



Measurement of Benzo[a]pyrene Concentration in Tobacco Combustion using MQ-6 Gas Sensor

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ABSTRACT– Benzo[a]pyrene is one of the compounds from the Polycyclic Aromatic Hydrocarbons (PAHs) group that is found in various places as a by-product of combustion. In addition, this compound also has carcinogenic properties so it has a bad impact on human health. Therefore, research is needed to detect the presence of benzo[a]pyrene compounds by designing a measurement system for this detection, especially in burning tobacco. The measurement system that has been designed uses a RobotDyn Mega WiFi 2560 microcontroller and an MQ-6 gas sensor that has been calibrated with benzo[a]pyrene compounds. The results showed that the concentration of benzo[a]pyrene detected when burning tobacco at a mass of 0.33 gram was 4.86 ppb, 7.38 ppb for 0.436 grams mass burning, and was 8.81 ppb for burning at a mass of 0.52 grams. Therefore, this measurement system has been able to detect benzo[a]pyrene compounds.

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Introduction

Air pollution is an important global issue that requires serious attention due to its impact on human health and air quality [1]. Increased concentrations of air pollution can also be caused by organic compounds such as benzo[a]pyrene that cause the air to become contaminated[2]. Benzo[a]pyrene is a Polycyclic Aromatic Hydrocarbons (PAHs) present in many places as a by-product of incomplete combustion and pyrolysis of carbon-containing fuels[3]. Benzo[a]pyrene is the most carcinogenic of the various polycyclic aromatic hydrocarbons (PAHs) and is commonly used as an exposure marker for risk assessment[4]. Benzo[a]pyrene found in cigarette smoke can cause significant DNA damage in smokers lung tissue[5]. In addition, it can increase the HPV virus, which is a group of viruses that can trigger the growth of warts on various parts of the body, up to 10 times, which accelerates the likelihood of cervical cancer[6].

Benzo[a]pyrene was detected in burning tobacco with different types of tobacco. In the study[7], the concentration of benzo[a]pyrene detected in tobacco combustion results from 0.42 ng g⁻¹ to 79.7 ng g⁻¹. Benzo[a]pyrene has also been shown to induce oxidative stress and inflammatory responses in HIV-infected astrocytes and macrophages[8].

There are several sensors and methods used for the detection of benzo[a]pyrene compounds. One of them is an affinity sensor developed to detect benzo[a]pyrene in river water[9]. In addition, benzo[a]pyrene can also be detected with fluorescent sensors[10]. There is also a method

conducted for the detection of benzo[a]pyrene in edible oil using a SERS-based method[11].

Based on the description that has been described, a monitoring system for benzo[a]pyrene compounds using an MQ-6 sensor was developed. According to the datasheet from [12], it is explained that the MQ-6 sensor can detect LPG, iso-butane, and propane compounds with high sensitivity. However, in this study the sensor is used to detect the concentration of benzo[a]pyrene compounds contained in the source to be tested, namely charcoal. The MQ-6 sensor is used because the sensor is able to detect various gases. This monitoring system uses the RobotDyn Mega WiFi 2560 microcontroller.

Material and Methods

A. System Design

In this measurement system, the MQ-6 gas sensor is used to detect the concentration of benzo[a]pyrene. This sensor is sensitive to LPG, iso-butane, and propane with a measurement range of 200 ppm - 10,000 ppm [12]. This system is equipped with a microcontroller to process the signal so that it can be used for the MQ-6 sensor to detect the concentration of benzo[a]pyrene. The microcontroller used is RobotDyn Mega WiFi 2560, where this module has been integrated with the internet by having an ESP8266 module. The processed analog signal will be sent through the microcontroller module and will be processed and obtained

sensor readings in the form of ppb. Data that has been converted into ppb will be sent to RobotDyn Mega Wifi 2560.

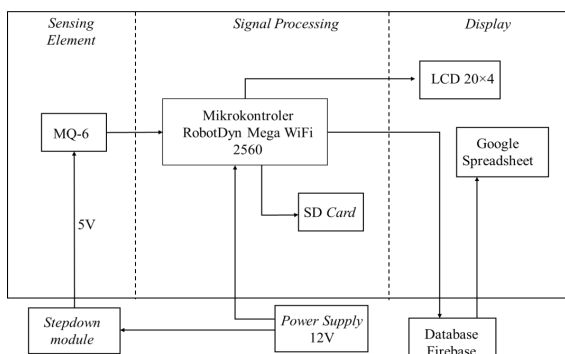


Figure 1 Block diagram of measurement system

B. Callibration

This calibration test was carried out with the aim of ensuring that the sensor work system has the appropriate sensitivity and accuracy values. Then the main purpose of this test is to adjust the MQ-6 sensor to compare the ratio value (R_s / R_0) with the concentration value in ppb (parts per billion). This test is very important to determine the work of the sensor in the process of detecting and measuring benzo[a]pyrene compounds.

The first step in this calibration test was to make a concentration solution. The solution consists of benzo[a]pyrene solids dissolved using 70% methanol in a ratio of 1:5. Furthermore, the concentration calculation is carried out through several processes such as determining the total mass evaporation rate, the total volume evaporated, the volume of each compound, and the concentration of each compound. This calibration test uses a variety of evaporation times including 10, 50, 100, 500, 1000 seconds. The results of the calibration obtained an equation that will be entered into the program code.

