INFLUENCE OF POLYANILINE DEPOSITED ON Mg TOWARDS SENSITIVITY TO LPG AND CO_2

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I declare that this thesis entitled "*Influence of Polyaniline Deposited on Mg towards Sensitivity to LPG and CO_2*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	:	2 MAY 2009

Special Dedication of This Appreciative Feeling to My…

Beloved father and mother;
Mr. Hassim Damawi and Mrs. Saniyah Mohd Noor

Loving brothers and sister;
Haffiza, Haffizan, Hazwan and Hamira

Also some special who gave me encouragement

For Their Love, Support and Best Wishes.

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ABSTRACT

Gas sensors are primarily used in the gas and oil industry and have a very commercial value due to its higher sensitivity properties in detecting minor leakage. As the sensors heterojunction are composed of combination metal oxide and organic polymer, the use of sensor would expect upgrade in term of their sensitivity, selectivity and stability. Two methods used for heterojunction fabrication are chemical bath deposition and electrodeposition. The sensors sample are tested based on I-V characteristic would inevitably inflict low current values. In this experimental work, MgO was employed due to its high conductivity and lower operating cost while polyaniline was used due to its high mechanical strength. Two different gases were used, which are LPG and CO_2 respectively. Preliminary results showed that the sensor sample was successfully giving the conductivity effect. Further studies also revealed that the response time of sensor was mainly influenced by the different concentration of gases used. The higher gas response for LPG is 45% while for CO_2 is 55%. Low concentration of the gases can be improved in future study by carrying out the larger scale of sensing chamber.

ABSTRAK

Penggunaan alat sensor gas pada dasarnya adalah lebih tertumpu kepada industri gas dan minyak kerana gas sensor mempunyai nilai komersial yang tinggi berikutan sifat sensitivitinya dalam mengesan kebocoran-kebocoran kecil. Sensor gas ini adalah terdiri daripada kombinasi oksida logam dan polimer organik di mana penggunaan kedua-dua bahan ini dijangka dapat meningkatkan tahap sensitiviti, pemilihan dan juga kestabilan. Dua kaedah yang telah digunakan dalam pembuatan sensor ini adalah pemendapan mandian kimia dan pengelektroendapan. Sensor gas ini telah diuji berdasarkan ciri-ciri *I-V* yang menghasilkan penurunan nilai arus. Di dalam kajian ini, MgO digunakan kerana ia mengkonduksi arus yang tinggi dan kos penggunaannya yang lebih rendah. Dua jenis gas digunakan ialah LPG dan CO_2. Keputusan kajian pada peringkat permulaan menunjukkan gas sensor ini dikenalpasti dapat mengkonduksi arus elektrik dengan baik. Kajian berikutnya membuktikan masa reaksi sensor dipengaruhi oleh kepekatan gas yang digunakan. Reaksi gas untuk LPG adalah 45% manakala untuk CO_2 adalah 55%. Kepekatan gas yang rendah dapat dipertingkatkan pada kajian akan datang dengan menggunakan unit pengesan berskala besar.

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LIST OF SYMBOLS

I	-	Electrical current
A	-	Ampere
V	-	Voltage
R	-	Gas Law Constant
%	-	Percentage
g	-	Gravity = 9.81 m/s
μ	-	Micron
K	-	Kelvin
atm	-	Atmosphere
mL	-	Milliliter
M	-	Molar
V	-	Volume
P	-	Pressure

LIST OF ABBREVIATIONS

CO_2	-	Carbon Dioxide
DC	-	Direct Current
EB	-	Emeraldine Base
IR	-	Infrared
LPG	-	Liquefied Petroleum Gas
MgO	-	Magnesium Oxide
MOX	-	Metal Oxide
PANI	-	Polyaniline
PVA	-	Polyvinyl Alcohol
PVC	-	Polyvinylchloride
TiO_2	-	Titanium (II) Oxide
ZnO	-	Zinc (II) Oxide

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

A gas sensor is a transducer that detects gas molecules and which produces an electrical signal with a magnitude proportional to the concentration of the gas. The transducer itself means a device that transforms one type of input energy into output energy of another. Unlike other types of measurement, that are relatively straightforward and deal with voltage, temperature, and humidity, the measurement of gases is much more complicated. There are literally hundreds of different gases and there is a wide array of diverse applications in which these gases are present, so that each application must implement a unique set of requirements.

