Food Adulteration Detection using Microcontrollers and Sensors

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Bachelor of Technology

in

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CERTIFICATE

This is to certify that the work contained in this report entitled **"Food Adulteration Detection using Microcontrollers and Sensors"** is submitted by the group members Mr. Harsh Hegde (Roll. No: 16ECE1007) and Mr. Rahul Rajesh (Roll. No: 16ECE1019) to the Department of Electronics and Communication Engineering, National Institute of Technology Goa, for the partial fulfillment of the requirements for the degree of **Bachelor of Technology** in **Electronics and Communication Engineering**.

They have carried out their work under my supervision. This work has not been submitted else-where for the award of any other degree or diploma.

The project work, in our opinion, has reached the standard fulfilling of the requirements for the degree of Bachelor of Technology in Electronics and Communication Engineering in accordance with the regulations of the Institute.

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Abstract

There has been an alarming increase in Formaldehyde contamination in the Indian subcontinent in various edible products. Vegetables, fish, poultry and dairy products are most affected by this and it poses a threat to the health of the consumers. This thesis presents the complete design, implementation and testing analysis of a formalin detection kit based on microcontrollers and sensors.

As all volatile organic compounds such as formalin self-vaporise, the concentration of the VOC compound can be detected by sensing the presence of VOC gas using a volatile organic compound (VOC) sensor. The output signal from the gas sensor is fed to a microcontroller unit which converts the electrical signal into a digital value. A complete kit using display, alarm and sensor is implemented and tested and the results are validated by VOC sample solutions prepared in a chemical laboratory at different concentration levels.

Results show that detected levels of VOC compound are consistent with VOC concentration used in samples. The system also displays the humidity and the temperature of the given sample. The system gives out a sound alarm when excessively high level of adulterant is detected in samples which are regarded as dangerous for health. Additionally, comparative assessment shows that the detection kit analyses the samples quantitatively as well as qualitatively which makes our kit unique.

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Chapter 1

Introduction

Formaldehyde is a toxic substance known to have adverse effects on human health. It is known to cause irritation in the eyes, nose, skin and can also damage the nervous system. The liquid form of Formaldehyde, known as Formalin, is known to be widely used in chemical industries due to it's low cost and high reactivity.

Due to its extensive use and toxicity, formaldehyde is known to pose a significant danger to human health. Data collected from across the world and research supported by scientists has led the International Agency for Research on Cancer to classify formaldehyde as a known human carcinogen [1]. Studies have shown that there is a strong correlation between exposure to formaldehyde and the development of leukemia in humans. People exposed to formaldehyde in different professions, such as embalmers and other funeral industry workers, have an increased risk of developing leukemia and brain cancer as compared to the general human population [2].

In spite of all the dangers associated with formaldehyde, formalin has been reported to be added to food materials fraudulently to mask the smell and extend the shelf life of food in South East Asian countries. India, as a developing nation has experienced industrial and agricultural growth.

Along with the rapid growth, formalin, pesticides and chemical pollution has increased considerably in the past decade in almost all kinds of food such as vegetables, poultry, dairy etc. Merchants in India are known to add chemical pollutants to preserve food and make these look fresh and attractive in the market for longer periods, thus maximizing profits. Goa had its share of formalin adulteration scare when raids conducted by the Food and Drugs Administration in the fish markets found fish to contain high levels of formalin.

Formalin scare: Goa imposes 15-day ban on fish supply from other states

EXPRESS NEWS SERVICE
PANAJI, JULY 18

THE GOA government has imposed a 15-day ban on fish imports from neighbouring and southern states, in order to give its Food and Drug Administration (FDA) time to detect formalin in fish. Formalin, a carcinogen, is used as a preservative in storing fish.

The decision was announced at an urgent press meet called by Chief Minister Manohar Parrikar on Wednesday.

The state has been gripped with fear after the FDA found that fish being sold in the state had high levels of formalin. In the last few days, the FDA raided several fish markets, but later said the organic substance found in fish was within the permissible limit.

The matter took a political turn with the ruling party and Opposition not being able to reach a consensus on the permissible levels and the presence of the chemical in fish stocks. "This (the decision) is only as an abundant caution in the interest of the health of citizens, to avoid controversies and confusion," Parrikar said.

