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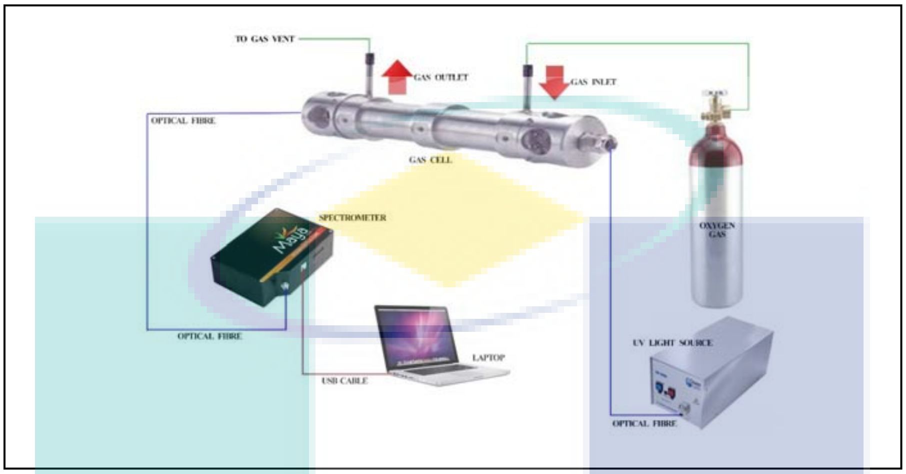

OPTIMIZATION OF THE WAVELENGTH OF LAMBDA SENSOR

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ABSTRACT (120 words)

The increased importance of oxygen gas detection in many areas such as environment, clinical, food and automotive industries, promoted to a development of a new optical sensor. Most of the commercially available oxygen sensors are based on chemi-absorption sensors [1-3]. These types of sensors have their own drawbacks and have been discussed in previous report [4]. One of the main disadvantages is that they are not selective to a single gas alone especially when detecting the gas in the presence of other atmosphere gases [5]. Therefore a development of a new oxygen sensor using an optical method is necessary as an alternative method. In this research, the potential

future development of an optical oxygen sensor in the UV region between 200-230 nm is reported.

1. INTRODUCTION

The monitoring systems for oxygen gases are widely demanded in various applications such as for the chemical processes, atmospheric monitoring and automotive industry. To satisfy the demand, many methods and techniques have been explored and developed by the researchers.

The conventional sensor used for oxygen detection is based on colorimetric [6], semiconductor [7], catalyst combustion [8-11], and electrochemical sensor [12-14]. The major weakness of colorimetric method is slower response reversibility, harder to reset the detector quickly and cannot measure instantaneous oxygen levels [15]. Semiconductor type sensor has several weaknesses such as high input power, lower resolution, higher temperature and humidity dependence, difficult to achieve sensitivity, selectivity and specificity in presence of mixture gases [15-16]. Catalyst-combustion and electrochemical sensors particularly have lower humidity and temperature dependence, lack of long-term sensitivity and tend to suffer from possible cross-contamination or poisoning effects of some gases and vapor [15].

2. RESEARCH METHODOLOGY

Open-path technique is one of the most common methods in gas detection using the spectroscopic principles for the optical fibre sensor. This technique is widely used because it allows a significant proportion of the light sensed by the detector interacted with the test gas and it is capable to simultaneously detect different gas substances in mixture at real time. Open-path technique for this optical sensor is the open-path absorption sensor that is designed to monitor the absorption spectral lines of oxygen and then evaluate the cross sensitivity of oxygen with other atmosphere gases such as carbon dioxide (CO_2) and water vapor (H_2O). The technique is best suited to measure gaseous compounds because of the unique characteristic of each compound that allowed their identification.

In the development of the sensor, the optical fibre is one of the main players. Theoretically, light travels in straight lines and reflecting off headed obstacles. But, optical fibres allow light to travel in any direction and bending around corners. Optical fibres are capable of carrying more information over longer distances. A single mode optical fibre can transmit trillions of bits per second when the signals are wavelength multiplexed.The experimental setup is shown in Figure 1. Ultraviolet (UV) light source used was the DH-2000 from Ocean Optics which was a Deuterium-Halogen lamp. Type of fibre used to transmit the light from the light source was a 600 µm core size Optran UVNS, UV Non Solarising. Two collimating lens were placed at both ends of the gas cell which approximately 1 cm in diameter and 54 cm long. The lenses were used to focus the incident and transmitted light. Next, the transmitted light was then passed through another optical fibre at the other end of the gas cell to the light detector. Maya2000 spectrometer from Ocean Optics was used as the light detector. The spectrometer which provides resolution to 0.65 nm (FWHM) has from 190 to 1100 nm range was connected to the computer with Spectrasuite software installed. Ocean Optics developed the software for the benefit of the users to have data acquisition from the spectrometer and able to perform data processing of the initial and transmitted intensity of the analysed gas.

