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AN ARCHITECTURAL AVENUE OF ELECTRO-OPTICAL BIOSENSOR ACTIVITIES FOR THE DETECTION OF FORMALIN ADULTERATION IN PRESERVED FOODS PACKAGING

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Abstract

Formalin is a highly toxic and hazardous agent, but it is fraudulently added in food to prevent food spoilage. Recently, various cases were reported of difficulty in breathing, cancer, asthma, and allergy, damage of pulmonary, poisoning and even death due to consumption of formalin from food. Therefore, formaldehyde should not be used in any food products and to ensure formaldehyde free products, sensitive, simple and fast techniques for detecting formaldehyde in preserved food are increasingly important. For this purpose, a simple Electro-optical biosensor was developed. Electro-optical biosensor is Photovoltaic which gives output in the form of voltage by converting some amount of incident light into voltage. The sample absorbed some part of light from LED which passes through it. The sample also transmits some amount of light which falls on the LDR (photodetector) which generates a voltage proportional to the amount of light falling on it and using ADC, voltage is converted to digital values. This voltage values are then fed to a microcontroller, which is programmed to convert voltage values to optical density which is displayed on the LCD. The detection limit ranges from 0.5 to 2 ppm. The proposed electro optical sensor has potential advantages owing to its rapid response to high reproducibility, high selectivity, repeatability, reliability and real- time procedure for analysis of formalin concentration.

Keywords- Biosensor; Preserved food; Formalin; Electro-optical properties.

1. INTRODUCTION

Formalin is a 37% solution of formaldehyde and is widely utilized in medicines and antiseptics, textiles, papers, plywood, paint and plastic industries [1-2]. Its application is extended further as food preservatives found in dried mushrooms, dried foods, some Italian cheeses, and fish to prevent microbial deterioration and extend shelf life [3-9]. The prolonged exposures to formalin cause, many health issues in consumers as formalin is an allergenic, harmful, carcinogenic and lethal as well beyond certain concentration [10-12]. It causes symptoms like difficulty in breathing, burning in the eyes, irritation of nose and throat, headaches, aggravate symptoms of bronchial asthma, necrosis of mucous membranes, ulceration, coughing [13] and laryngospasm [14]. It is classified as a human carcinogenic agent by the International Agency for Research on Cancer (IRAC) [15-17], the World Health Organization (WHO) and the US Environmental Protection Agency [18]. Hence an accurate, precise and sensitive analysing technique is necessary to ensure formalin free products. Several standard techniques such as gas chromatography, fluorometry HPLC, visible absorption and colorimeter, are used to determine the formalin concentration [19-23]. Unluckily, these conventional techniques involve costly and massive apparatuses, time delay, lack selectivity and impracticable to the real time analysis of formalin concentration [24]. For this purpose, sensitive, simple and fast electro-optical biosensor was designed to sense the formalin concentration in preserved food.

2. MATERIALS AND METHODS

2.1 Materials and techniques required

To design and develop a simple Electro-optical sensor, materials used were, A cardboard box, A LED light source (UV purple LED Light), A photodiode and Connecting wires.

The project was designed on the basis of following parameter constants and techniques.

- Source of light source: LED (UV purple LED Light), wavelength 390 to 395nm
- Photodetector: Light dependent resistor (LDR)
- Platform: Arduino UNO
- Microcontroller: Microchip ATmega328P
- Software: Arduino IDE (Integrated Development Environment) Input Voltage: 7 to 20 Volts

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- Operating Voltage: 5 Volts.

2.2 Installation and Configuration of Arduino IDE

Step 1: Select a suitable board. In this study Arduino UNO was used, for which the standard USB cable required is shown in fig-1.

Step 2: Download the Software (Arduino IDE)

Arduino IDE comes in various versions which are available on Arduino Official website; it can be downloaded from the Download page. Depending upon the software compatibility with different operating system like Linux, Windows and IOS; select the software. Once the file is downloaded, the folder should be unzipped (Fig-1).

Step 3: Power up the Arduino board.

