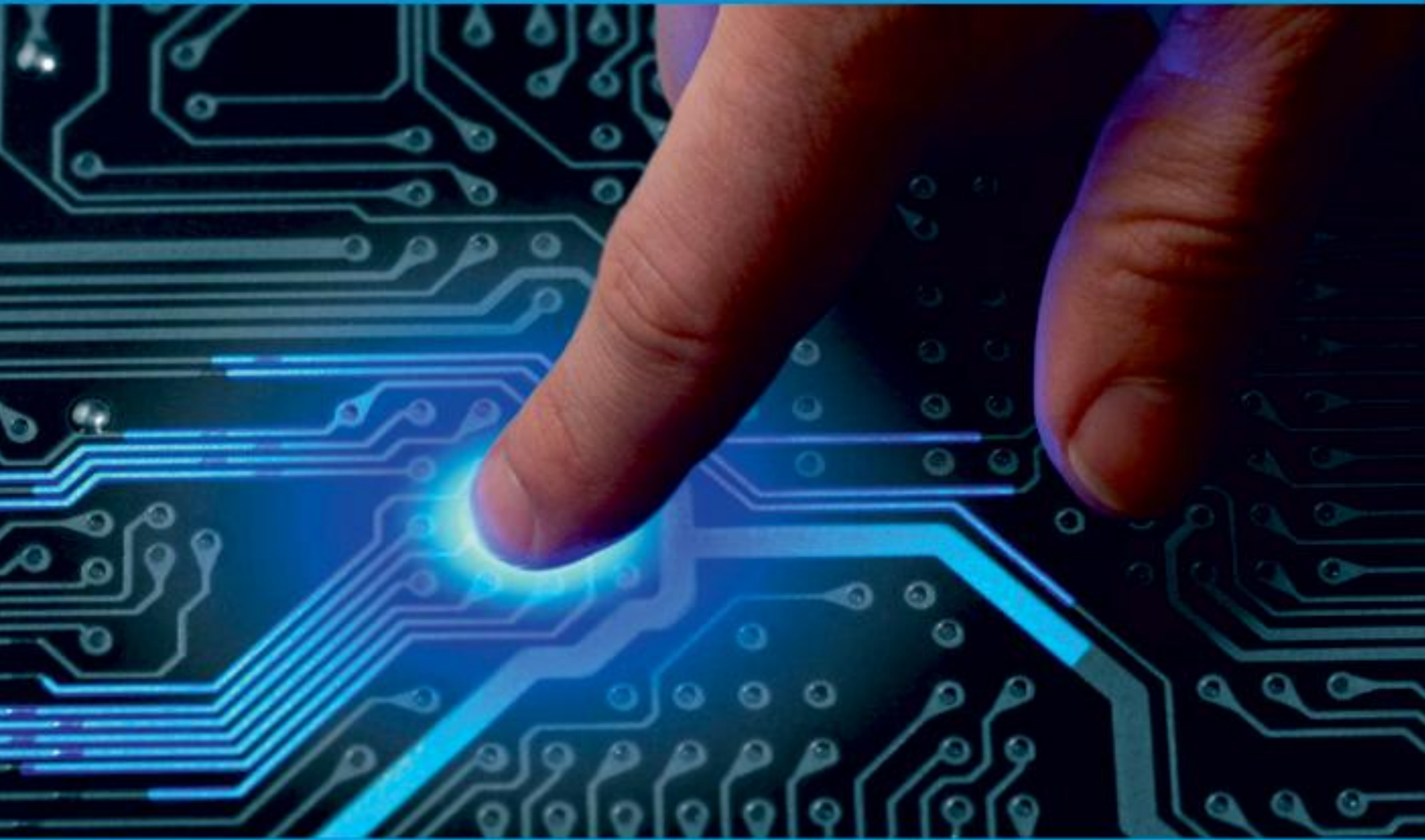
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 9, Issue 7, July 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.542

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542

|| Volume 9, Issue 7, July 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0907146 |

Adulteration in Milk using Optical Fiber Sensor

Sumit Kumar[1], Sarthak Sinha[1], Suresh Kumar[1], Pooja V. Deshmukh[2]

Dept. of Electronics and Tele-Communication Engineering, Bharati Vidyapeeth (Deemed To Be University) College of Engineering, Pune, India[1,2,3,4]

ABSTRACT: This research paper is about determining the amount of adulteration present in milk using Optical Fiber. For this experiment, a Plastic Optical Fiber (POF) as a channel, a Light Emitting Diode (LED) as a light source, Photoresistor or Light Dependent Resistor (LDR) for detecting the light intensity and Arduino Uno microcontroller for processing the signal was used.