"The ban will be effective on trucks from all states. We will post officers and instructions will be issued to not to allow trucks carrying fish to enter the state," he said.

The chief minister gave the state machinery 15 days to make arrangements for a permanent facility to check and test levels of formalin and other chemicals in fish.

"I don't want any confusion. Fish is a staple food. Let FDA set up proper facilities in the meantime to ensure that testing is done regularly and frequently. We do not have enough facilities. It (fish consignments) is coming from all sides, you require teams. The ban has been imposed under FDA laws," he said.

Rough estimates suggest that 200 tonnes of fish is imported everyday to Goa and the ban is likely to lead to a shortage of fish in the state. Due to the ongoing Monsoon, it is difficult to venture into sea to catch fish.

The FDA conducted a first set of raids and before the results could come from the laboratory, they claimed that the formalin was within permissible limits in the seized fish.

While the raids were in progress, fish traders had protested and approached MLAs of their areas. The issue took a turn for the worse after tourists and local residents started avoiding fish in markets.

Parrikar didn't comment on any of these issues, or on the FDA results. "I am not going into tests, since I have banned the fish. There is no point in discussing issues, which possibly no one has understood properly. So, I will not comment on that," he said.

SOMETHING FISHY ON THE TABLE PAGE 7

Figure 1.1: Formalin Adulteration in Goa
Source: The Indian Express

In a study at schools in Indonesia, children's meals were tested, and an alarming 49% of them were found contaminated with formalin [3]. A Survey conducted in Kandy market of Sri Lanka revealed that among 260 fish samples tested, in 34 samples formalin was used to prolong the shelf life of fish [4]. The lack of accurate methods to determine the presence of adulterant in food has made the detection of illegally adulterated food difficult.

Rumours of formalin in fish hits trade

Checks Show Fish Safe, Say Officials

Oppili P & Ekatha John | TNN

File Photo

HARD HIT: Fishermen of Kasimedu had been sending most of their catch to Kerala and are now affected

Chennai: Rumours that fish sent from Tamil Nadu to Kerala was laced with formalin has affected the trade in the state, particularly in Chennai. With a ban on fishing along the west coast in place, fishermen in places like Kasimedu in Chennai had been sending most of the catch to Kerala and other places. The quantum of the loss is yet to be ascertained.

In order to assuage buyers, officials of the fisheries department and the Food Safety and Standards Authority of India (FSSAI) conducted thorough checks at the fishing harbor and fish markets and found, apart from finding decayed fish in a couple of places, none laced with formalin. Search teams used a kit developed by Tamil Nadu Dr J Jayalithaa Fisheries University.

FSSAI officials said they were working with the fisheries department on the issue and that fish samples were collected and tested in Tuticorin and Kanyakumari districts.

The fishermen, however, do not seem satisfied. South Indian Fishermen Welfare Association president K Bharathi said the government instead of just conducting checks should also spread awareness among people. "The fish that had formalin traces were sent from Andhra Pradesh to Kerala and not from Tamil Nadu," he added.

Fishermen in the state had begun getting a good catch very recently after the ban ended but have again been hit by the rumours, he said. Tuna from Tamil Nadu was one of the most sought after in Kerala and used to fetch up to ₹120 per kg. Now, traders in Kerala have rejected it.

"There are no takers even after the price was reduced," he said.

Prof develops kit to check fish quality

Chennai: A kit developed by Jeyashakila, a professor at Tamil Nadu Dr J Jayalalithaa Fisheries University in Tuticorin, has come in handy to check quality of fish, especially to see if it is laced with formalin.

Jeyashakila, who is also the head of the Referal Laboratory at the university, said a sample of the fish skin has to be put in a vial with a diluent. A chemical is added to the mixture which reacts if formalin is present in it. If the mixture turns fluorescent yellow, it is positive. If the sample remains colourless, it is negative. The test takes about five minutes to check for the presence of formalin. Using one kit, 25 samples can be tested, she added. TNN

Figure 1.2: Formalin Adulteration in Chennai
Source: The Times of India

Knowing that food adulteration is increasing rapidly and considering the lack of user friendly and effective food adulteration detection kits, we know the importance and necessity of designing a system that can detect the presence of an adulterant instantly. This system designed with a sensor to detect the adulterant and a microcontroller system to process the data and alert the user.

