mempunyai bauan yang berbeza. Sampel-sampel tersebut ialah pewangi yang berbau epal, limau, dan bunga mawar. Maka, dapat disimpulkan disini, bahawa perubahan sahutan yang berbeza-beza antara individu pengesan menjadikan projek ini dapat diteruskan untuk meraih pencapaian yang hebat dalam bidang yang berasaskan pengesan gas sempena aplikasi *e-nose.*

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LIST OF ABBREVIATIONS

E-nose	-	Electronic nose
FGS	-	Functionalized Graphene Sheet
PS	-	Polystyrene
PVPD	-	Poly-vinyl-pyrrolidone
PEG	-	Poly- ethyl-gycol
PCB	-	Printed Circuit Board
DAQ	-	Data Acquisiton
USB	-	Universal Serial Bus
PCA	-	Principal Component Analysis
cm	-	Centimeter
mm	-	Millimeter
µm	-	Micrometer
nm	-	nanometer
ml	-	Milliliter

LIST OF SYMBOLS

	-	
%	-	Percentage
Wt%	-	Percentage of Weight
Vol%	-	Percentage of Volume
s	-	Seconds
k	-	Kilo
R	-	Resistor
L	-	Length
A	-	Area
ρ	-	Resistivity
V	-	Volt
M	-	Mega
Ω	-	Ohm
T	-	Temperature
$^{\circ}$C	-	Degree of Celcius
θ	-	Angle
N_2	-	Natrium dioxide
Au	-	Aurum
Cu	-	Copper
Cr	-	Chromium

CHAPTER 1

INTRODUCTION

1.1   Background of Study

As we all know, there are five major human senses which are sight, touch, taste, hearing, and smell. The sense of smell is needed for us to recognize whether the environment is safe or not. Thus, the world needs a device that can do measurement suites at different situation without worrying about poisonous gas. Back at old years, canaries are used to detect a poisonous gas in a mine. The worker will bring the canaries and fly them into the mine such that if it is true the poisonous gas exists, then the birds will goes slowly silent and die. So, they will know how far the gas exists and they can start work just until the measurement had done. These poor birds had to risk their just to make sure human life is not in danger.

After years of realization, a gas sensor is built throughout the world to magnify the important part of risking a life for prospective purpose. Apart from that, wide applications of gas sensor are found that need to be study each of them. There also variety of gas sensor exists in order to fit the industrial needs. One of them is chemically based gas sensor that captured remarkable work for odor detection. This work might not be harmful yet very significant in medical, food processing industry, and humidity monitoring system especially in space ship [1, 2].

A sensor is a device that measures physical quantity and converts it into a signal which can be analyzed by observer. For a chemical based sensor, it responds to chemical reactions that change some physical or electrical property by itself. There is various type of gas sensor nowadays that being helpful in industries. This project is focusing on the chemoresistive sensor to perform better quality of gas sensor based on electronic nose system. Electronic nose is defined by [1]:

"The electronic nose (e-nose) is an instrument, which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern-recognition system, capable of recognising simple or complex odours

(J.W Gardner, 1999)

Basically, the electronic nose consists of number of arrays which chemically react to the tested vapor. This chemical is said comprises of polymer based composite that complemented by conductivity material such as carbonized material. Thus, the reaction of gas sensor gives a magnitude response in term or resistance upon the exposure of vapor. This is because of the polymer swells and breaks the conductivity network caused to create material resistivity. Therefore, the sensor response is read by interface circuit that can convert the sensor measurement into electrical properties. This will provide signal generation in which the data can be processed and classify the vapor response.

