ONLINE MEASUREMENT METHOD FOR COLOURS AND ITS CONCENTRATIONS IN TEXTILE EFFLUENT WATER

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Abstract: *The dark colours in industry effluent water are mostly caused by synthetic dyes and wood extracts. Spectrometers are used offline to measure the colour of effluent water. The properties and specifications of effluent water colour are all related to the wavelength of the light that is reflected by the water. To measure the colour concentration of effluent water, optical method is designed. The concentration of colours such as red, blue and green are measured using special photodiode. The focus of this paper is on the selection of sensor and its calibration with various colour concentrations. For experimental purpose, colour solutions of various concentrations have been prepared and their actual optical density is measured using spectrometer. Optical method is proposed in this work to monitor colour intensity in a continuous mode of operation. Based on the results obtained, the proposed sensor is accurately measured for various colour concentration.*

Keywords: *Arduino, TCS 3200, Colour Measurement, Bio-reaction.*

1. Introduction

The colour of an object or a substance depends on many factors such as the physical properties of the object in its environment as well as the perceptional ability of the perceiving eye and brain; this means that the objects possess the colour of the light reflected by the colour of the object. This can be measured using computer based video image analysis [1]. Turbidity and clear water reference value methods are used to find the grey water colour [2]. An Automated colour system uses a 3-bit pseudo flash converter than the conventional design to get the proper colour measurement [3].

This method depends on the spectrum of the incident illumination, the property of reflecting surface, and the angles of incoming rays of light and viewing. Also, there are some properties which may contribute to the colour reflected by the object due to light, or transmit light or even emit light by themselves. The colour seen in light is due to the spectral properties of the light interacting with the spectral sensitivities of the light receptors in the eyes.

The reason for colouration is Azo-bond (N=N) in all the compounds as shown in the below Fig 1. The concentration depends on the compounds and the strength of the double bond.

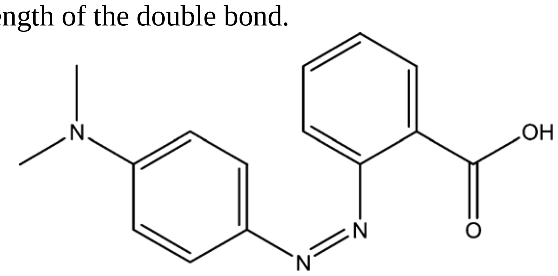

Fig. 1. Azo bond structure in colour compounds

Even the presence of small amount of colour or in small concentration, greatly influences the visibility, appearance and quality of the substance, even in liquid substances. So it should be measured without any disturbance.

For measuring the concentration, it is done with the help of finding optical density using a spectrometer or a contact type colour intensity measurements which lead to disturbances in the measurement of color concentrations. The optical method of measurement would be the apt one to measure colour without any disturbance as it is a non-contact type [4-5]. The touch-probe uses the edges of components which are done based on results of calculation of the intersection of planes and other features based on a few spots. In case of optics, edges can be found directly. The defining factor of the analysis by Touch-probe systems is the quantity of details that they gather. Any characteristic that is measured using optical method is faster and more accurate due to the sum of information that has been quickly gathered. Scheduling time for machine placement is also reduced. Measurement of colour is essential in the textile industry to remove the colour from effluent water [7].

In the proposed measurement techniques silicon photodiode is used for the colour measurement. A photodiode is a semiconductor device that can convert light into electric current. The current is produced when the photons are absorbed in the photodiode. A diminished amount of current is also raised when no light is present Photodiodes are similar to regular semiconductor diodes except that they may be either displayed. Anaerobic biotechnology methods are used to remove the dye colour in effluent water [8]- [9]

The collision of a diode and a photon of sufficient energy produces an electron-hole pair. This mechanism is known as the inner photoelectric effect. When the absorption takes place in the depletion region, it causes the holes to move toward the anode, and the electrons to move towards the cathode, this results in the production of a photocurrent. The total current obtained through the photodiode is the sum of the dark current and the photocurrent, so the dark current must be minimized to maximize the sensitivity of the device. The output obtained from the sensor is a square wave with frequency directly proportional to light intensity falling on the photodiode.