Arduino can be powered either by USB connecting to PC otherwise through an external power supply. Using USB connect the Arduino to PC, if the power is supplied correctly to the board the green LED should glow.

Step 4: Launch software.

Once software downloaded successfully, file should be unzipped. After opening the folder, there will be an icon indicating infinity label; to begin IDE select the application.

Step 5: Open the first project.

Two options will appear once you run the software: For creating new project:

Go to File → New.

For opening a built-in example:

Go to File → Examples → Basics → AnalogReadSerial

Step 6 − choose the board.

Select the right board name that should match with the board associated with the PC in order to avoid errors occurring during uploading the program to board. Select Tools → select board.

Step 7 − choose the serial port.

After selecting your board, now pick serial port. Select Tools → Serial Port. This is possibly going to be COM3 as for hardware serial ports COM1 and COM2 are generally reserved.

Step 8 – Uploading program to the board.

Click the on "Upload" button to upload the program. If the TX and RX LEDs flashes on the board then the program is uploaded successfully and in the status bar a message "Done uploading" will appear.

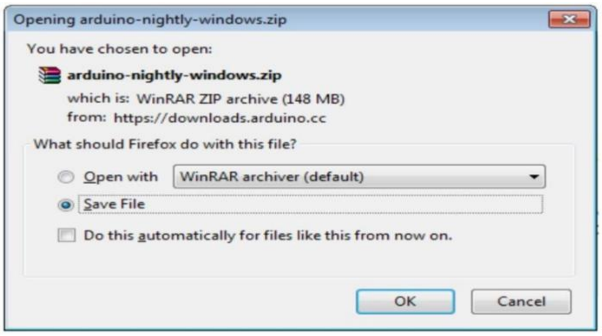

Figure 1 Download the Software

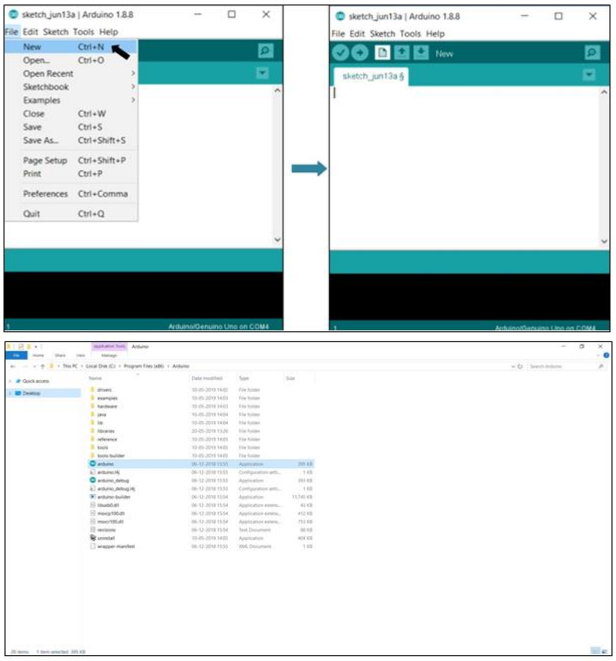

Figure 2 Launch software

2.3 Assembly of the components of the sensor:

To design and develop a simple Electro-optical sensor, following materials were used

- A cardboard box
- A LED light source (UV purple LED Light)
- A photodiode
- Connecting wires

A closed provision is made to load samples into the sensor using cardboard. In one side of the chamber a LED (Ultra Violet LED UV Light) is fixed and on the other side of the chamber an LRD is placed to detect the transmitted light from the sample placed between the LED (light source) and the LDR (Fig. 3).

The sample chamber is connected to the Arduino board through two resistors. The voltage generated by the LDR is fed to the Arduino where the analog values change to digital values and microcontroller is programmed to change the voltage to Optical density. Further board was connected to LCD for displaying optical density (Fig. 4 and 5).