There are many different technologies currently available for the detection of gases, each with certain advantages and disadvantages. The five types most suitable and widely used as gas monitors for area air quality and safety applications are electrochemical, catalytic bead, solid state, infrared and photoionization which can be discuss below. All of these sensors are commonly used for detection of toxic and combustible gases in the work area for human and property protection or for process control. One common characteristic of these sensors is that they are not specialized to detect any one specific gas. Each sensor is sensitive to a group or a family of gases. In other words, the sensor is non-specific and is subject to interference by other gases.

1.1.1 ELECTROCHEMICAL SENSORS

The oldest electrochemical sensors date back to the 1950s and were used for oxygen monitoring. The miniaturized electrochemical sensors became available for detection of many difference toxic gases in explosive limit ranges, with the sensors exhibiting good sensitivity and selectivity. A variety of electrochemical sensors are being used extensively in many stationary and portable applications currently. Figure 1.1 shows a small collection of such electrochemical sensors.

Figure 1.1 Electrochemical Sensors

These sensors operate by reacting with the gas of interest and producing and electrical signal proportional to the gas concentration. They are minimally affected by pressure changes but still important to keep within the same pressure since the differential pressure within the sensor can cause sensor damage. In summary, different electrochemical sensors may appear very similar but they are constructed with different materials including such critical elements as sensing electrodes, electrolyte composition and porosity of hydrophobic barriers.

1.1.2 Catalytic Bead Sensors

Catalytic bead sensors are used primarily to detect combustible gases. Initially, these sensors were used for monitoring gas in coal mines where they replaced canaries that had been used for a long period of time. It itself is quite simple in design and is easy to manufacture. In simplest form, it was comprised of a single platinum wire. A catalytic bead sensor is shown in Figure 1.2.

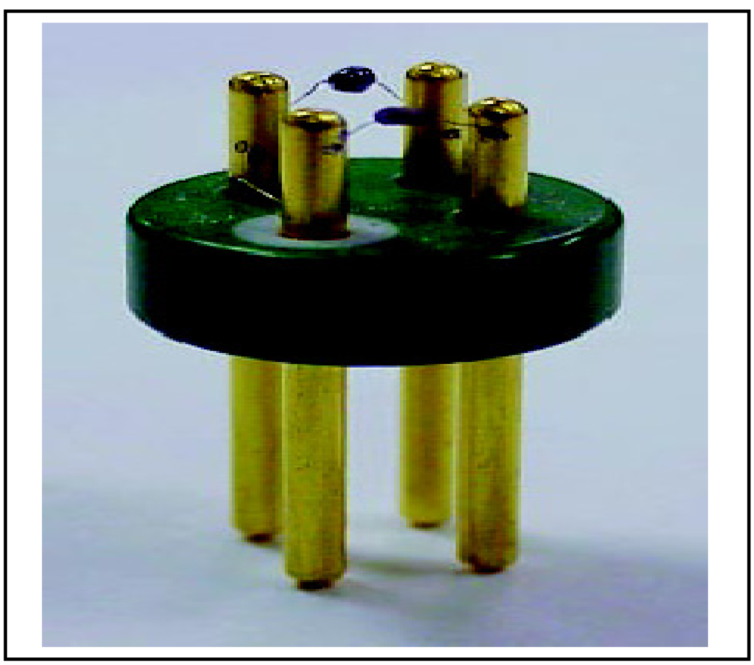

Figure 1.2 A Catalytic Bead Sensor

Combustible gas mixtures will not burn until they reach an ignition temperature. However, in the presence of certain chemical media, the gas will start to burn or ignite at lower temperatures. The phenomenon is called a catalytic combustion. The platinum possesses excellent mechanical properties, thus it is physically strong and can be transformed into a fine bead wire which can be processed into small sensor beads.

Furthermore, platinum has excellent chemical properties. It is corrosion resistant and can be operated at elevated temperatures for a long period of time without changing its physical properties. It is capable of producing a constant reliable signal over an extended period of time. For overall technology, the particularly true in selecting, preparing and processing all the chemicals needed to make the final sensor.