2. Experimental setup

2.1 Sample dye preparation

The Samples such as red dye (Red-RR), blue dye green dye should be collected from a textile industry and should be mixed with normal water or distilled water to make it into a dye solution as shown in Fig 2. For preparing the 10 samples of red dye solution first take 0.05g of Red-RR and dilute with 200ml of water which is a very high concentration of red dye solution. Then, take 10 beakers with 50ml of water and the concentrated solution should be poured into each beaker such that each one is differentiable with the help of naked eye. The same should be done for the other two colours. Totally 30 samples should be prepared for red, blue and green colours.

Fig. 2. Sample dye preparation

2.2 Photodiode selection

In the experiment 8×8 photodiodes (TCS 3200) are used for the measurement of the colour intensity. Sixteen photodiodes have red filters, 16 photodiodes have green filters, 16 photodiodes have blue filters, and 16 photodiodes are clear with no filters. The sensor consists of four types of photodiodes and selection of sensor is reported in table1. All photodiodes of the same colour are associated in parallel. The sensed output can be obtained by only from 16 photodiodes. The 16 photodiodes selection can be executed by

Table 1. Selection of photodiodes

S2	S3	PHOTODIODE TYPE
L	L	Red
L	H	Blue
H	L	Clear(no filter)
H	H	Green

applying the selected courses, which can be controlled either manually or by the program. It is convenient to get the colour output in terms of frequency.

2.2.1 Frequency divider selection

Output-frequency scaling can be controlled by two logic inputs, S0 and S1. It consists of an internal light-to-frequency converter that generates a fixed-pulse width pulse train. Scaling can be done by internally connecting the pulse-train output of the converter to a series of frequency dividers. Divided outputs are 50%-duty cycle square waves with relative frequency values of 100%, 20%, and 2%. The functions of the sensor are shown in Fig 3 using block diagram.

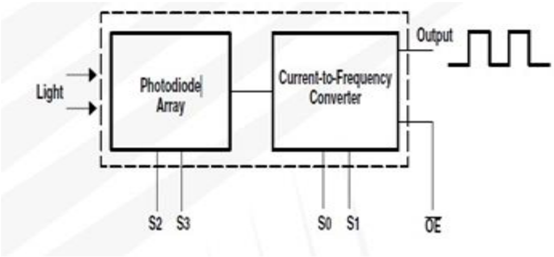

Fig. 3. Functional block diagram of the sensor

The scaled output changes both the full-scale frequency and the dark frequency by the selected scale factor reported in table 2. The frequency-scaling function allows the output range to be optimized for an assortment of measurement techniques. The scaled-down outputs are useful when using a low-cost microcontroller, or where period measurement techniques are employed.

Table 2. Selection of frequency scaling

S0	S1	Output Frequency Scaling (fo)
L	L	Power Down
L	H	2%
H	L	20%
H	H	100%

2.3 Colour Measurement

Light is an electromagnetic radiation that has properties of waves. The electromagnetic spectrum can be separated into several bands based on the wavelength. Visible light has a narrow group of wavelengths in between of about 380 nm and 730 nm [8]. In this experiment, the system can obtain a respected frequency output for the wavelength (680nm) of the colour dye solution detected. The frequency range changes for the channel to channel. Fig 4 shows the experimental setup for the measurement of colour. The output usually varies from 15 KHz to 200 KHz with the blue channel of photodiodes. As per the property of light, low wavelength rays spread more. So blue has most scattered light according to the channel in our organization. The photodiode matrix senses the scattered rays and produces the output in terms of frequency.

Fig 4. Experimental Setup for Measurement of colour

Fig 4 shows the online colour measuring system which has the sensor that collects the data from the sample and the collected data is being transmitted to the Arduino UNO .In the Arduino all the data processing takes place and the output is being displayed on the LCD monitor. Automatic Colour removal process implemented further using this measuring system.

