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Optimum Wavelength for Oxygen Detection using optical absorption

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Abstract.

Oxygen gas detection systems are used in many areas such as environment, clinical, food and automotive industries. Most of the detection systems are based on chemical absorption sensing method. This type of sensing method has their own drawbacks. Therefore, a development of a new oxygen sensor using an optical method is necessary as an alternative to the current sensors. A preliminary study on the molecular absorption cross section for oxygen gas is vital to determine the optimum wavelength is reported. The experimental setup consists of four major components which are light source, gas cell, detector and optical fibre cable. For the light source, a deuterium-halogen bulb will be used as it can provide a broadband wavelength light source from 215 nm – 2500 nm. A miniature spectrometer will be used as the detector and the gas cell is connected to the light source and detector using the optical fibre cables. A software package to display absorption of oxygen molecules is installed in a computer to study on the optimum wavelength. The experiment results show that the light is most absorbed at 230 nm and absorption is increased by cell length. The highest absorption was observed to be in a 100 cm gas cell length with pressurized 5 bar of 99% pure oxygen gas. Based on this result, a wavelength of 230 nm is selected as optimum wavelength to detect oxygen.

1. Introduction

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 chemical absorption sensors which are based on chemical components that can react with oxygen gas [1–3]. This will change the electrical properties of the chemical components and change the electrical properties parameter of the material such as resistance, capacitance or conductance [4–6].

The changes of these parameters will then be measured to quantify the gas concentration. These types of sensors have their own drawbacks and have been discussed in previous paper [7]. 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 [8]. Therefore, a development of a new oxygen sensor using an optical fiber to transmit light is necessary as an alternative to the current sensors. As for the initial stage a study on the molecular absorption cross section for oxygen gas is vital to determine the optimum wavelength to work on. This is a crucial step in the development of an optical fiber based sensor as reported in many researches[9–11].

Figure 1 below shows an absorption cross-section line of oxygen gas recorded by many researchers since 1971 from Max Plank Institute. As it can be seen from Figure 1, the line for oxygen varies and the rate of absorption is different. However, the curve is shown that rate of absorption is descending from 200 nm to 230 nm. This is common due to too many factors such as Temperature difference, different light source and detector.

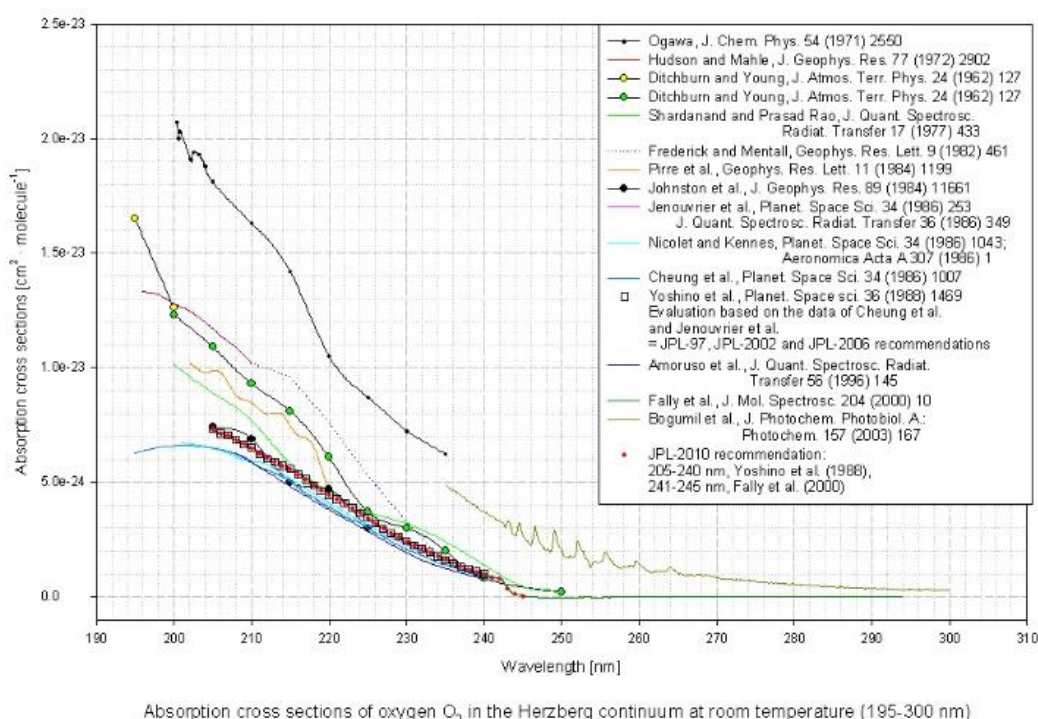


Figure 1. The MPI-Mainz UV/VIS Spectral Atlas of Gaseous Molecules of Atmospheric Interest

2. Methodology

An experiment on the molecular absorption for oxygen gas already done determine the optimum wavelength to work on.