1.1 Literature Review

There are many proposals about the ways in which volatile organic compounds such as formaldehyde can be detected in adulterated food. Numerous analytical methods, such as mass spectrometry-gas chromatography (MS-GC) [5], and high performance liquid chromatography [6] have been reported and used for the detection of formaldehyde in food materials. However, these are analytical and sensitive methods to detect adulteration which do not have field portability.

Electrochemistry is another method which can be used to detect adulterant but that has disadvantages due to signal interference by other compounds. Fluorometric methods [7, 8] have good selectivity, but fluorescent compounds that have good reactivity with formaldehyde have to be synthesised in order for this to work.

There have been several colorimetric methods that have been proposed for on-site formaldehyde detection which provide for rapid detection with visual qualitative feedback. These methods are based on the basic reaction between the amines and an aldehyde (reaction of electrophilic carbon of formaldehyde with aryl amines and nucleophilic alkyl) to induce changes in colour, such as chromotropic acids, sol-gel matrix [9], polymers [10], and porous glass [11].

These, however are non-degradable substrates and contribute to environmental problems which are not ideal. A solution is provided to this in [19], where a biodegradable colorimetric film has been proposed for determination of formaldehyde contamination [12]. Colorimetric film using gold nanoparticles and silver nanoparticles has been reported for better sensitivity [13]. Colorimetric methods however, provide only qualitative assessments.For quantitative analysis, a spectrophotometer is required which limit the field applications.

Chapter 2

Related Work

2.1 Formaldehyde Meter Z300

Formaldehyde Meter Z-300 has been used widely in India for detecting formalin in food items. In 2013 however, according to the report published by the Council for Scientific and Industrial Research, it was found inappropriate for detection as the Z-300 meter's measurement of formalin in fresh and soaked fruits differs according to moisture, temperature and time [14].

Figure 2.1: Formaldehyde Meter Z300. [14]

The meter indicated marginally inflated levels of formalin in fresh food stored in warmer temperatures. Later, a formalin detection kit for fish® using chemical solutions was developed by CSIR. The kit developed by CSIR has three types of solutions namely solution A, B and B. When testing on food materials such as fish, the cut parts of the fish were washed along with water and the washed-out water was then transferred to a test tube. Here around 14 drops of Solution A was added and the mixture was allowed to react for 40 seconds. If there was no colour change, 14 drops were added from solution B and allowed to react for 40 seconds. Finally, Solution C was added and if the colour of the mixture changed to either red or pink, the presence of formaldehyde in the food materials was confirmed. If there was no colour change, the food material was contamination free [6].

Limitations: This apparatus is probably suitable for expert users only to test collected samples in the laboratory. Moreover, detection depends on physical inspection of color papers used in test that require good eye sights and attention as well.

2.2 FOODsniffer

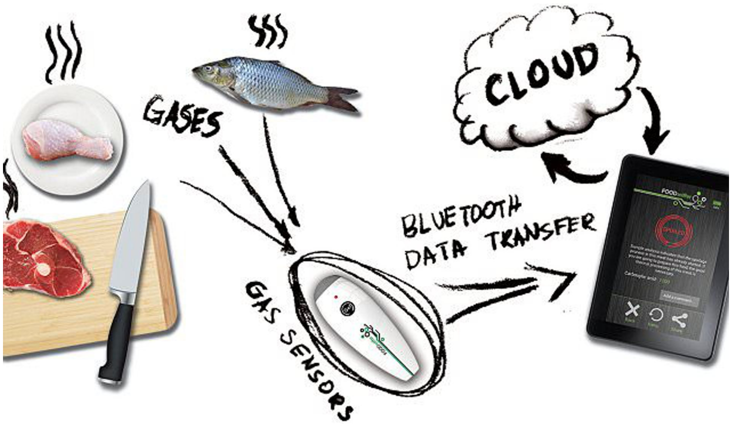

Figure 2.2: Working Principle of FOODSniffer. [14]

FOODsniffer: A smart portable kitchen gadget designed by Swiss scientists to check if fish, poultry or raw meat is starting to spoil, fresh or already spoilt.Bacteria that cause foodborne illness can make us sick before food looks, smells or tastes bad.