1.1.3 Solid-State Gas Sensors

Today, solid-state sensors are available for the detection of more than 150 different gases including sensors for the gases which could otherwise only be detected using expensive analytical instruments. Each sensor has different characteristics and different manufacturers offer different levels of performance and quality. A solid-state sensor consists of one or more metal oxides from transition metals such as tin oxide, aluminium oxide, etc. Figure 1.3 below has shown the solid-state sensor.

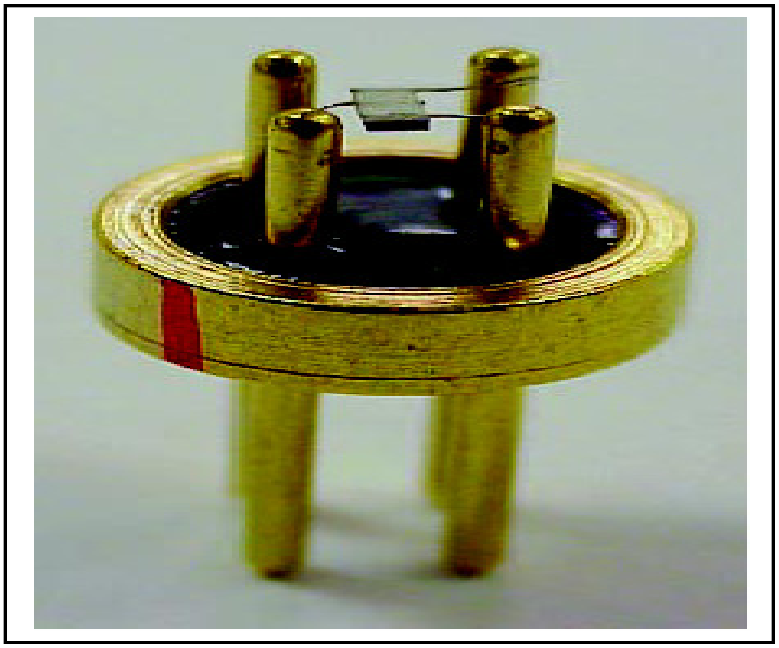

Figure 1.3 A Solid-State Sensor

In the presence of gas, the metal oxide causes the gas to dissociate into charged ions or complexes which results in the transfer of electrons. Meanwhile, pair of biased electrodes is imbedded into the metal oxide to measure its conductivity change. The changes in the conductivity of the sensor resulting from the interaction with the gas molecules are measured as a signal. Typically, a solid-state sensor produces a very strong signal especially at high gas concentrations.

1.1.4 Infrared Gas Sensors

Infrared gas (IR) detection is a well-developed measurement technology. The gases to be detected are often corrosive and reactive. With most sensor types, the sensor itself is directly exposed to the gas, often causing the sensor to drift or die prematurely. The detector does not directly interact with the gas to be detected. The gas molecules interact only with a light beam and only the sample cell are directly exposed to the gas stream. Figure 1.4 below has shown an example an infrared gas sensor with the gas cell assembly exposed.