Then, the data will be stored in memory like our brain for the further vapor recognition. From this, it is been realized the e-nose system can have a repeatedly kind of measurement and it is recommended in sensor technology. After that, the odour identification system is available to ensure the system can have a decision making that straight forward state the name of the vapor. Moreover, this system provides wide information to the user as well in decision making that in some cases that could not be done by human. Figure 1.1 describe figuratively about the e-nose system along with the human nose.
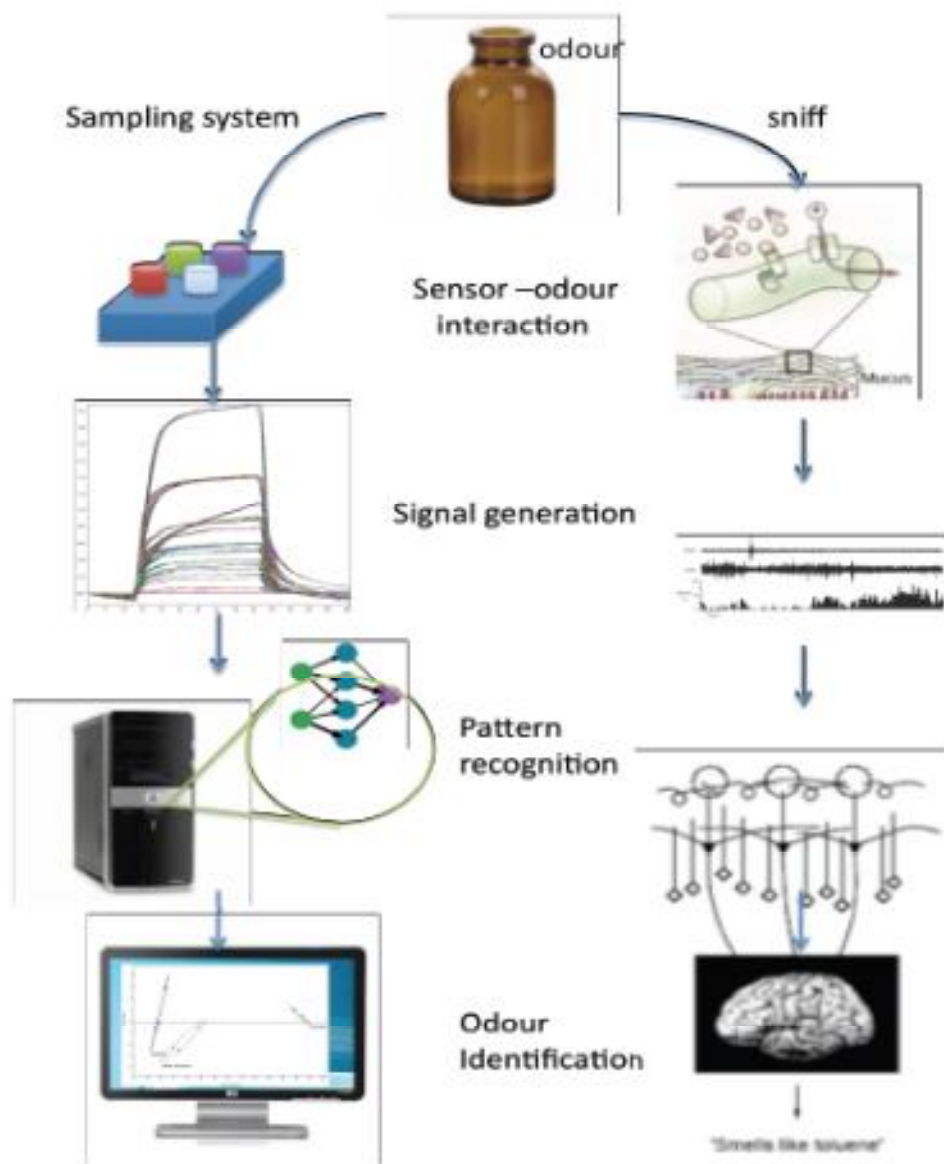
Figure 1.1: Electronic nose and human nose

1.2 **Motivation of study**

There are numerous research had been held on the polymer and carbon black composites. The ratio of polymer-carbon black is 80:20 weight percentage (wt%) mixed well in ethanol. This project investigates what is the response if these polymers composite are combined with additional material like graphene. It also tries to explore whether graphene could give same or greater response by comparing the wt% of each sensor. It is recommended that this investigation can be added up to the large numbers of sensor arrays that have been done by previous studies. Need to mention here, this project based on the preliminary work that focused deeply on the gas sensor only as a preparation for e-nose system development.

1.1 **Objective of the Project**

The objective of this project is to to design a chemoresistive gas sensor array and to investigate the electrical properties of graphene-carbon black-polymer semiconductor composite suitable as e-nose gas sensor.

1.3 **Scopes of Project**

The scope of work for this project is to introduce new material composites with different design development. Various weight of percentage of each composite will be investigated thoroughly on their electrical properties indeed to compare each sensor array. Moreover, the project is limits up to the signal generation only because it just covers the performance of gas sensor including the pattern recognition system instead of presenting the whole e-nose system as referred in Fig. 1.0. Therefore, odour identification which has decision making will not be covered in this project.

1.4   Summary

E-nose is different from other gas sensor like gas chromatography. What makes them different among each other? By using gas chromatography, the tested gas must be separated to smaller components by itself first before being detected by the detector on the outlet. It also usually responds in delay of time and the result obtained is unequal to the expected. Apart from that, electronic nose have a sensor array that can detect the gas as a whole. Then, the pattern recognition part is functioned to discriminate the odor and classify them to the recognized type of odor. From that point of view, this will lead to the faster time respond and at lower cost.

In fact, a human nose has a millions of receptor to sense something surrounding. The need to have the similar respond as human nose, a higher number of sensor arrays in electronic nose system would be more preferable. For example, a butcher can estimate the freshness of the meat at one storage room but he could not detect accurately as well for the large amount of meat processing work. This can be done by using e-nose technology to allow the meat processing goes well at time given. Furthermore, a study has been done said that amines found in meat might give important part in odorous emissions in some case.

Such that, the crucial part of this project is to understand thoroughly the electrical property of carbon black polymer composite, graphene polymer composite and the combination of both carbon black and graphene polymer composites. Then, each array will be coated differently with these materials so that it will gain different respond and information corresponding to individual array. As mentioned, the graphene and carbon black composite is combined with over various type of polymer.The new material is suggested to improve the electronic nose performance. It also would help increase the sensitivity and the selectivity of an electronic nose system.

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