That means, we cannot always sense the spoilage by smelling the meat, poultry or fish with your nose or inspecting it with our eyes. But many volatile organic compounds are emitted by decomposing beef, poultry and fish that can be detected by volatile organic compound (VOC) gas sensor employed in FOODsniffer. This kit can determine if the edible products pose a health risk to us and have been left non-refrigerated for a prolonged period which may lead to food poisoning [14].

Figure 2.3: FOODSniffer

Limitations: This device gives only qualitative assessment of food samples under investigation whereas quantitative indication of any/specific harmful chemicals/agents present in food samples is missing that could limit its use in many applications, especially for law enforcing agencies and food inspectors to monitor quality and contamination of food, if any.

Chapter 3

Proposed method

Our proposed system aim is to include both qualitative and quantitative assessment of food samples. Formaldehyde can be naturally present in raw foods at low levels. This makes the quantitative analysis a certain necessity to detect those food samples where formaldehyde of high concentration has been added intentionally. Formaldehyde is a volatile organic compound with low boiling point (-19 C). This leads to a substantial amount of molecules evaporating through the aqueous solution of the compound (Formalin) and entering the surrounding air . This property is exploited for the measurement of adulterant concentration in samples.

Because, the conductivity in the surrounding air is directly dependent on the concentration in the sample. In open air, diffusion will occur quickly but if the sample is kept in a closed container better results can be obtained. The conductivity in sensor changes with the concentration of formaldehyde. More the level of concentration, higher the level of conductivity in sensor which is based on the ceramic substrate of sub-miniature Al2O3 based metal oxide semiconductor material

An output signal can be generated through this change of conductivity corresponding to the concentration of gas(ppm). The block diagram of the formalin detection kit is depicted in Figure 3.1 HCHO sensor is used as input device which is placed very near to food sample under investigation and the concentration of formalin is displayed.

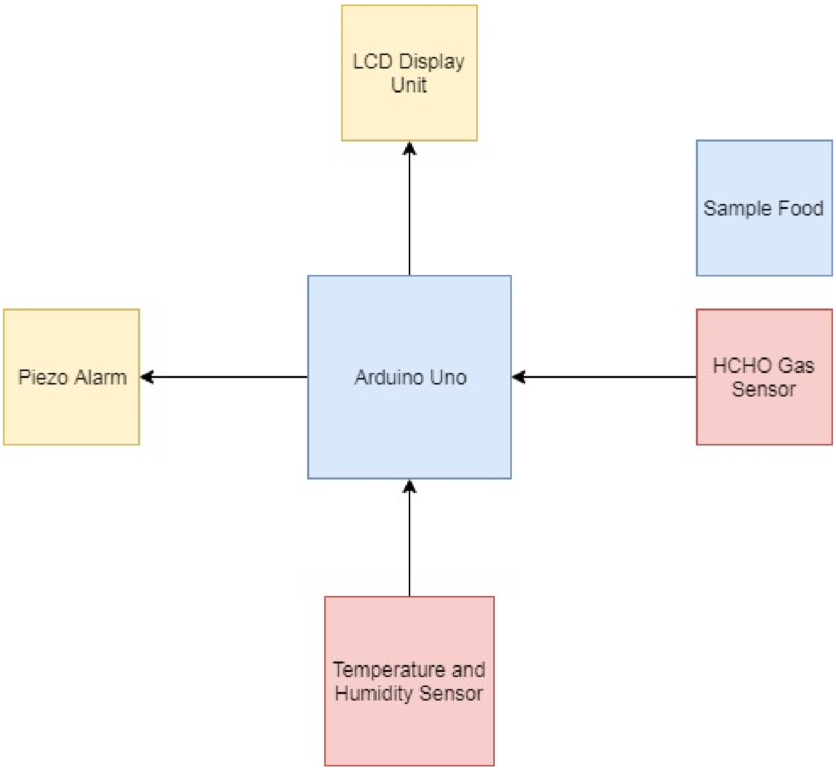

Figure 3.1: Schematic Diagram of the Formalin Detector Device

This formalin detector shows three different statuses based on the concentration of formalin present. It considers a food as "safe" if it has negligible amount of formalin, as "unsafe" if it has moderate concentration of formalin, as "danger" if it has high level of formalin. The working principle of the microcontroller-based formalin detector is shown in Fig. 3.1. It is straightforward. The sample food will be sniffed using the sensor.