When the cladding is removed from the optical fiber some of the light gets scattered because Total Internal Reflection (TIR), the principle on which Optical Fiber Communication works, does not take place. As a result, milk in which POF is submerged acts as the second medium and thus some of the light intensity gets lost in the surrounding. This change in light intensity is read by the LDR, which is connected at other end of POF, which generates the corresponding set of values for different concentrations of milk, and is read by the microcontroller. It was observed that as the quantity of water in the milk increases the voltage signals generated by the LDR also increases.

KEYWORDS: Adulteration in milk, Cladding, Milk impurity, Optical fiber sensor, Total Internal reflection

I. INTRODUCTION

Milk is considered to be the 'ideal food' because it is having abundant nutrients required for both infants and adults. It is easily digestible and hence is readily absorbed and thus especially important for infants, nursing women, children and elderly people. However, if adulterated, it not only becomes inferior in quality but also an economic burden on the user and also hazardous to consumers. Various milk brands in India are selling their dairy products labelled as pure 100% milk which is a marketing strategy to earn more profit. The packaged milk is adulterated with other liquids. According to a report in 2018, Food and Drug Administration (FDA) officials said that over 65% of milk is adulterated in India. Two out of every three Indians drink milk adulterated with detergent, caustic soda, urea and paint.

The common adulterants are sugar, water, salt, starch, chlorine, hydrated lime, sodium carbonate, formalin, ammonium sulphate, hydrogen peroxide (H_2O_2) and non-milk proteins etc. Water is the most commonly added adulterant used in milk which in turn decreases the nutritive value of milk. If contaminated water is added to milk, it becomes a serious health concern to the milk consuming community. Milk adulteration came into a global concern after breakthrough of melamine contamination in Chinese infant milk products. Some methods used to detect water adulteration are Frequency admittance measurements, E-nose, Electrical conductivity, Ultrasonic transmitter receiver system, Near Infrared (NIR) measurement, Freezing point osmometry and freezing point cryoscopic method. All these methods require expensive equipments. Creating an Optical Fiber Sensor can solve the economical and feasible issues faced during detection of adulteration of water in milk.

II. THEORY

Optical Fibers works on the principle of TIR. When light rays goes from a denser medium to a rarer medium, there's a maximum angle called Critical angle, at which light rays gets reflected without undergoing any refraction. The critical angle is given by sin-1(n2/n1) in degrees, where n2 is the refractive index (R.I.) of denser medium 2, n1 is R.I. of rarer medium 1. In this project some part of outer covering of POF, cladding, is removed and thus the inner part core is exposed to the surrounding. Due to this the condition for TIR is not satisfied, as a result some of the light escape through the POF. Here, milk acts as the second medium. As the concentration of milk changes, R.I. also changes and we see a gradual change in the light intensity detected at the other end of POF by photodetector. Optical Fibers come in various types like: Single-mode fiber, Multi-mode fiber, Step Index fiber, Graded Index fiber. Depending upon the type of application different types of Optical fibers can be used.

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III. METHOD

The experimental setup is shown in Figure (2). The part of POF immersed in the milk is without cladding. Optical fibers without cladding are not readily available in the market. However, there are some mechanical methods by which cladding can be removed. In this project, a sharp razor was used to peel- off the cladding very precisely. A white LED was used as a light source having wavelength of about 550nm. Generally, white LEDs are made by the combination of Blue LED and Yellow Phosphorus. In this method, a LED which emits blue colour radiation is used to excite a yellow colour phosphor (Yttrium Aluminium Garnet). This results in the emission of yellow and blue light and thus resulting mixture of blue and yellow light gives the appearance of white light.

The length of POF taken in this experiment was of 25cm and 0.75mm in diameter made of PMMA (polymethyl metacrylate). The part of POF without cladding was allowed to bind on a cylindrical object example: a pen. Using a hair dryer or heat gun, hot air was blown to give it the desired shape as shown in Figure (1). The spiral turn was having radius of 5mm and the number of turns used were five. To read the light intensity received at other end of POF, a LDR was used that can sense the light intensity upto peak wavelength of 600nm. The resistance of LDR changes in accordance with the light around it. In sufficient light its resistance is of the order of Kilo Ohms whereas in complete dark it may reach upto few Mega Ohms. The analog values read by the LDR is sent to Arduino Uno microcontroller for processing the signal. The above microcontroller can be operated using 5V DC supply or can be directly powered by using B-type USB (Universal Serial Bus) cable. Arduino shows the values in the range of 0 to 1023 where it can be easily converted into mV by using formula 'Float voltage= sensor value*(5.0/1023.0)'. The output is displayed on Serial monitor option available in Arduino IDE software.

The milk samples were collected from both packaged sources and from milk farms. The experimental reading was taken within one hour of collecting milk from the sources. The milk quality can vary depending on the nutrition of the animal and also the type of breed it belongs to.