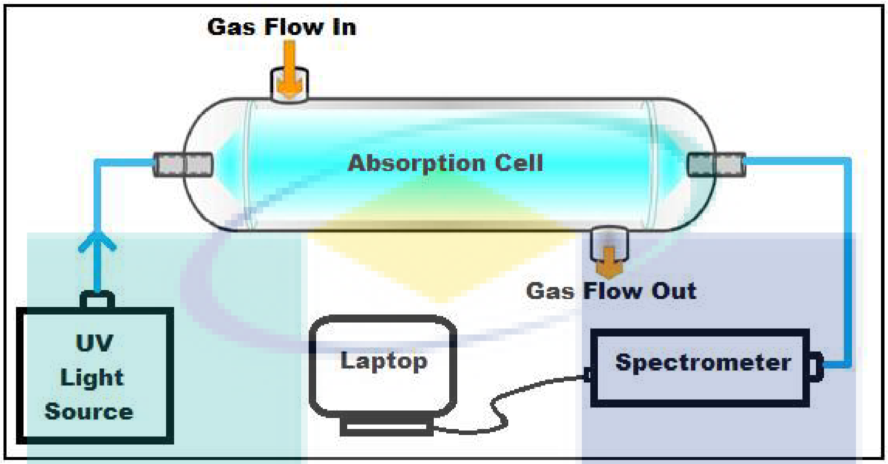

Figure 1: Generic design of the oxygen sensor.

3. LITERATURE REVIEW

The oxygen sensor is also reported and developed previously by using different technology such as MEMs [16-17] and MOS sensor [18-20] which have their own disadvantage. One of the main disadvantages is that they are not selective to single gas detection alone.

There are various types of oxygen sensor [21-24] were developed for applications in industry and research, but the oxygen optical fibre sensor is more applicable for the automotive industry due to its immune to high temperature, fast response, no electromagnetic interference and can be easily measured in mixed gases content [25]. Every different gas species absorbs light at a different wavelength. Therefore, it gives the gas its own special absorption characteristic and for oxygen gas, it has its own absorption line. Figure 2 below shows an absorption cross-section line of oxygen gas recorded by many researchers since 1971. As it can be seen from Figure 2, the line for oxygen varies and the rate of absorption is different. However, the curve is almost similar where the rate of absorption is descending from 200 nm to 230 nm. This is common due to too many factors such as different light source and detector used. Temperature difference will also affect the rate of absorption.

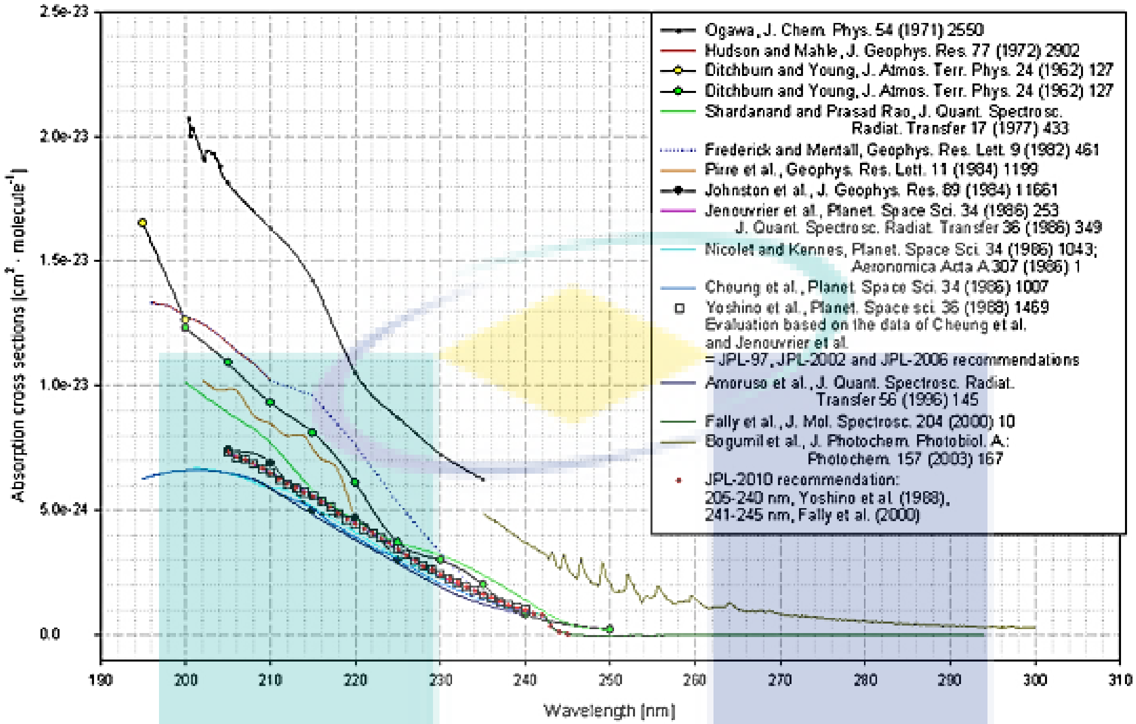

Figure 2: Theoretical data of oxygen absorption spectrum

Based on Figure 2, it can be seen that the theoretical absorption cross section of oxygen gas absorbs light within the wavelength range of 195 nm to 235 nm. However, the absorption study for this oxygen gas is restricted to 200 nm – 230 nm wavelength range as the gas absorption spectrum has a decent absorption at this range. Hence, there is some potential point will be selected for detection of oxygen gas in the UV region for this optical fibre sensor development. Therefore, the cross sensitivity studies must focus on this wavelength range of (200 nm – 230 nm) for any gas interference observation and testing. It is important to determine absorption wavelength to avoid any cross-sensitivity issue with surrounding gases existing within the vehicle exhaust.