For better measurement, the food should be kept in a closed container. From there, the sensed data values will be processed by microcontroller. Depending on the defined threshold values in the code it will produce different results and status of the food. We will then conduct a few trials at different concentrations of Formaldehyde at constant temperature and humidity to find the system response, using this we shall map the concentration vs the system response.

3.1 Hardware Design and Implementation

The microcontroller Atmega 328/P is interfaced with other components: display unit, piezo buzzer, sensor, and bluetooth module. The Atmega328/P is known to reach throughputs close to 1 MIPS/MHz by executing complex instructions in a one clock cycle. This motivates designing the device with optimized power consumption versus processing speed.

3.1.1 Temperature and Humidity Sensor

The Temperature and Humidity (DHT) sensor in the device that contains two parts: a thermistor and a capacitive humidity sensor. This is required to assess the temperature and humidity of the sample food if kept in a closed container. DHT sensor has thermistor capable of operating temperature range 0-50C. Thus, there is a linear relationship between resistance and temperature as given by - ΔR=kΔT.
Where, ΔR = Change in resistance,
K = Temperature coefficient of resistance. ΔT = Change in temperature.

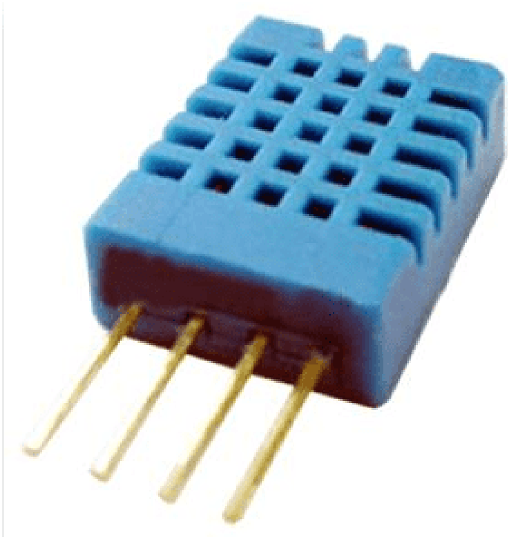

Figure 3.2: DHT11 Sensor

3.1.2 VOC Gas Sensor

The Grove-HCHO Sensor used by us is a semiconductor based VOC gas sensor. The conductivity of this sensor changes with the level of concentration of Volatile Organic Compound gas in the surroundings. The conductivity is converted into an output signal that corresponds to the concentration of gas through circuitry. The limit of determination of gas concentration in this sensor is up to 1ppm and more. Besides formaldehyde, it is also suitable for detecting volatile compounds such as toluene, ethanol, benzene etc.

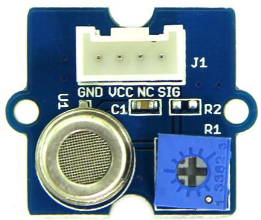

Figure 3.3: VOC Gas Sensor

3.1.3 Piezoelectronic Buzzer

Piezoelectronic buzzer is a device that produces audible outputs. It has simple procedure to make sound with microcontroller unit. It works (produces an alarming sound) by applying a mechanical pressure on certain materials called as piezoelectric materials when it is introduced with an alternating electric field.

3.1.4 Microcontroller Programming Compiler

The Arduino which is based on Atmel microcontroller unit is programmed solely by using C programming language. Programming has been done for four separate components: LCD display unit, DHT sensor, Bluetooth module, VOC sensor.

Figure 3.4: Piezzoelectronic Buzzer

Figure 3.5: Microprocessor

3.1.5 Complete Kit

The detector kit consists of five components: microcontroller unit, display unit, piezo buzzer, temperature and humidity sensor. All components are housed in a transparent box. There is a small opening in the box for the sensor so that it can be held near samples.