3. Results and Discussion

Ten samples prepared each of primary colours (Red, Green and Blue). As it is discussed before, there are different types of photodiode used in the sensor module. According to the requirement, the channel should be chosen. In order to obtain better result, it has been tested with all the channels that are available. In order to identify the concentration of each colour, optical density values are measured to calibrate the photodiode-sensor. Optical density is the degree to which a refractive medium delays transmitted rays of light. There for each concentration, the optical value are not the same.

Photodiode tuned to measure the wavelength of 640nm as per datasheet requirement, the red filter produced exact reading as per the data sheet for the dark red solution. The same can be calculated using the below formula.

$\lambda = c / f$ Where c = velocity of light in space ($3* 10^8$m/s), f = frequency in Hz,

λ= wavelength in nm.

Let us take a reading of 64.44 KHz (Table 3), then substituting the equation, we get

$$\lambda = (3*10^8) / (46.74* 10^3) = 641.8 \text{ nm}$$

Therefore all the frequency reading output taken at wavelength of 640nm.

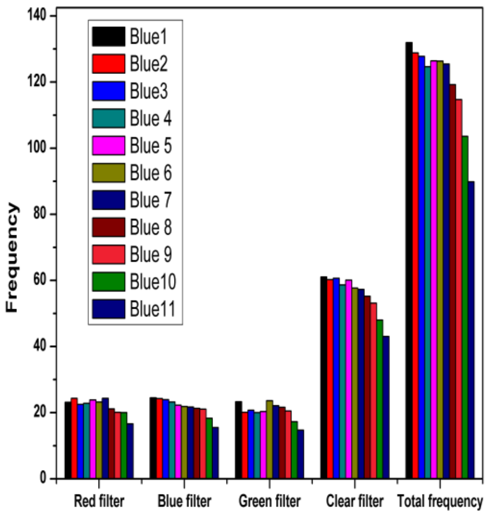

Fig. 5. Optical sensor output for various concentrations of Blue samples in different channels

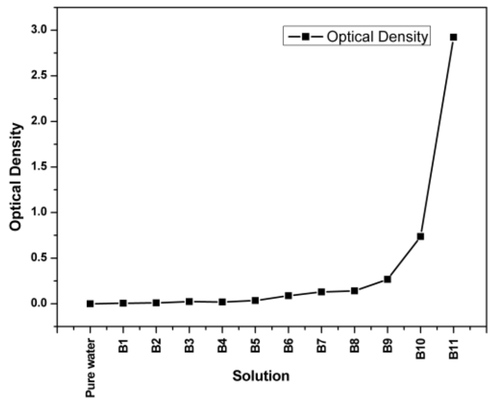

Fig. 6. Spectrophotometer output for different concentrations of Blue dye samples

As the concentration increases, the optical density also increases. Thus, in this case optical density values have been measured using a spectrophotometer. The prepared dye sample is poured into a glass beaker continuously to measure the colour concentration and the graphs are used to show the output of the sensor in all the four channels (Blue Filter, Green Filter, Red Filter and Clear Filter). The graph shown in Fig 5 is the output frequency for the different concentration of blue dye samples in different photodiode channel.

The graph is shown in Fig 6 gives the output optical density for the different concentration of blue dye samples.

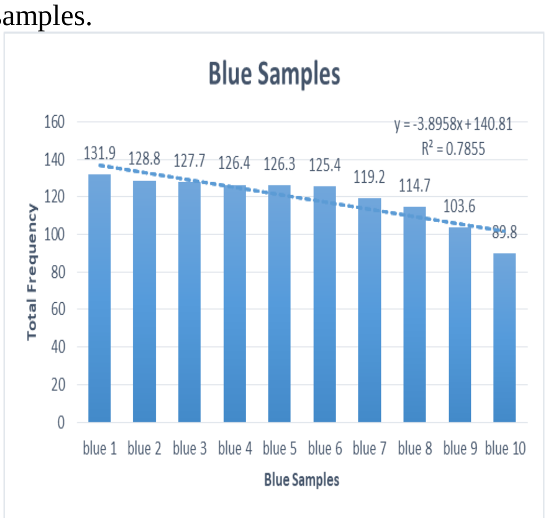

Fig. 7. Frequency readings for various concentrations of RED-RR dye

All the four modes of photodiode are used during the measurement of colour. The selection of mode done using embedded (Arduino) kit and all the four mode frequency outputs are added to measure the colour as per Fig 7. As the concentration of colour changes, the total frequency output also changes. This setup helped to automate the color removal process of textile waste water effluents.