4. FINDINGS

The result of the measured oxygen is shown in Figure 3. It shows an absorption cross-section spectra of 99.9% pure oxygen gas and its trendline using a spreadsheet. The trendline is set to a polynomial with a degree of two. Figure 3 also shows the theoretical absorption cross section for oxygen reported previously by many researchers [26-28]. It can be seen the shape of oxygen trendline has a similar shape to the theoretical data provided. The experimentally measured spectra have higher absorption values as compared to the theoretical lines. As explained earlier, this is common due to many reasons such as the type of light source used and different type of detector. It can also due to temperature difference which may result in different absorption values. It is also clearly seen in the graph that the measured line has much better resolution compared to the others. This oxygen detection setup is much better for future development of the oxygen sensor as the exact wavelength can be selected for the purpose of detection.

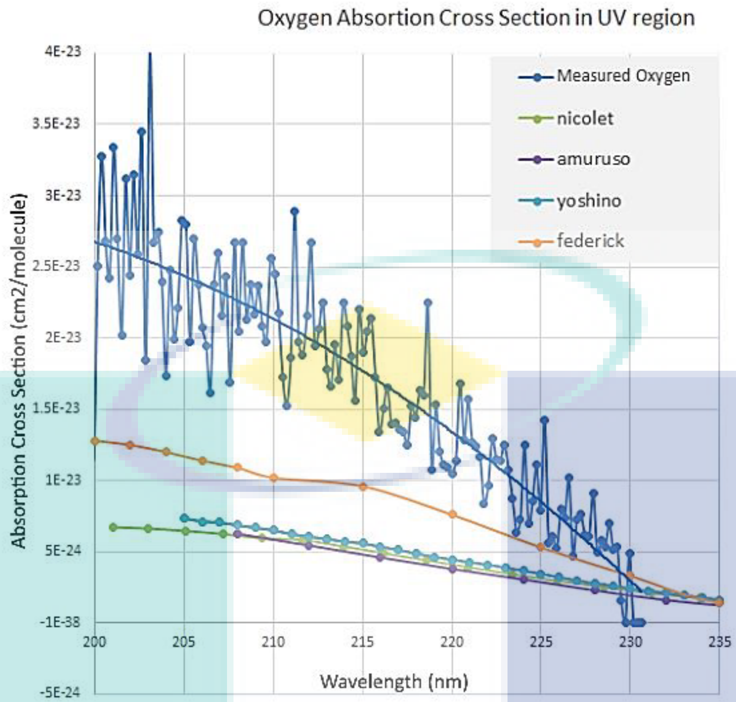

Figure 3: Oxygen absorption cross section spectrum between 200 nm and 230 nm.

5. CONCLUSION

This research has reported that a potential development of a UV optical fibre based sensor for the detection of oxygen. The result has shown that the setup is able to detect oxygen at a range of 200 nm – 230 nm and the trendline for measured oxygen displayed has a similar shape with the spectrum from the MPI Mainsz database. This initial result is crucial in the development of the UV based oxygen optical fibre sensor in the future. Future work will focus on the cross sensitivity of other car exhaust gases such as carbon monoxide, sulfur dioxide, water vapour, etc.

ACHIEVEMENT

i) **Name of articles/ manuscripts/ books published**

a. The Potential Development Of Oxygen Optical Fibre Gas Sensor For Automotive Industry, Journal of Telecommunication, Electronic and Computer Engineering (JTEC), Vol 10, Issue 1-3, Pg 1-4, 2018.

b. Spectra Comparison For An Optical Breathing Gas Sensor Development, AIP Conference Proceedings 1835, 020035 (2017); https://doi.org/10.1063/1.4981857

c. An Ultraviolet Halitosis Detection Using An Open-Path Optical Fibre Based Sensor, International Journal of Engineering Inventions, e-ISSN: 2278-7461, p-ISSN: 2319-6491,Volume 7, Issue 5 [May 2018] PP: 25-30

d. A Review on Optical Fibre Sensor Topology and Modulation Technique, International Journal Of Engineering Technology And Sciences (IJETS) Vol.7 (1) June 2017

ii) **Title of Paper presentations (international/ local)**

a. The Potential Development Of Oxygen Optical Fibre Gas Sensor For Automotive Industry-4th International Conference On Electrical, Control And Computer Engineering, Inecce17. Langkawi

b. A Potential Development Of Haze Detection System Using An Open-Path Optical Method-3rd International Conference On Electrical Engineering And Electronics Communication System (Iceeecs 2017)- Vietnam

iii) **Human Capital Development**

Masters graduate- PEK18001 Nurulain Nadhirah Binti Shaipuzaman

iv) **Awards/ Others**

CITREX2017 – Silver medal

v) **Others**

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