Chapter 4

Results

After designing the device. For testing, we have decided to use our device on ethanol/formaldehyde solutions with different concentrations obtained from the Chemistry Lab of NIT Goa and Food Safety and Standards Authority of India, Goa. When we kept the sensor near the sample solution, the device displayed the sensor value, humidity, temperature, status and also the necessary instructions. Formaldehyde was not easily available but ethanol was used instead as it is a suitable replacement. Ethanol is considered a volatile organic compound by the National Pollutant Inventory.

4.1 Experiment 1

We performed the following experiment on January 7, 2020. At first, we took 1ml C2H5OH for measuring the concentration of ethanol using our device and wrote down the value of sensor when it is shown on the LCD display. Then we mixed the previous sample with 1ml H2O to make the ethanol concentration one half of the previous one. Thus we repeated this process and the sensor values are recorded below in Table-1:

Table 4.1: Ethanol Concentration and Sensor Value (Experiment-1)

Serial No.	Concentration	Sensor Value
1	1 ml 40% C2H5OH	651
2	1 ml 40% C2H5OH + 1ml H2O	563
3	1 ml 20% C2H5OH + 1ml H2O	554
4	1 ml 10% C2H5OH + 1ml H2O	476
5	1 ml 5% C2H5OH + 1ml H2O	398
6	1 ml 2.5% C2H5OH + 1ml H2O	301
7	1 ml 1.25% C2H5OH + 1ml H2O	255
8	1 ml 0.625% C2H5OH + 1ml H2O	203
9	1 ml 0.3125% C2H5OH + 1ml H2O	130
10	1 ml 0.15625% C2H5OH + 1ml H2O	93
11	1 ml 0.078125% C2H5OH + 1ml H2O	86
12	1 ml 0.0390625% C2H5OH + 1ml H2O	74
13	1 ml 0.01953125% C2H5OH + 1ml H2O	63
14	1 ml 0.009765625% C2H5OH + 1ml H2O	63

4.2 Experiment 2

We did the following experiment on January 7, 2020 too. As with the previous case, we collected the ethanol from the Chemistry Laboratory of NIT Goa and then mixed it with water to obtain ethanol solutions with different concentrations.

Table 4.2: Ethanol Concentration and Sensor Value (Experiment-2)

Serial No.	Concentration	Sensor Value
1	1 ml 40% C2H5OH	643
2	1 ml 40% C2H5OH + 1ml H2O	608
3	1 ml 20% C2H5OH + 1ml H2O	521
4	1 ml 10% C2H5OH + 1ml H2O	486
5	1 ml 5% C2H5OH + 1ml H2O	412
6	1 ml 2.5% C2H5OH + 1ml H2O	345
7	1 ml 1.25% C2H5OH + 1ml H2O	258
8	1 ml 0.625% C2H5OH + 1ml H2O	221
9	1 ml 0.3125% C2H5OH + 1ml H2O	167
10	1 ml 0.15625% C2H5OH + 1ml H2O	126
11	1 ml 0.078125% C2H5OH + 1ml H2O	91
12	1 ml 0.0390625% C2H5OH + 1ml H2O	78
13	1 ml 0.01953125% C2H5OH + 1ml H2O	72
14	1 ml 0.009765625% C2H5OH + 1ml H2O	69

4.3 Experiment 3

We recorded the following set of data on February 10, 2020 in the Chemistry Laboratory

Table 4.3: Ethanol Concentration and Sensor Value (Experiment-3)

Serial No.	Concentration	Sensor Value
1	1 ml 40% $C2H5OH$	546
2	1 ml 40% $C2H5OH$ + 1ml $H2O$	484
3	1 ml 20% $C2H5OH$ + 1ml $H2O$	437
4	1 ml 10% $C2H5OH$ + 1ml $H2O$	328
5	1 ml 5% $C2H5OH$ + 1ml $H2O$	253
6	1 ml 2.5% $C2H5OH$ + 1ml $H2O$	198
7	1 ml 1.25% $C2H5OH$ + 1ml $H2O$	141
8	1 ml 0.625% $C2H5OH$ + 1ml $H2O$	96
9	1 ml 0.3125% $C2H5OH$ + 1ml $H2O$	81
10	1 ml 0.15625% $C2H5OH$ + 1ml $H2O$	78
11	1 ml 0.078125% $C2H5OH$ + 1ml $H2O$	73
12	1 ml 0.0390625% $C2H5OH$ + 1ml $H2O$	67
13	1 ml 0.01953125% $C2H5OH$ + 1ml $H2O$	63
14	1 ml 0.009765625% $C2H5OH$ + 1ml $H2O$	58

4.4 Experiment 4

We recorded the following set of data on February 18, 2020 in the Chemistry Laboratory with higher grade Ethanol.