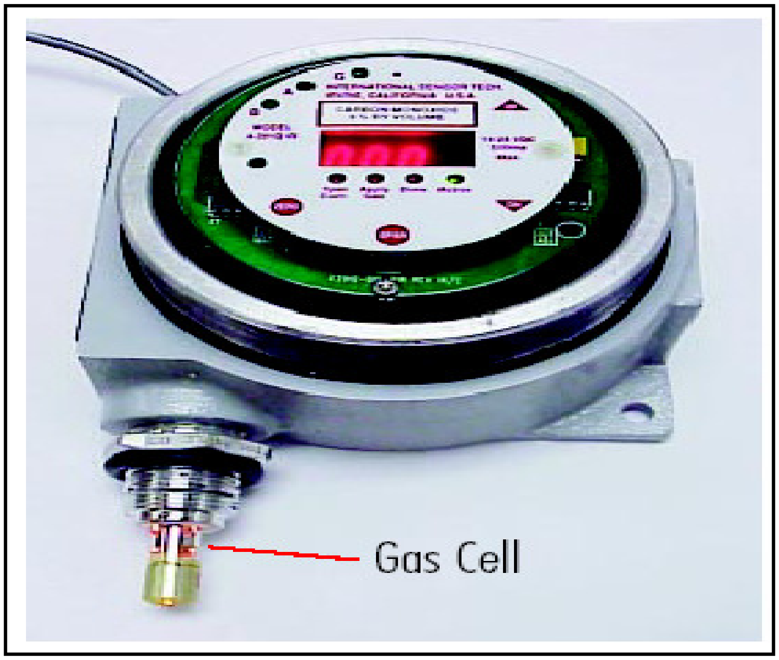

Figure 1.4 Infrared Gas Monitor with the Gas Cell Assembly

The infrared detection principle incorporates only a small portion of the very wide electromagnetic spectrum. The portion used is that which we can feel as heat. A regular incandescent light bulb is a good infrared source. A heated wire filament radiates sufficient energy in the 1-5 μ, micron range for the detection of most hydrocarbons, carbon dioxide and carbon monoxide.

Infrared detectors convert electromagnetic radiation energy or temperature changes into electrical signals. Normally, the size and mass of the device are important in determining its response time. The basic characteristics are including DC stability, no bias and responding to all wavelengths.

1.1.5 Photoionization Sensors

The photoionization detector utilizes ultraviolet light to ionize gas molecules and is commonly employed in the detection of volatile organic compounds. The electronic that lamps were used today led to the design of small portable photoionization detectors as shown in Figure 1.5 that have proven to be both practical and reliable. It is which offer fast response and the ability to detect low gas concentrations.

The ions produced by the ionization process are collected by electrodes and the current generated is a measure of the analyte concentration. If the energy of an incoming photon is high enough, photo-excitation can occur to such an extent that an electron is completely removed from its molecular orbital. The greater the concentration of the component, the more ions are produced and the greater the current.

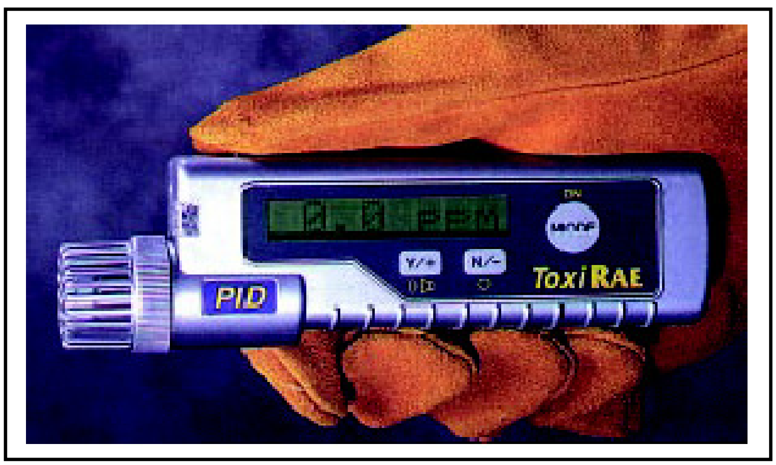

Figure 1.5 A Pocket Photoionization Monitor

The gases that we are going to test in this study are liquefied petroleum gas (LPG) and carbon dioxide (CO_2). LPG is defined as a petroleum product composed predominantly of any of the following hydrocarbons or mixtures including propane, propylene, butanes and butylenes. The most important is that LPG products are gases at atmospheric temperatures and pressures but they can be liquefied and maintained in their liquid state with relative ease.

Meanwhile, CO_2 is known as a colorless, odorless gas and acidic oxide but it is non flammable at atmospheric temperature and pressure. It is an important greenhouse gas that helps to trap heat in our atmosphere through the greenhouse effect. However, a gradual increase in CO_2 concentrations in Earth's atmosphere is helping to drive global warming, threatening to disrupt our planet's climate. The certainty is these gases are potentially hazardous due to high possibility of explosion accidents caused by leakage or by human error.

1.2 Problem Statements

Nowadays, the industry's demands for detecting and monitoring of toxic and inflammable gas sensors operating at lower temperature which are inexpensive have become more intense. Most of the industrial, domestic or residential needs the sensors in terms of ease of installation, economic and function well in any condition or surrounding. They are being set to invest the small cost but require the high efficiency of sensors.

Semiconductor inorganic gas sensors like doped or undoped SnO_2, ZnO or Fe_2O_3 have been well studied to detect most of reducing gases and they are considered interesting for their low cost and simple sensing methods. Nevertheless, there still exist some problems with them, for example high working temperature of 423 to 623 K for SnO_2 and 673 to 723 K for ZnO. At