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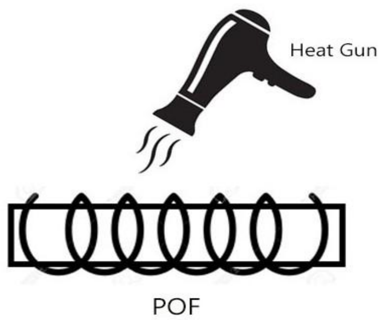

Figure1: Curling the POF using Heat Gun

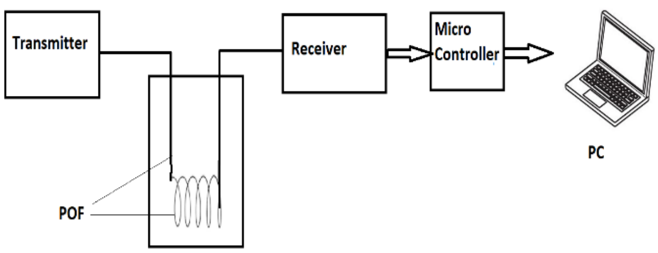

Figure2: Experimental Setup

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IV. SIMULATION WORK

100 ml of milk was taken for the experiment. Each time its concentration was varied by adding water to it. The experimental results were obtained after calculating the average of 10 samples of each type.

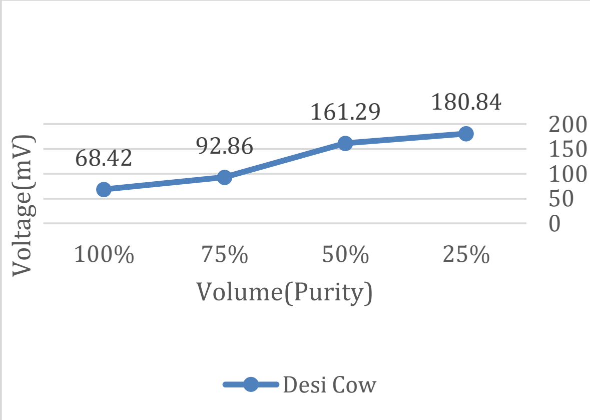

Figure3*:* Plot of variation of output voltage for Cow milk in different concentrations over time

The output values for Cow milk is as shown above. There has been a linear increase in the output values with an increase in impurity level. As the impurity changes, the refractive index of the medium surrounding POF also changes which account for different voltage values shown at the output.

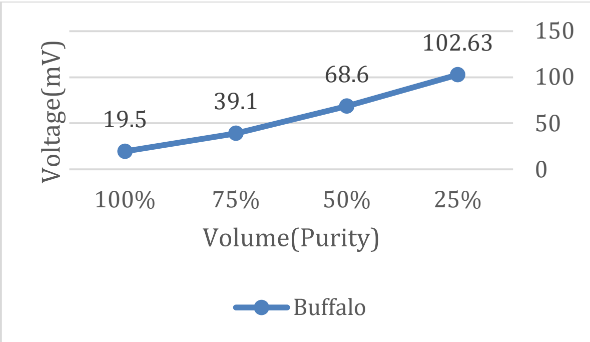

Figure4*:* Plot of variation of output voltage for Buffalo milk in different concentrations over time

The output values for buffalo milk is shown above. As it is clear from the above graph that it also shows the same trend as it was shown in case of Cow milk. The slope of the above trace remains almost the same throughout the graph.

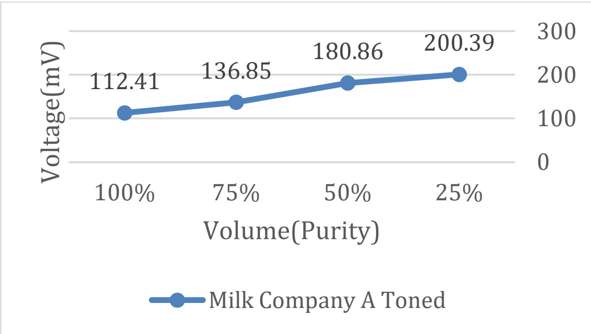

Figure5: Plot of variation of output voltage of Company A milk for different concentrations over time

The output values for Toned milk of Company A is shown above. The quality of toned milk of Company A can vary from place to place depending upon the nutrition of cow or buffalo from where the company derives milk for it's use.

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V. CONCLUSION AND FUTURE SCOPE

The use of POF for detection of adulteration of milk is advantageous as compared to other expensive and complicated methods. The main advantage being it is cost efficient and has a long-life. It can be used for maximum operating temperature of 70 degree Celsius. The major disadvantage being that POF requires high precision during installation. This project can be further extended to a device for checking the milk quality in real time. Today, we need to physically extract a sample from the source location and then do the testing in a laboratory but with the help of this device testing can be done on the spot that can save a lot of time for us.

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