The main component of experiment

- DH2000-BAL provided by Ocean Optics Inc. combine deuterium and halogen light source. The combination of this two light source will provide continuous light in the wavelength of 200 nm until 2500 nm which will cover the whole UV region
- A stainless steel gas cell (8 mm inner diameter) with different length from 10cm until 100cm was mounted with collimating lens at both ends will be used to measure the O₂ absorption line.
- A miniature spectrometer, HR2000 from Ocean Optics to detect the UV absorption
- SpectraSuite software provide by Ocean Optics Inc. is being used as the software to calculate, analyse and obtain the absorption graph of oxygen gas.
- A pressurize 99% pure oxygen gas source. Pressurize oxygen about 5 bar was used to boost the absorbance of UV light in the cell.

The arrangement of the experiment components are shown in Figure 2 below.

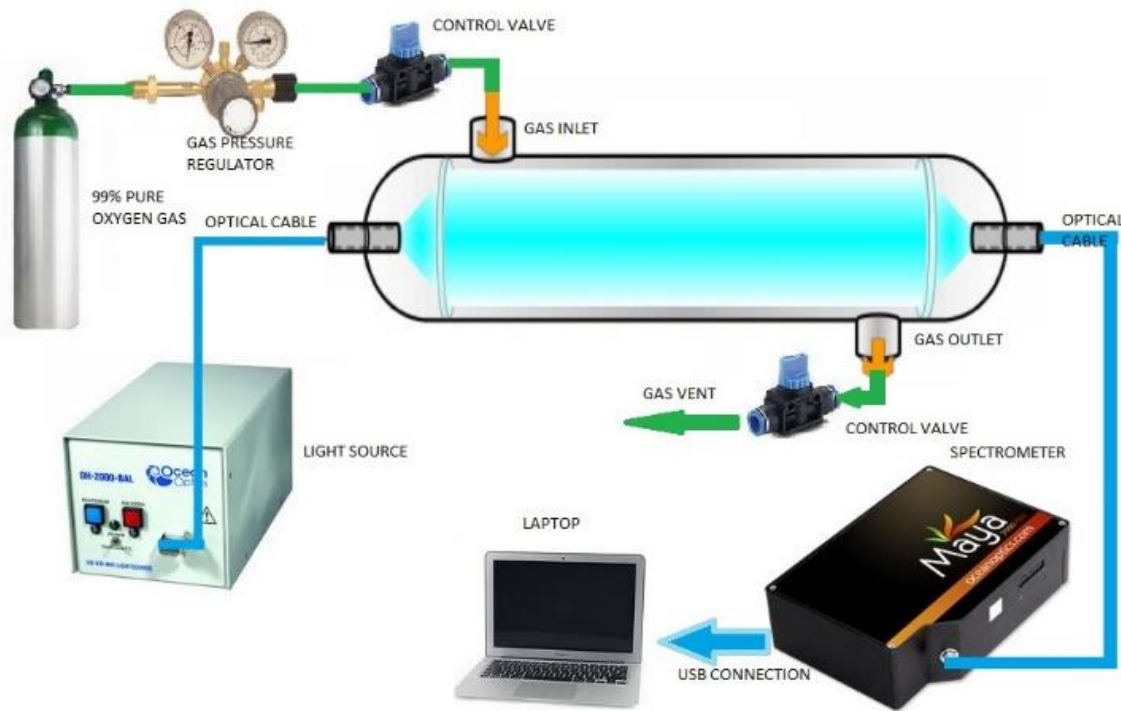


Figure 2: Experiment Setup

The experiment is carried out in a lab where the surrounding temperature is approximately 25 Celsius. Before oxygen is measured and pressurized, oxygen gas is released into the gas cell and air vent valve is open to remove any available gases. About 30 sec the air vent valve is closed.

The light source is switched on for 15 minutes to stabilize the intensity. Once oxygen gas is released and pressurized to 5 bar into the test cell, the intensity reading is recorded using Spectrasuite software provided by Ocean Optics Inc. The integration time is set to 1 s. Absorption of the transmitted beam by oxygen gas is detected by the miniature spectrometer.

3. Result and Discussion

The absorption graphs were recorded in different gas cell length. For 10 cm length, refer to the Figure 3. For 25 cm length, refer to the Figure 4. For 50 cm length, refer to the Figure 5. For 100 cm length, refer to the Figure 6.