Table 4.4: Ethanol Concentration and Sensor Value (Experiment-4)

Serial No.	Concentration	Sensor Value
1	37% C2H5OH	706
2	37% C2H5OH + 1ml H2O	705
3	18.5% C2H5OH + 1ml H2O	705
4	9.25% C2H5OH + 1ml H2O	658
5	4.625% C2H5OH + 1ml H2O	593
6	2.3125% C2H5OH + 1ml H2O	535
7	1.15625% C2H5OH + 1ml H2O	408
8	0.578125% C2H5OH + 1ml H2O	244
9	0.2890625% C2H5OH + 1ml H2O	203
10	0.14453125% C2H5OH + 1ml H2O	140
11	0.072265625% C2H5OH + 1ml H2O	115
12	0.0361328125% C2H5OH + 1ml H2O	83
13	0.01806640625% C2H5OH + 1ml H2O	68
14	0.009033203125% C2H5OH + 1ml H2O	68

4.5 Result Analysis

Data from all experiments are plotted on a single two dimensional graph. Concentration of ethanol and the sensor values are displayed. Sensor value is found maximum for 40% ethanol which is termed as pure ethanol solution. As the ethanol concentration in the solutions is decreased, the sensor value is also decreased as it should be. It is to be noted that, the sensor does not display the percentage concentration of the ethanol in which we generally measure, rather its unit is in parts per million (ppm).

Volatile organic compound measurements depend on medium, temperature, concentration of gas, humidity, etc. Sensor values from all sets of data do not start from zero rather they start from 50-80ppm which indicates the lowest concentration of ethanol. Then, as the concentration is increased, the sensor value increases linearly. When the concentration of ethanol is very large, the sensor value goes into saturation and hold a constant value.

Figure 4.1 shows the concentration level of Ethanol(X-axis) vs. Sensor Value (at Y-axis) of experiments-1- 4. The graph is almost linear when the concentration of ethanol is about 5-10%. When the concentration of ethanol is above 10%, the concentration of Ethanol vs. Sensor Value graph is a nonlinear one.

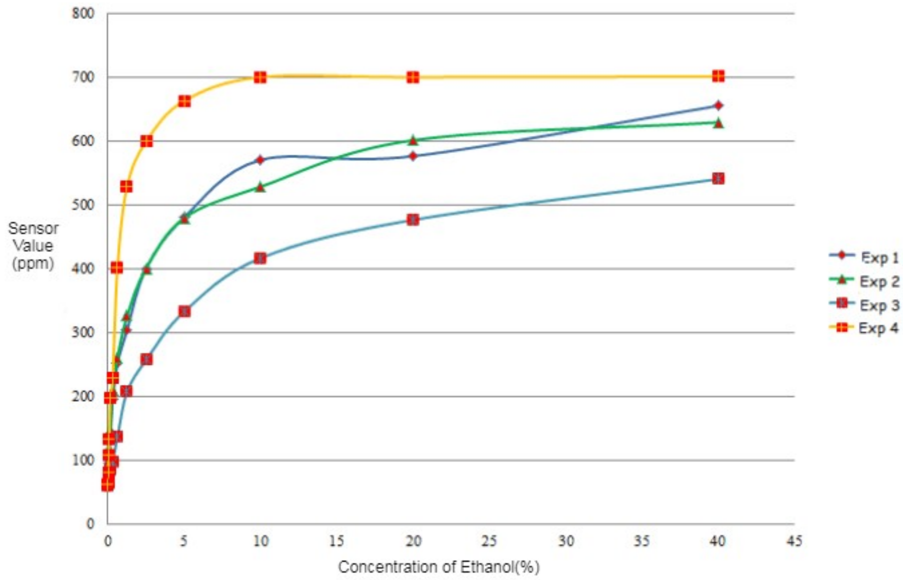

Figure 4.1: Concentration of Ethanol(X-axis) Vs Sensor Value(Y-axis)

4.5.1 Remark-1:

The graph shows the status of sample food based the on concentration of ethanol present. These are shown in Fig.4.1. Here, we defined two different threshold values of the sensor at 150 and 300 ppm. When data taken from a sample crosses the lower threshold, it will display “Unsafe” status and if it crosses the upper threshold, it will display “Danger” status. The threshold values can be easily changed in the program to match the national and international safety limits.