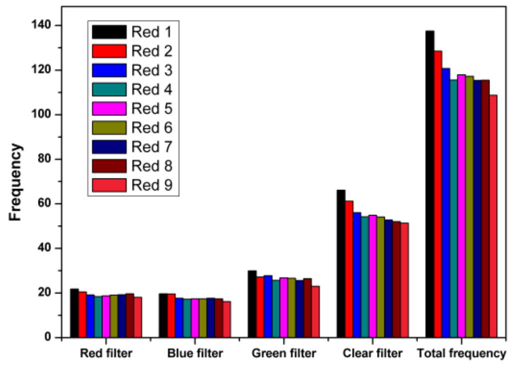

Fig. 8. Optical sensor output for various concentrations of Red samples in different channels & Total Frequency

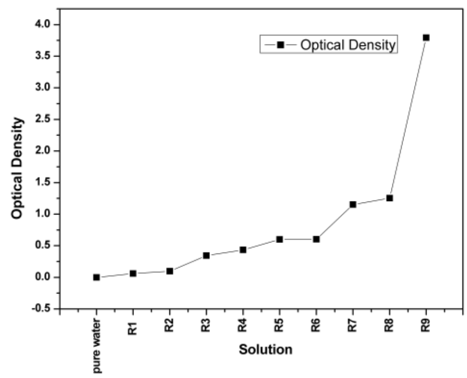

Fig. 9. Spectrophotometer output for different concentrations of Red dye samples

The graph is shown in Fig 8 shows the output frequency for the different concentration of red dye samples in different photodiode channels & total

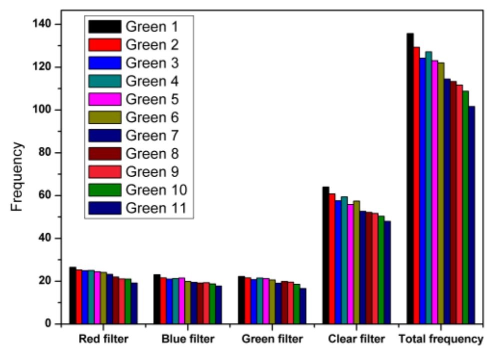

Fig. 10. Optical sensor output for various concentrations of Green samples in different channels.

frequency of all the four modes decreases as the concentration of colour samples increases.

The graph is shown in Fig 9 about the output of optical density values for the different concentration of red dye samples. The graph shown in Fig 10 explains the output frequency for the different concentration of green dye samples in different photodiode channel. The graph is shown in Fig 11 about output of optical density values for the different concentration of green dye samples. For getting high resolution and precious measurement, it has been decided to choose all four channels and take the reading simultaneously. The main advantage of choosing all channels is, the values from all the filters can be obtained and compared to obtain the expected outcome.

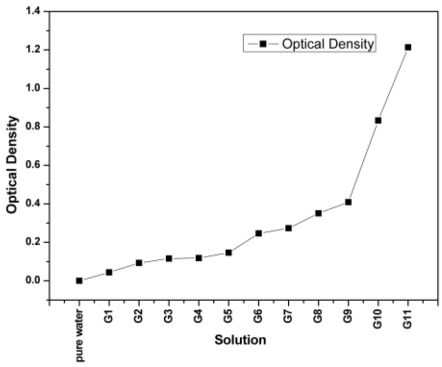

Fig. 11. Spectrophotometer output for different concentrations of Green dye samples

4. Conclusion

The experimental work has been carried out to demonstrate how a colour concentration can be measured continuously. In this work, optical sensor module is used for monitoring the changes in the concentration of a substance in a continuous fashion. This method is cost effective. The four channel photodiode and optical density of spectrometer are used to design the colour measurement of textile effluent water. This setup is further developed for removing the colour from the textile effluent water in the closed loop.

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