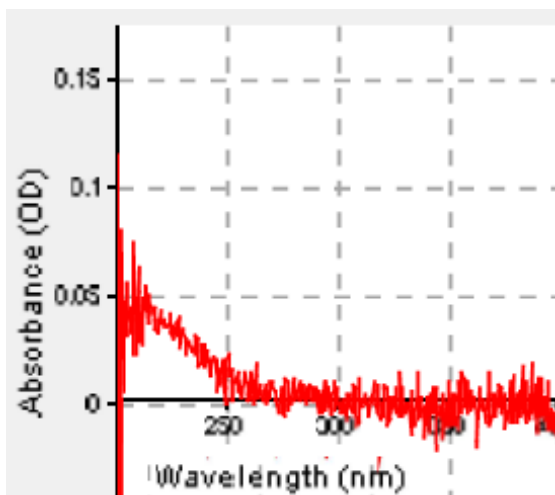


Figure 3. Absorption Graph in 10cm gas cell

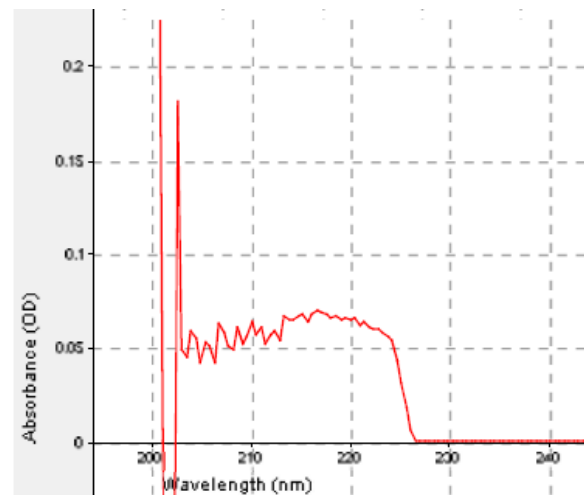


Figure 4. Absorption Graph in 25cm gas cell

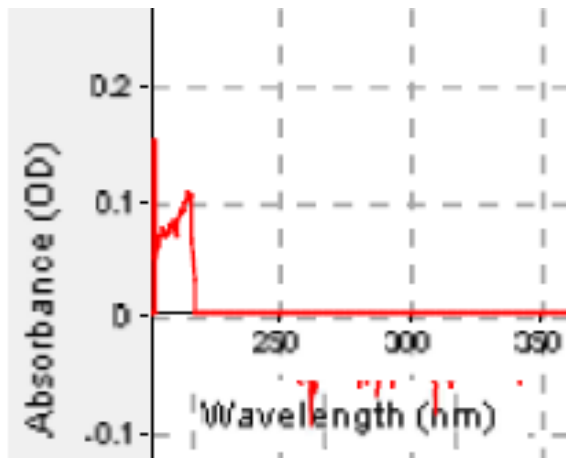


Figure 5. Absorption Graph in 50cm gas cell

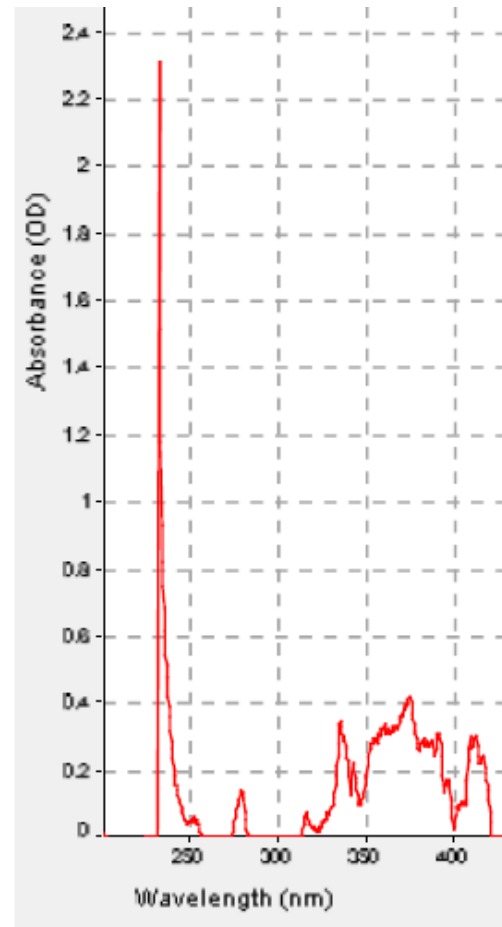


Figure 6. Absorption Graph in 100cm gas cell

Referring to all the graphs, absorption of oxygen region is about 210 nm to 220 nm range. The clear range can be seen in Figure 4. From the experiment, it is clear the absorbance of oxygen was depending on the cell length. Absorption rate of light source was proportional to the cell length. The experimentally measured spectra have less range of region compared to the past research finding due to many reasons such as the type of light source used, different type of detector and temperature difference which may result in different absorption region, but the range from this experiment still in range as others finding [12].

4. Conclusion

From this experiment, it has reported that a potential development of a UV optical sensor for the detection of oxygen. The result has shown that the setup is able to detect oxygen at a range of 210 nm – 220 nm wavelength. It is clear that more absorbance can be seen in longer cell length. This initial result is crucial in the next development of optical based oxygen sensor hardware selection to work in the selected wavelength.

5. References

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