4.5.2 Remark-2:

Our microcontroller-based food adulterant detector kit can detect the concentration level of adulterant present in solid as well as liquid edible samples. It can also determine and display both the humidity and temperature of that sample. This device can help people to be well aware of the safety and the purity of the foods before consumption.

4.5.3 Remark-3:

For now, this device has some limitations. When the concentration of adulterant is too high, the volatile organic compound (VOC) gas sensor cannot show accurate value. We mention that formalin is a solution of water and about 40% formaldehyde by volume. When the value of the gas of adulterant is above the value of 40%, our "Microcontroller-based formalin detector" cannot detect and display the results accurately. The highest saturated value of volatile organic compound (VOC) gas sensor is recorded as 706 units. But as we are concerned with the safety of edible products, this limitation does not cause any problem. Because for much lower concentration of adulterant, the safety limits of foods will be exceeded which can be measured accurately by our kit.

4.6 Comparative Assessment

The developed kit is compared against two commercially available kits; one locally developed formalin detection kit by Council for Scientific and Industrial Research (CSIR) and another developed by Swiss Scientists, called FOODsniffer . CSIR detection kit is designed to detect formalin in fish using changes in colors in a solution prepared by suitable mixing of chemicals associated with the kit. The kit is tested with same samples prepared for testing the developed kit and it can detect the presence of formalin by changing colors in solutions.

However, the kit is unable to measure/detect the level of formalin present in samples under investigation and for low levels of formaldehyde concentration, color change is not observable. The required procedure and preparation of solution is not easy to follow by general consumers during shopping and hence the kit has not attracted general consumers despite their health concerns. Furthermore, much more time to detect formaldehyde in a single sample which is a significant inconvenience when it is required to use commercially in food markets.

FOODsniffer is also tested with the same samples prepared for testing the developed kit and it is found that it can detect the presence of formalin qualitatively not quantitatively whereas our developed kit can successfully and accurately detect formalin in samples qualitatively as well as quantitatively. The detection time for FOODsniffer and the developed kit is comparable and almost instantaneous in both cases [14].

Chapter 5

Conclusion

A microcontroller based Food Adulteration detection kit is designed that can offer a fast and simple detection of food adulteration. Our device makes use of a Volatile Organic Compound Gas Sensor which reliably detects the presence of the adulterant in edible products. Experimental results verify that the kit successfully detects adulterant in samples/solutions prepared in the laboratory containing different concentration levels.

The device not only detects the presence of an adulterant, if any, in food samples. but unlike other kits available in the market, our device even shows the level of adulteration in the food product. Our device replicates a human nose to smell harmful substances present in the food samples.The level/concentration of formalin(i.e adulterant) can be shown in ppm (parts per million). Furthermore, we have seen through comparative assessment that our device can detect and measure the presence and level of adulterant present in samples under investigation both qualitatively and quantitatively which is a clear advantage of our device over existing ones.

Further development of our device will focus on bringing more promptness, efficiency and effectiveness in adulterant sensing operations. Greater portability through miniaturization will be a key feature for future development. In adopting the device for commercial applications, it will require reproducbility and robustness. Specialized industrial processes will be needed to develop for reproducibility. Some focus will be on designing the outer visible portion of the device which is important while the device is being used by the end-consumer.

The total package will also need to be cost effective. Connection to cloud or server may also be considered where all the previous data will be stored. Concentration values for both safe / potentially harmful samples will be stored before commercial use. By checking similarity of sensor data with those, the device will decide the safety status of the sample food. These will also be useful for calibration of the device. These are the further improvements we need to work on. Consumers can use this device to ensure food safety for their family. Government officials can also use this device for conducting safety operation in various fruit shops fish markets, etc. Furthermore, it can be useful in fields of forestry a variety of commercial agricultural industries to check the naturally occurring formaldehyde content in food materials.

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