C. Measurement

Measurement of benzo[a]pyrene concentration was conducted by burning tobacco in the emission collection chamber. The process of this measurement stage is carried out by measuring the mass of each sample as the initial mass which was used as a calculation of burned mass. After the tobacco was burned, the pump was activated to flow the emissions into the measurement chamber and then injected to the measurement system to be detected using an MQ-6 sensor. Each test was repeated 3 times with the same mechanism in each test.

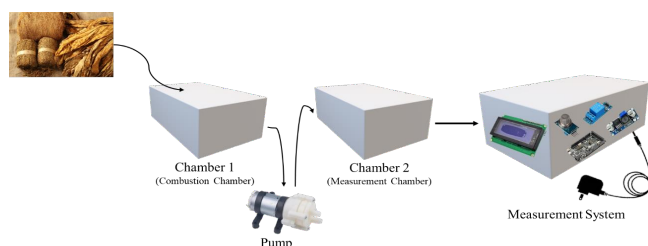


Figure 2 Measurement setup

Results and Discussion

A. Sensor Validation

In this calibration test, the first step was to calculate the value of R_0 , which is the resistance of the sensor to ambient air in a constant state. After that, the value of R_s , which was the resistance value of the sensor under certain conditions when the sensor is exposed to gas during the sensor validation test, is calculated. The R_s value was obtained from the voltage generated by the sensor when was exposed by the gas.

This calibration test uses the mole fraction method which is the ratio between the number of moles (n) of a component to the number of moles of all components in the solution. This fractionation is a method for separating extracts based on different levels of solubility[13]. In addition, this fractionation aims to separate compounds based on their polarity, so that the number and type become different fractions[14]. The mole fraction calculated in this calibration process is from benzo[a]pyrene compounds and methanol compounds

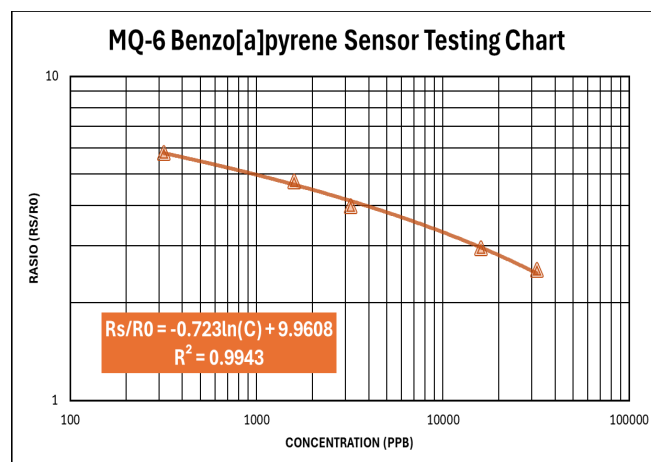


Figure 3. The calibration graph

After the calibration process is carried out, the equation used to measure the concentration of benzo[a]pyrene in ppb units is obtained. The equation obtained is shown in Equation 1.

$$R_s/R_0 = -0.723 \ln(C) + 9.9608 \quad (1)$$

B. System Testing on Tobacco Combustion

The concentration of benzo[a]pyrene obtained varies based on the mass variation burned. In Table 1, the concentration data formed from 3 times the test results were obtained. The lowest concentration obtained was 4.86 ppb with a mass of tobacco burned as much as 0.33 grams. Then the highest concentration obtained was 8.81 ppb with a mass of tobacco burned was 0.522 grams.

Table 1 Concentration of benzo[a]pyrene in tobacco burning

Type	Mass Burned (gr)	Concentration (ppb)
Tobacco leaf	0.33	4.86 ± 3.24
	0.436	7.38 ± 4.13
	0.522	8.81 ± 5.17

The graph of benzo[a]pyrene concentration measurement in burning tobacco is shown in Figure 4.

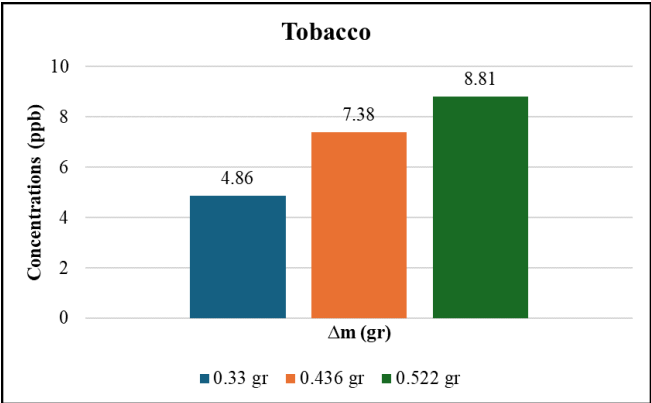


Figure 4 Measurement results of total benzo[a]pyrene concentration from tobacco burning process

Based on the results of the tobacco combustion data obtained, the increase in benzo[a]pyrene concentration can be influenced by various factors during the data collection process. Then from the data, it can be concluded that the more mass that is burned, the higher the measured concentration. Tobacco combustion emissions containing benzo[a]pyrene compounds can have an impact on human health and the environment. The impact on human health caused by these emissions is liver cancer, bladder cancer, cervical cancer, and ovarian cancer[15]. In addition, the impact on the environment is an increase in air pollution in the surrounding environment[16].

Conclusion

In this study, we have succeeded to measure benzo[a]pyrene emitted to tobacco combustion by using MQ-6 gas sensor. The concentration of benzo[a]pyrene emitted by tobacco combustion depends on the burned mass.

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