Figure 3 Sample chamber, with a LED (light source) in one side and a LRD on the other side of the chamber

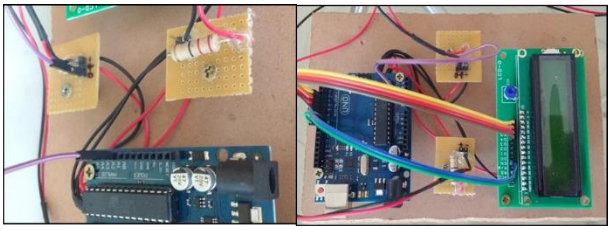

Figure 4 Connection set up of sample chamber, Arduino board and LCD

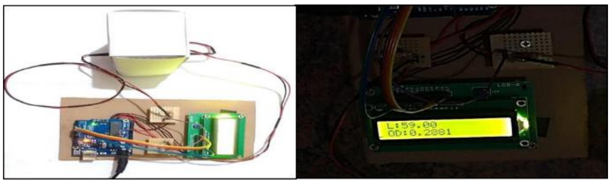

Figure 5 Setup of the Electro-optical biosensor

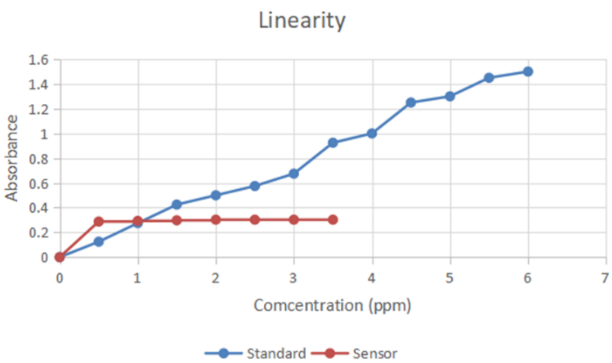

Figure 6 Linearity curve of the Electro-optical biosensor

Table 1 Optical density data for varying HCHO concentration using biosensors

Concentration (ppm)	0	0.5	1	1.5	2	2.5	3
OD @ 390nm	0.2881	0.2930	0.2979	0.3027	0.3027	0.3027	0.3027

Table 2 Absolute error/Relative error data for varying HCHO concentration using biosensors

Concentration (ppm)	0.5	1	1.5	2
Absolute error	0.1631	0.018	-0.1271	-0.1973
Relative error	1.3048	0.065	-0.2990	-0.3946

3. RESULT AND DISCUSSION

3.1 Determination of Standard curve

Table 1 illustrated the Standard graph of Optical density data vs varying HCHO concentration using electro optical sensor

3.2 Formalin Detection using Electro-optical biosensor

Electro optical sensors was used for analysing formalin concentration quantitatively. For diverse concentrations of formalin (0.5 -2 ppm), Sensor characteristics such as Accuracy, Range, Span and Linearity was checked thrice.

3.2.1 Accuracy Assay

For diverse concentrations of formalin (0.5 -2 ppm), Sensor characteristics such as Accuracy, Range, Span and Linearity was checked thrice. Table 2 illustrate Absolute error/Relative error data for varying HCHO concentration using biosensors

3.2.2 Range and span assay

Electro optical sensor can detect maximum value of 3027 and minimum value of 2881 and also span value of 146

3.2.3 Linearity assay

For diverse concentrations of formalin (1, 3, and 6ppm) linearity of sensor was checked thrice. Figure 4 illustrate linearity curve of electro optical sensor.

4. CONCLUSIONS

At present, several standard techniques such as gas chromatography, fluorometry HPLC, visible absorption and colorimeter, are used to determine the formalin concentrations present in food. Unluckily, these conventional techniques involve costly and massive apparatuses, time delay, lack selectivity and impracticable to real time analysis. So far very few sensors are designed for the real time determination of formalin concentration. In this work a simple Electro-optical biosensor was developed. Electro-optical biosensor is Photovoltaic which gives output in the form of voltage by converting some amount of incident light into voltage. Then a microcontroller is programmed to convert this voltage values to optical density which is displayed on the LCD. The detection limit ranges from 0.5 to 2 ppm. The proposed electro optical sensor has potential advantages owing to its rapid response to high reproducibility, high selectivity, repeatability, reliability and real- time procedure for analysis of formalin concentration.

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CONFLICT OF INTEREST

There is no conflict of interest to declare

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